FIRE FIGHTING

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CHAPTER - 1

INCENDIARY BOMBS-TYPES, EFFECTS AND PROTECTION

1. Aim

The aim of this precis is to study the types of incendiary bombs, their effects and protective measures against the same.

2. Construction

A typical incendiary bomb consists of a container, usually a metal case filled with an incendiary agent and fitted with a fuse to ignite the same on impact. The casing sometimes is made of a material which itself will catch fire and burn fiercely. This may start fires at places wherever the burning pieces of the casing are scattered. An incendiary agent is a chemical capable of getting ignited quickly and in turn setting fires to materials and causing burns to people. During combustion of such an agent, sufficient heat and flames are generated to set fire to ordinary combustible material. The different types of Incendiary agents are discussed below.

3. Incendiary Agents

These agents can be divided into four classes:

(i) Spontaneously inflammable material: Phosphorus is the most important material under this head. On exposure to air it combines with Oxygen and gets ignited spontaneously, adheres to clothing causing burns and burns with a pungent smell.

(ii) Metallic Oxides: Thermite/Thermate is an important Incendiary agent, in this class. This is used in industries for welding iron and steel.

(iii) Oxidising combustible material: Magnesium is an important metal in this category. It burns with dazzling light. It cannot be quenched with water.

(iv) Flammable material: Resins, solid oil and flammable oils like petrol fall under this category. These can be used either as liquid primary incendiary agents or secondary incendiary material to propagate and prolong incendiary action of the primary material in a bomb.

4. Types of Incendiary Bombs

Generally small bombs are dropped in a scatter type to saturate the area targets. The bombing is done intensively for specific buildings which are more difficult to ignite and heavier type of bombs are used.

(i) Phosphorus Bombs: These are small bombs containing phosphorus. During the last war they were used by the Japanese. Phosphorus is harmless when wet, but it ignites as soon, as it becomes dry.

(ii) Solid Oil Bombs (6 lbs): Consists of light sheet metal casing filled with solid oil. The bomb is opened by a small explosive ejection igniter, which ignites and expels the fillings. The incendiary effect is entirely upwards and therefore not very effective.

(iii) Kilo-Electron Bombs: This was the most effective incendiary missile used during the last war. It consists of magnesium case filled with Thermite. The thermite filling is ignited first and burns at a temperature of 3000°C for about a minute melting and setting fire to the magnesium casing which in turn burns for about 10 minutes at a temperature of about 1300°C. It looks violent for the first minute and therefore causes fear and panic in the public. There being no explosion when it falls, it is not easily noticeable. After ignition it can penetrate through wood and metals and thus spread fire in places not easily accessible. Chemical Extinguishers are not very effective against these bombs. The weight being very light a large number can be carried in one bomber. Since Thermite contains its own Oxygen it cannot be extinguished by quenching or smothering.

(iv) Magnesium Bomb with High Explosive Attachment: Explosive attachment when attached to a Magnesium Bomb controls. turns it into a potential lethal weapon. Such an attachment assists in the rapid spread of fire because when the explosion takes place the burning fragments of the bomb are flung in all directions and each of these may start a fire.

(V) Large Solid Oil Bombs (250-500 lbs) Consist of light casing filled with heavy oil or oil and petrol mixture and containing a small explosive charge to detonate the bomb. In this category, is a bomb called Napalm Bomb described below:

(vi) Napalm Bomb- Napalm Bomb combines in one single missile, characteristics of an incendiary and an anti-personnel bomb. The size of Napalm Bomb is expressed in terms of the capacity of its filling in litres. The bomb commonly used has a filling of 455 litres. The body of the bomb is usually made of Aluminium. alloy. The filling is in the form of a gel 90% of which is mechanical transport fuel 1. e. petrol. The gelling agents often used are Alco-Soap. Napathenate and Palmitate or Pyridine and Xylenol and account for the remaining 10% of the filling of the bomb.

5. (a) Effects of Incendiary Bombs

A large number of Incendiary bombs could be carried in a plane and dropped over a city. resulting in simultaneous out-break of fires at a number of places. It becomes impossible for the regular fire services to attend to so many fires at different places and at the same time. Most of these fires turn into major can Migrations causing wide-spread destruction to life and property, and in case of a saturation attack in a compact built up area, large number of such bombs are dropped with a view to set on fire every possible structure. When large number of building in an area are on fire, a great column of heated air and swirling smoke rising from the centre of the area causes inward rush of wind at high velocity. Sometimes the velocity of the wind rushing towards the centre of the conflagration is great enough to hamper the progress of firefighting and rescue operations.

This wind might limit the area of fire, but on the other hand, it feeds the fire with such a large supply of Oxygen that it is practically uncontrollable. Such a condition in an area of burning materials is termed as "fire storm".

(b) Effects of Napalm Bomb: The Napalm Bomb is preferred to conventional incendiary bomb because it can be dropped by an aircraft from low altitude without risk of blast and splinters. When a bomb is dropped from air, its filling is ignited and scattered in all directions causing several fires around the ground burst. Besides, there is also a possibility of a large fire starting at the point of explosion. The flames from a Napalm Bomb shoot up to 9 to 12 M in 8-10) seconds on explosion and the burning contents are spread all round. The area affected is elliptical, about 40 M long and 15 M across. The scatterings from the bomb keep on burning for about 10 minutes. The temperature reached in the fire caused by Napalm Bomb is about 1500°C. The bomb also produces high concentrations of carbon monoxide which can be lethal in closed structures or built up areas.

Napalm Bomb is likely to set ablaze all combustible or inflammable objects which may be hit by its burning contents. In case, the burning gel falls on personnel, it sticks to the body like coal tar, keeps on burning and produces very serious burns.

6. Destruction by I. B. in Second World War:

Incendiary bombs were used during the last war in ever increasing quantities. In July, 1943) the British attack on the German city of Ham burg by Incendiary bombs was responsible for the destruction of about 60 per cent of the city. In March and April, 1945, the incendiary bomb attack on Tokyo left practically the entire city in ruins. It is estimated that about 80 per cent of the damage done to the cities during the last war was due to Incendiary Bombs.

7. Principles of protection against Incendiary Bombs and resultant fires.

The following are the important measures that should be taken for protection against Incendiary Bombs.

(1) Removal of inflammable material from the buildings especially the top floors and roof spaces.

(2) **Dispersion of important Inflammable stores**: These should be kept where the risk of fire is least.

(3) **Observation:** Early information about the falling of the bomb helps to control the fire and hence the necessity of fire watching.

(4) **Means of access:** Arrangements should be made to reach all parts of the buildings.

(5) **Small fire-fighting equipment:** Like buckets of water and sand, stirrup pumps, shovels and axes etc. should be readily available at position known to all users.

(6) **Training:** Every able-bodied man and woman should understand the action to be taken to deal with the incendiary bombs and fires.

(7) **Water:** Storage of water should be arranged.

(8) **Chemical Fire Extinguishers:** The use of the fire extinguishers should be known to all where these extinguishers are sup plied to deal with the fires.

8. Methods of dealing with incendiary bombs

(1) Magnesium Bombs:

(a) Sand Method: In this method the bomb is smothered with a three-quarter filled sand bag and then removed to a safe place. This method is used if the bomb can be reached before surrounding materials have caught fires and or if the bomb falls in close proximity to stores which might be damaged by the spluttering caused by the water method. When using sand the bomb should be approached crouching by a man wearing eye-shields, carrying a three-quarter filled sand bag across his face and body. The sand bag should be placed on the bomb and the sand NOT poured out.

(b) Water Method: In this method a fire spray of water is played on the bomb. casing causing it to react violently and burn itself out in a comparatively short time. This is done by means of a hand stirrup pump and hose fitted with an immediate change-over nozzle for spray and jet. At first the surrounding fire is extinguished by playing a jet of water on it. This jet should not be used on the bomb itself, which must be extinguished with the spray as soon as the material fire has been put out. If the water is applied in a larger volume, either in the form of a jet or from a bucket of water, the effect is that while the accelerated combustion takes place, the burning magnesium will be violently scattered in all directions. Water applied in the form of a fine spray does not cause this violent scattering.

(c) Magnesium Bomb with High Explosive attachment: A certain proportion of incendiary bombs may contain an explosive charge. When this type of bomb explodes it scatters molten magnesium and steel splinters over considerable distance and the steel splinters are capable of causing lethal wounds at close quarters and serious wounds at 50 feet. Whilst burning, these bombs behave in the same way as the ordinary incendiary bomb until explosion takes place. They generally explode within about 2 minutes after the bomb starts to burn. If an incendiary bomb falls on the premises in which It would quickly cause a serious fire, the risk that the bomb may be of the explosive type must be accepted and the bomb must be tackled alone. If it is necessary to attack the bomb from close quarters, use should be made of cover which is available.

(ii) Solid Oil Bombs: The methods employed for small Magnesium bombs are also applicable to dealing with small solid oil bombs. As burning oils float on water, care should be taken not to direct a stream of water on a pool of oil and thus spread the fire. Chemical extinguishers, particularly those of the foam types are specially effective against burning oil,

(iii) Phosphorus Bombs: Fire caused by Phosphorus filled bombs are easily extinguished with sand or water but they reignite on drying. It is, therefore, necessary after extinguishing a Phosphorus fire with water, to keep all contaminated material wet until it can be removed. In removing phosphorus in sand or when wet with water great care should be taken because phosphorus causes dangerous burns.

(iv) How to deal with fires caused by Napalm Bombs: The following action should be taken to control the fires caused by Napalm Bombs:

(a) If the main body of the fire is at a place where no combustible material is likely to be set alight either directly or by the radiated heat from the burning gel, it should be left alone to burn itself out. However, if the radiated heat from the fire is likely to endanger the surrounding property, which may be of a combustible nature, such property should be cooled down by spraying water over it with the help of stirrup pumps or by hand.

(b) If the main body of fire has already involved a large quantity of combustible material, it is safe to call the fire brigade immediately.

(c) Small fires due to scatterings of the bomb should be tackled immediately with the help of sand or dry loose earth. If dry powder extinguishers are readily available, several small fires could be extinguished with spectacular rapidity by a single extinguisher.

(d) If the burning gel hits any person, an attempt should be made to dislodge the burning gel from the body with the help of a stick simultaneously, an attempt should be made to extinguish the burning gel by throwing sand or dry loose earth on it. The burning clothing should not be extinguished with water. The affected person should lie down on the floor and roll. He should also be wrapped in s blanket or any thick sheet.

9. First Aid:

Burns caused by burning gel from a Napalm bomb causes severe third-degree burns. Suitable burn dressing should therefore by kept handy for immediate first aid and the affected persons removed to hospitals immediately.

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CHAPTER 2

NAPALM BOMB-EFFECTS AND PROTECTION

1. Aim:

The aim of this precis is to study the effects of Napalm Bomb and the protective measures against the same.

2. Construction:

It is one of the typical large sized all bombs filled with gelled gasoline. The gelling agents are alco-soaps, particularly. Napathenate and Palmitate. This is why it is called as Napalm Bomb. The gelling powder is added to petrol between 5 and 12% by weight according to the required thickness of the gel It has a long life. It remains fluid between minus 35°C to plus 65°C so that while being carried in an aircraft, it does not become brittle or too thin due to extremes of temperatures. The body of the bomb is made of aluminium alloy A 1000 lbs. Napalm consists of about 100 gallons of filling.

3. Use of Napalm as a Flamethrower:

Napalm burns at a heat of about 2060°C and produce, high concentration of carbon monoxide which is lethal in confined places like air raid shelters. It sticks to the body like coal tar and keeps burning. It is also used as flame throwers and it gives a continuous rope of blazing gel at a target 150 yards away, whereas earlier flame throwers could rarely get beyond 30 yards.

4. Effects :

Usually Napalm is ignited with white phosphorus. Fine phosphorus particles are driven into the Napalm gel by an explosive charge and these particles ignite when exposed to oxygen. Many times, these deadly phosphorus particles will also be lodged deep in the tissues of the victims of Napalm attack and may continue to smoulder there; often e enormous heat given off by the weapon one will be enough to hamper both attempts at escape and rescue. Infect the fear of fire on such a vast scale has been found to produce even among hard boiled soldiers, what has been called "Irrational mobilization".

The Napalm Bomb removes oxygen from air in the vicinity of the fire, but a man can live for some time in an atmosphere containing considerably less oxygen.

The flame from a napalm bomb shoots up in 8-10 seconds of explosion and the burning contents are spread all round. The area affected is elliptical shape and is about 130' long and 50' across. The flash rises 30' to 40' high and lasts for about 8-10 seconds. The contents keep on burning for about 10 minutes on the targets. The temperature reached in the fire. Caused by Napalm bomb is about 1500°C. Napalm bomb is likely to set ablaze all combustible or inflammable objects which may be hit by its burning contents.

5. Destruction by Napalm Bomb

A.U.S. Defence department report released reveals that on an average of about 1500 tons of Napalm bombs were dropped every month in Vietnam. This represents employment of Napalm the biggest horror weapon in use today on a scale unprecedented in the history of war fare Napalm bombs caused more deaths in Japan towards the end of World War II than the Hiroshima and Nagasaki bombs. It was also used in North Korea to slow down enemy advance.

6. Method of use

The bombs are usually Jettison able on a target from about 100-200 from ground without risk of blast and splinters of conventional bombs. When the bomb hits the ground, it burst open along the seams throwing the fuel forward and also igniting it. Burning fuel from the bomb is scattered over a "Cigar sped area" with the burning being most intense along the central of the cigar.

7. How to deal with fires caused by Napalm Bomb

The following action should be taken to control the fires caused by Napalm bombs.

(a) If the main body of the fire is at a place where no combustible material is likely to be alight, either directly or by the radiated heat from the burning gel it should be allowed to burn itself out. However, if the radiated heat from the fire is likely to endanger the surrounding property which may be of combustible nature; such property should be cooled down by spraying water over it with the help of stirrup pump or by hand.

(b) If the main body of fire has already involved a large quantity of combustible material; it is safe to call the fire brigade.

(c) Small fires due to scatterings of the bomb should be tackled immediately with the help of sand or dry loose earth. If dry powder extinguishers are readily available, several small fires could be extinguished with spectacular rapidity by a single extinguisher.

(d) If the burning gel hits any person, an attempt should be made to dislodge the burning gel from the body with the help of a stick. Simultaneously, an attempt should be made to extinguish the burning gel by throwing sand or dry loose earth on it. The burning clothing should not be extinguished with water. The affected person should lie down on the floor and roll. He should also be wrapped in a blanket or any thick sheet.

(e) Slit trenches, ditches and folds in the ground gives considerable protection as SAH they form a barrier against the rush of burning fuels.

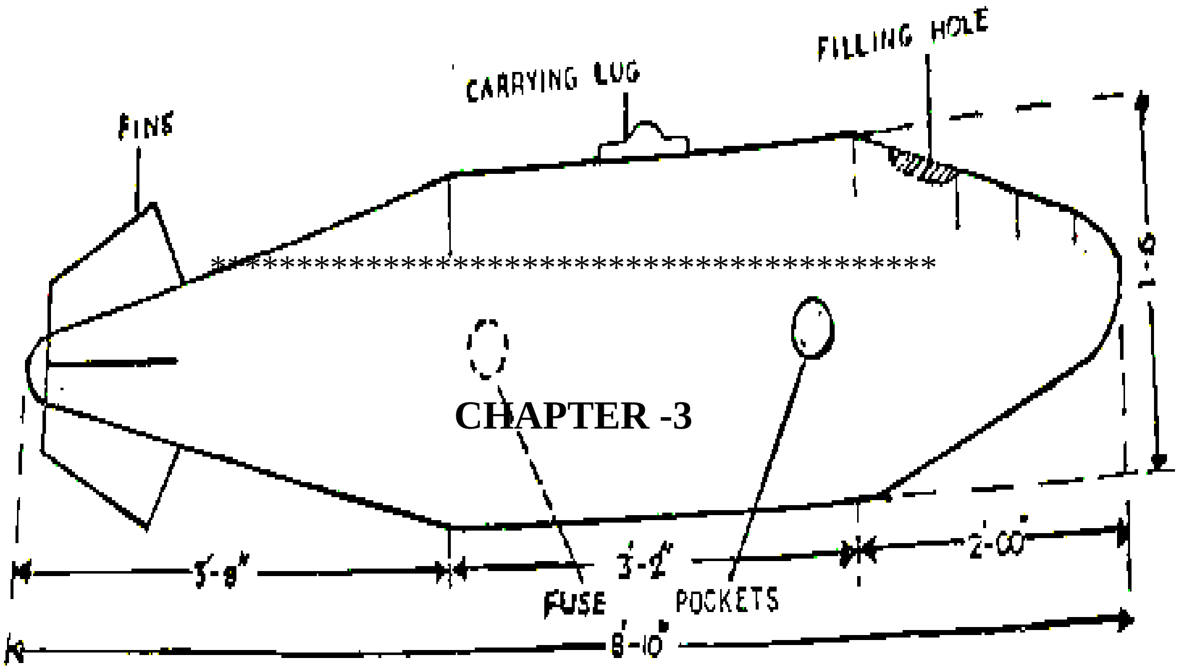
(f) Not to panic even though there is fire all around and a feeling of suffocation as it I will get extinguished soon and the feeling 201 of suffocation does not last long.

7. First Aid:

Burns caused by burning gel from a Napalm bomb causes severe third-degree burns. Suit able burn dressing should therefore by kept handy for immediate first aid and the affected persons removed to hospitals immediately.

8. Conclusion

Napalm is probably the cheapest as well as one of the most effective weapons invented in modern times. The Americans have improved upon the Napalm and a second-generation weapon known as Napalm Bomb with polystyrene, petrol and gel and benzene in 2:1:1 proportion is being produced at the rate of about 22.000 tons a month.



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CHAPTER -3

NAPALM BOMB - 455 LITERS

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CHAPTER- 3

HOUSE FIRE PARTY-ORGANISATION AND FUNCTIONS

1. Introduction

Fire had been a major tool of destruction during the IInd World War. It was responsible for about 75% of all air raid damage to European cities. Since then, the development and sophistication of conventional weapons and nuclear weapons and development in their delivery systems, have enhanced the threat of fire as 'an agent of destruction in the event of wars to come.

It is, therefore, necessary to organise a well-disciplined prompt fire service, under the Civil Defence Organisation. The Auxiliary fire service and House Fire Party service of the town to play a supporting yet important role with respect to fire watching, fire controlling and extinction and to prevent big conflagration.

2. Aim

Aim of this Chapter is to study the organisation and functions of House Fire Party service.

3. Organisation

In event of enemy air raid, and its design of damage in the form of incendiary bomb attack, a large number of fires may start simultaneously, these may further turn into big conflagration. Also, during the use of Nuclear weapons, the possibility of secondary fires at distant places I.e. In the B Zones and beyond from Ground Zero cannot be neglected. Hence the various localities in the towns are classified according to risk categories for the purpose of Civil Defence.

(i) Class A Risk: Large business premises. warehouses, large retail shops and stores, large works, ammunition stores and factories, aeroplane stores, docks, timber yards, railway depot, oil and petrol depots, refineries and similar risks.

(ii) Class B Risk: Localities containing small factories, medium sized shops, warehouses not exceeding three storeys store yards (excluding timber yards), public garages, oil depots and similar risks.

(iii) Class C Risk: Localities containing residential buildings and small shops. In addition to the regular fire service of the town Auxiliary Fire Service, House Fire Parties are organised by Civil Defence authorities in the Civil Defence Town. The House Fire Parties are organised at the scale of one party per five hundred (500) population area. Each House Fire Party is of four persons and reserve of 25% are to be enrolled and trained. Each party is equipped with (a) One Stirrup Pump, (b) Two buckets, (c) One Torch, (d) One hand axe.

The House Fire Party service is regarded as an extension of the warden service. The Chief Warden is normally in charge of it. In very large towns it may be suitable to place the house fire party service under the command of separate officer though as a rule this is not advisable.

The Staff Officer of the Chief Warden and Divisional Wardens are responsible for organisation of house fire party, recruitment and training and storages, maintenance and distribution of the equipment. Each Staff Officer should be provided with one clerk, Staff officers will be as per requirement for House Fire Party.

4. Training:

The warden shall arrange to give the following training to the member of the House Fire Party on their enrolment:

(i) Civil Defence Organisation and service.

(ii) Incendiary bomb effects and control

(iii) Stirrup pump drill, maintenance etc.

(iv) Basic rescue and first aid.

(v) House Fire Parties formation, equipment and responsibilities.

In each warden post area the post warden and his deputy will in charge of the house fire party located there.

5. Organisation of House Fire Party

House Fire Parties comprises of four members. They are as follows:

(i) House Fire Party leader
(ii) Pump man.
(iii) Bucket Man

In time of emergency or as the situation may demand house fire party may be compelled to be restricted to three members only. The details of which has been discussed further in the chapter on Drills

6. Functions of House Fire Party

It is the responsibility of House Fire Party to watch for the small fire during the enemy air raid caused by incendiary bomb attack Once having located the fire in their incipient stage the house fire party has to go into action immediately and deal with as many fires as possible to prevent conflagration.

7. Conclusion:

The House Fire Party tackles only small fires. Their skill and professional approach reduce the burden of Firefighting on the Auxiliary Fire Service (manned by Home Guards) and the regular fire service of the town.

A well trained and well organised House Fire Party service will not only check fire spreading but help in maintenance of the morale of the public during an air raid.

8. Scale and Equipment

(i) Aim: To determine the requirement of Civil Defence personnel, equipment required to man the House Fire Party Service.

(ii) Scale for House Fire Party: The authorisation of House Fire Parties to be raised. Kept in reserve and the House Fire Party Equipment and its reserve to be maintained in a Civil. Defence Town has been prescribed in the Master Plan of Civil Defence, furnished by Director General of Civil Defence, Ministry of Home Affairs, Govt. of India.

Manpower:

(a) House Fire Parties	:	2 per 1000 population.
(b) Leader	:	1 per party.
(c) H.F.P. Members	:	3 per party.
(d) Staff Officer	:	1 per each Divisional Warden.
(e) Clerk	:	1 per Staff Officer.

The Director of Civil Defence may at their discretion reduced the scale of House Fire Parties as considered appropriate.

(iii) Scale of equipment for House Fire Party service:

(a) Personal equipment per member:

(i) Helmet : 1
(ii) Whistle : 1

(b) Party Equipment:

(i) Stirrup Pump : 2
(ii) Buckets : 1
(iii) Torch : 1
(iv) Hand Axe : 1

(iv) Reserve: 25% of the manpower required for house fire party service is added to actual requirement as reserve.

10% of Party equipment is added to the actual equipment required to get the total equipment required for the House Fire Party service.

(v) Care and Maintenance of equipment:

The stirrup pump is an excellent, elementary firefighting equipment. Hence it is an important basic appliance for fighting incipient and small fires. It is used effectively by the House Fire Party. The stirrup pump is designed to tackle incendiary bombs and resultant small fires.

Failures to deal effectively with fires, can be avoided by proper care and maintenance of the stirrup pump.

The stirrup pump is made of brass and is liable to rust if proper care is not taken. The care and maintenance of the stirrup pump is considered under two heads (a) Testing, and (b) Care and Maintenance.

(a) Testing :

Stirrup pump should be tested with water preferably once a week. Faults regarding the stirrup pumps may develop with regards to the following points: -

(i) Rusted ball valves: The ball valves are accessible by removing the strainer and the handle. The rust is removed with pocket knife or emery paper.

(ii) Ball valves being struck to its seating: Ball valves struck to its seating can be freed by pushing a pin or piece of wire up through the strainer.

(iii) Choked strainer: The strainer is easily cleaned with a pin or piece of wire or a wire brush.

(iv) Choked hose nozzle: This should be cleaned by unscrewing the nozzle and clearing out the hole and the apertures of the slide valve

(b) Care and Maintenance

(i) Stirrup pump should be used only to spray water. No strong disinfectants or insecticides or chemical should be sprayed with the pump, as they are likely to cause clogging of the barrel and deterioration of the hose.

(ii) All exterior surfaces of the pump should be kept dry.

(iii) Expel all water from the pump and hose after use. To do this suspend the hose from high level to ensure that water is being drained off. This can be easily achieved by lifting the hose from the pump onwards above shoulder level and working one hand progressively towards the nozzle.

(iv) Coil the hose neatly in clockwise action. Prevent sharp bends and twists being formed as this will result in damage to the hose pipe. Do not hang the hose pipe of the stirrup pump on a nail or spikes on which it is likely to get damaged. In fact, after the use the hose should be drain off its water, and the hose pipe coiled properly and attached to the pump with a string or strap.

(v) Clean all grit and dirt from the dual nozzle, so that it slides easily. Keep the jet and spray holes in the nozzle slide valve free of foreign water.

(vi) If water leaks from the top of the barrel. When a pump is in use, screw down the gland collar a little tighter, or unscrew the gland collar and repack with soft cord soaked in oil

(vii) Pour a small quantity of thick lubricating oil into the pump through the wire mesh (strainer) of the foot valve. Work the pump with full strokes so that oil will work thoroughly over the inner surfaces of the pump.

(viii) Dry the plunger rod carefully and apply thin coating of grease all over the working surface.

(ix) Store the pump away from sunrays and in a cool and dry place.

(x) While keeping the pump on the ground the hose should be on the top i.e. not below the pump. This is done to avoid damage to the hose.

(xi) While storing or hanging the pump from the wall, it should be hung from wall bracket about six feet from the ground. Here also the coiled hose pipe should be kept on the outer side, I.e. not near the wall.

(xii) Inspect the pump at least, once a week.

(c) Conclusion:

Prompt attention paid to the stirrup pump with respect to care and maintenance is sure to save lives and valuable property in an emergency.

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CHAPTER -4

AUXILIARY FIRE SERVICE ORGANISATION AND FUNCTIONS

1. Introduction:

Under emergency conditions, the Auxiliary Fire Service must be kept in state of readiness and the aim should be to obtained and trained at least twice the number of men that would be actually required to perform the duties provided for in the Fire precautions scheme. Auxiliary Fireman should be between 25 and 45 years of age and physically fit. They should be mentally examined before enrolment and must receive at least 96 hours training before they can be deemed efficient. Such an Auxiliary Fire. Service will consist of Trailer Pump Parties.

A reserve of 25% should be enrolled and trained. A reserve of 10% of the vehicles should be provided.

Auxiliary Fire Service should be placed under the local Fire service. Care and maintenance will be the duty of the Chief Fire Officer.

2. Auxiliary Fire Service (Trailer Pump Parties):

(i) Organisation: An Auxiliary Fire Service will consist of Trailer Pump Parties. Each Trailer Pump Party should have one Leader, one Driver-Mechanic, six Firemen and one Messenger. These are to be manned by Home Guards.

(ii) Scale: The scale is one Trailer Pump Party per 25,000 population, with the provision of 25% reserve.

(iii) Equipment: The equipment authorised at present comprises one Trailer Pump Unit per party. The auxiliaries etc. may be seen in the Ministry of Home Affairs, publication entitled "Master Plan for Civil Defence". The present scale of equipment together with the whole question of auxiliary fire services is under consideration in the Ministry of Home Affairs.

(iv) Location: The Auxiliary Fire Service Units should be located near enough the fire risk areas but sufficiently away from the likely targets. For this purpose, various localities in a town or city may be classified according to the following risk categories:

(a) Class "A" Risks: Large business pre mises, warehouses, large retail shops and stores, large works, ammunition. stores and factories, Aeroplane stores. docks, timber yards, railway depots, oil and petrol depots, refineries and similar risks.

(b) Class "B" Risks: Localities containing small factories, medium sized shops, warehouses not exceeding three storeyed store yards (excluding timber yards), public garages, small oil depots and similar risks.

(c) Class "C" Risks: Localities containing residential and small shop properties.

3. Equipment for Auxiliary Fire Fighting

(a) Appliances and Equipment for Medium Trailer Pumps:

Equipment	Qty
Medium trailer pump with 2 delivery outlets capacity about 250 gallons/minute at 100 lbs/ In^2 pressure, complete with towing bar.	1 No.
100 mm suction hose in 4.5 meters length with 100 mm suction hose coupling	2 No.
Suction wrenches (100 mm).	2 No.
Basket strainer.	1 No.
Three way, suction collecting head for connecting to nearest hydrant.	1 No.
63 mm rubber lined delivery hose 30 m length with male and female couplings.	10 No.
Hose bandages	6 No.
Double female couplings 63 mm.	2 No.
Rubber washers for 63 mm couplings.	40 No
Dividing breeching with control. 63 mm instantaneous	1 No.
Collecting breaching. 63 mm Instantaneous	1 No.
Branch with revolving head with branch pipe	1 No.
Branch pipes for 63 mm size instantaneous hose couplings	2 No.

Nozzles

(a) 6 mm	2 No.
(b) 12 mm	2 No.
(c) 20 mm	2 No.
(d) 25 mm	2 No.

Hydrant stand pipe, double outlet.	1 No.
Hydrant key,	1 No.
Portable canvas dam.	1 No.
Collapsible canvas buckets.	4 No.
Portable hand pump with hose and nozzle or stirrup pump.	1 No.
Torch flash light, 3 cells.	2 No.
Fire extinguisher, dry powder (2 Kg.).	1 No.
Fire extinguisher, carbon di-oxide (2 Kg.).	1 No.
First aid box for 10 persons.	1 No.
Rubber Gloves.	1 No.
Fireman's Axe, large.	1 No.
Shovels.	2 No.
Pick axe (1 Kg.).	1 No.
Crow bar with chisel and claws 1 m length.	1 No.
Hand grip saw 65 mm.	1 No.
Spanner, adjustable, 30 cm.	1 No.
Fire hook.	1 No.
Asbestos gauntlets. 40 cm.	2 No.
Mechanical foam compound 20 ltr. drum.	2 No.
Foam making branch pipe FB 5.	1 No.
Branch pipe universal	1 No.
30 m. length of 2 inch rope where buildings are high.	1 No.
Hose clamp.	1 No.
Shears or bolt clippers 60 cm.	1 No.
Sledge hammer 6.5 Kg.	1 No.
Ceiling hook (preventer) 7' overall with out	1 No.
Sand container with handled shovels.	1 No.
35' extension ladder, or 20' improvised Bamboo ladder.	1 No.
15 m length of 2 inch fibre rope.	1 No.
Spade.	1 No.
Pick.	1 No.
Hurricane lamps.	2 No.
Electric Torch.	1 No.
Suction adopters 100 mm female to 63 mm instantaneous male.	1 No.

(b) Appliances and Equipment for small Trailer Pumps :

EQUIPMENT	**QTY.**
Light trailer pump with 1 delivery outlets. capacity about 120 gallons/minute at 80 lbs/in pressure, complete with towing bar.	1 No.
100 mm suction hose in 4.5 meters length with 100 mm suction hose coupling.	2 No.
Suction wrenches (100 mm)	2 No.
Basket strainer	1 No.
Two way suction collecting head for connecting to nearest hydrant.	1 No.
63 mm rubber lined delivery hose 30 m length with male and female coupling.	10 No.
Hose bandages	6 No.

Double female coupling 63 mm.	1 No.
Rubber washers for 63mm couplings	40 No.
Dividing breeching with control 63 mm instantaneous.	1 No.
Collecting breeching 63mm instantaneous.	1 No.
Brach with revolving head with branch pipe	1 No.
Branch pipes for 63 mm size instantaneous hose coupling. (19mm nozzle)	2 No.
Hydrant stand pipe double outlet	1 No.
Hydrant Key	1 No.
Portable canvas dam	1 No.
Collapsible canvas buckets.	4 No.
Portable hand pump with hose and nozzle or stirrup pump.	1 No.
Fire extinguisher, dry powder (2 kg)	1 No.
Fire extinguisher, carbon di-oxide (2 kg).	1 No.
First aid box for 10 persons.	1 No.
Rubber Gloves.	1 No.
Firemen's Axe, large.	1 No.
Shovels.	2 No.
Pick axe (1 kg.)	1 No.
Crow bar with chisel and claws 1 m length.	1 No.
Hand rip saw 65 mm..	1 No.
Fire hook.	1 No.
Branch pipe universal (25 mm)	1 No.
30 m length of 2-inch rope where buildings are high. Hose clamp.	1 No.
Shears or blot clippers 60 cm.	1 No.
Sledge hammer 6.5 Kg.	1 No.
Ceiling hook (preventer) 7' overall with cutting edge.	1 No.
Sand container with handled shovels.	1 No.
35 extension ladder, or 20' improvised Bamboo ladder.	1 No.
15 m length of 2 inch fibre rope.	1 No.
Spade	1 No.
Pick	1 No.
Hurricane lamps.	2 No.
Electric Torch.	1 No.
Suction adopters 100 mm female to 63 mm instantaneous male.	1 No.

4. Water Supply

Water is used universally for fighting 'A' class, fire (i.e. substances like, paper, wood, cotton, cloth). The fire in this case is extinguished by cooling method which is well known theory-of extinction of fire. It is said that water is thus used because of :-

(i) It is a good coolant or cooling agent.
(ii) Costs less or practically nothing.
(iii) It is easily available.
(iv) It is also available in abundance.

However during an emergency, it is required to store or procure water for firefighting in a planned manner and to use it economically as water will then be most valuable. This is so because of the possibility of damaged water mains and the heavy use of water for firefighting. Also, water will be much required for industrial and human consumption. This necessitates prompt action by the wardens and the House Fire Party members to ensure continuous supply of water, in the warden post area/sector allotted; with the co-operation of the inhabitants of that area and the adjoining localities. This can be achieved by following methods:

(i) The warden as well as the members of the House Fire Party must be well con versant with the alternate water sources like, rivers, nalas, canals, wells, tanks, within their jurisdiction and in the adjacent sector.

(ii) The wardens and the members of the House Fire Party should induce all the householders to store sufficient water in their houses for fighting small fires.

It is important not only to utilise the resources available locally, but planning ahead for reinforcement in the following particular aspects:

(a) Every available means of conveying water should be made ready in case of need.

(b) Plans for supplementing the supplies of water in all high-risk areas by relaying its should be worked out and rehearsal.

(c) Every possible source of water supply should be explored to ensure that any and every supply which can be utilised is made available.
(d) Fixed tanks should be installed near the principal fire risks.

Adequate supply of water is vitally important for fighting a fire. Without adequate water supply, all other arrangements, howsoever, well organised may become ineffective. The following action should, therefore, be taken:

(i) Exploration of every possible natural source of water supply-lakes, ponds. Pools etc.
(ii) Installation of fixed tanks in principal fire risk areas.
(iii) Provision of tanks, reservoirs and wells.
(iv) Advice to the house holders to store sufficient water at all times.

The requirements for water supply for firefighting during air raids should be worked out on the scale given below :

Scale	Water supply require for fire-fighting in Gallons	
For CD town with three lakh population:		
a) Peace me At 400 GPM per 50.000 population	100 minutes supply @ 2400 GPM	2.40.000
b) Extra for War-time A 250 GPM per 25.000 population.	100 minutes supply @ 3000 GPM	3.00.000
	TOTAL	5.40.000

NOTE: The above formula is applicable to 2 CD towns of and below 3 lakhs population

For CD town with six lakhs population:

(a) Peace time At 400 GPM 50.000 population first 3 lakhs and at 400 GPM GPM per 1.00.000 subsequent population.	100 minutes supply @ 3600 GPM	3.60.000
b) Extra for War-time Al 250 GPM GPM per 25,000 population.	100 minutes supply @ 6000 GPM	6.00.000
	TOTAL	9.60.000

Note:-

(i) The above formula is applicable to all CD towns having a population of over the three lakhs.

(ii) The above yardstick is for general guidance only. Actual quantity of water required has to be assessed after taking into account other factors, like the layout of the built-up area topography and special, risks.

5. **Conclusion:**

Water being the main firefighting agent. Conveying and storing of water should be well planned and rehearsal by the warden’s house fire party members in collaboration with the local inhabitants.

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CHAPTER -5

CHEMISTRY OF COMBUSTION

1. Introduction

To enable the fire officers to visualise the extent to which he should expect a fire to spread and to decide his line of action to minimise this spread by taking suitable action in accordance with certain basic principles of combustion. It is, therefore, necessary for him. to gain some knowledge of these basic principles of the process of combustion.

2. Combustion

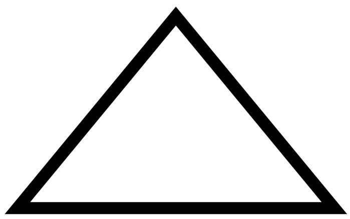
Combustion may be defined as a chemical reaction taking place between an oxidiser and an oxidisable with the evolution of heat and smoke or light. There may not be appearance of light always, but in combustion heat will always be evolved.

Smoke is the product of incomplete combustion, containing unburnt carbon particles. When ordinary materials burn in free air, the principal products of combustion are carbon dioxide and steam I. e. CO, and HO. With restricted supply of air, carbon monoxide (CO), may be produced and this with additional amount of Oxygen (that might be available at the spot) may form (CO) carbon dioxide gas.

It is essential to raise the temperature of each kind of materials to a fixed degree to initiate combustion and this temperature is known as "Ignition Temperature". The actual combustion takes place only after solid or liquid fuel has been vaporised or decomposed to produce gas and it is this burning gas within its range of in flammability in air or oxygen is called the "flame". The characteristics of flame is to produce heat and light but there are cases of combustion, where a flame might not be produced at all.

3. Triangle of Combustion

Ordinary combustion is a chemical reaction) between a fuel and oxygen, in presence of heat. In other words, it may be stated that three things are essential for a combustion which may be represented by the three arms of a triangle, namely heat, combustible materials and supporter of combustion or oxygen. Fire cannot take place in absence of any one of these factors.



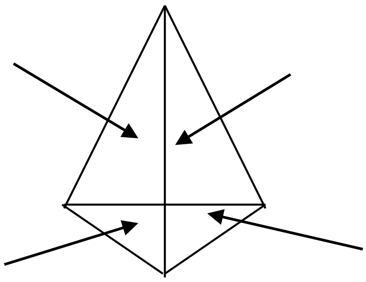
FUEL FIRE OXYGEN HEAT

Triangle of combustion

4. The Tetrahedron of Fire:

In combustion process, intermediate Free radicals" which also play a part in the continuity of flaming combustion, exist within the flames.

A new distinction had to be made where in glowing (non-flaming) burning required the original trilogy but, that in flaming combustion, a fourth element, namely the uninterrupted activity of the free radicals in the combustion chain reactions, had to be included. Hence, the term "tetrahedron of fire" was devised to provide for this fourth element.



UN-INHINITED CHAIN REACTION HEAT OXYGEN FUEL

Tetrahedron of fire

5. The Mechanism of Extinguishment

Extinguishment, here, consist of interrupting of combustion reaction by :-

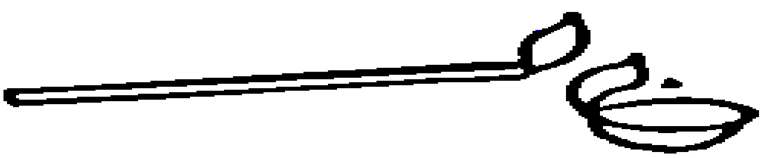
(i) Covering or removing the fuel, known as "Starvation"
(ii) Cooling the reaction temperature known as "Cooling"
(iii) Diluting or removing the oxygen supply, known as "Smothering.
(iv) Interruption of un-inhibited chain reaction.

Thus, whatever may be the equipment or the extinguishing media for fire-fighting, cooling, smothering, starvation and breaking of chain reaction are the processes for fire extinction

6. Apart from the supply of oxygen, the combustible substance is required to be raised to the ignition temperature, for the fire to occur. The knowledge of flash point, fire point and ignition temperature is important to every fire officer.

(i) Flash Point:

It is defined as the lowest temperature, at which an inflammable substance gives off sufficient vapour, so as to form a momentary flash with air, on the application of a pilot flame in the prescribed manner.



(ii) Ignition Temperature:

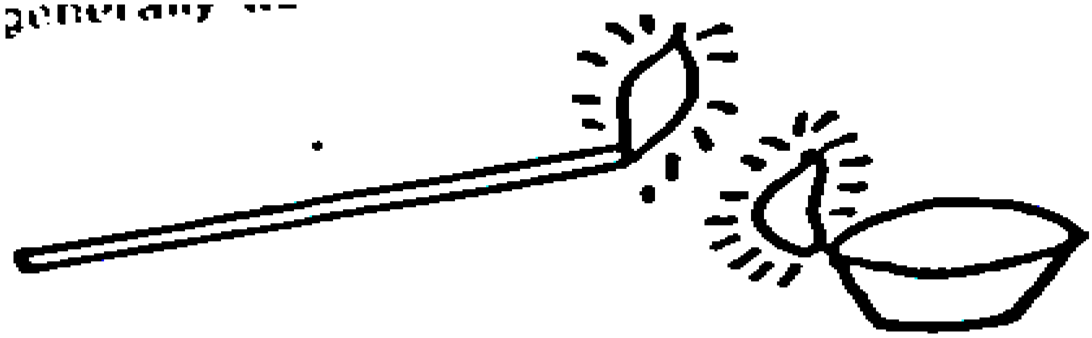
It is defined as the lowest temperature at which spontaneous ignition can take place.

(iii) Auto-ignition Point:

The self-ignition point (sometimes called the "auto-ignition point" or the combustion point) also refers to the temperature to which a sub stance must reach, before it will ignite, in the absence of flame, but in the presence of air.

(iv) Fire Point:

It is defined as the lowest temperature, at which the heat from combustion of a burning vapour is capable of producing sufficient vapour to enable combustion to continue. It is generally above the flash point.



7. Spontaneous Combustion

Spontaneous combustion occurs as a result of the heat generated by the reacting substance themselves, without the heat from any external source. e.g. When hot glycerine is poured on to crystals of potassium permanganate, the substance soon begins to fume and afterwards they burst into flame.

Apart from what has been stated above, there are many other chemical reactions which produce:

(i) Heat and light which comes under the definition of combustion even though oxygen does not take part in these reactions, e. g. burning of powdered metals like iron, magnesium, aluminium, or hydrogen in an atmosphere of chlorine gas.

(ii) Combustion (without heat & light) oxidation or rusting of iron is accompanied without rise in temperature and without a flame.

(iii) Combustion (without heat)-moist yellow phosphorus emits a bluish glow of light without evolution of much heat. This is known as "Phosphorescence".

8. Chemical Reaction: (Exothermic & Endothermic reaction)

Whenever there is any chemical reaction, either heat is liberated or heat is absorbed from the reacting substances. In the former case, it is called exothermic reaction and in the latter. case, it is called endothermic reaction.

9. Types of Combustion and Rate of Combustion:

According to the nature of combustion, it may be classified as follows:

(i) Slow or incipient combustion-is one in which the amount of heat and light emitted is feeble.

(ii) Rapid or active combustion-is one in which a considerable amount of heat and light is emitted within a short time.

(iii) Deflagration-is a case of combustion which takes place with a considerable rapidity, evolving heat and light.

(iv) Explosion-is very rapid combustion attended with a loud report, within an extremely short time, with generation of very high pressure and temperature.

Rate of combustion or the spread of fire would depend on the following factors:

(a) The area of solid or liquid in contact with air or oxygen.

(b) The amount of heat generated to raise the temperature of unburnt portion to its ignition temperature.

(c) The ability of the materials to conduct heat away rapidly from the burning portion.

(d) Atmospheric humidity, wind velocity, temperature and atmospheric pressure.

10. Specific Surface

The specific surface of a solid is the surface area in square centimetre per gram of that solid substance. Liquid and gases have no specific surface as compared to solids. These two take the shape of container.

On the basis of specific surface and fire susceptibility, all combustible solids may be divided under three categories as:

(i) Tinder: Solids with specific surface of more than 20 sq. cm. per gram.

(ii) Kindling: Solids with specific surface of 2 to 20 sq. cm. per gram.

(iii) Bulk Fuel: Solids with a specific surface of 0.04 to 2 sq. cm. per gram.

Tinder can be ignited by an ordinary match stick, but tinder requires a burning tinder for igniting it. Bulk fuel cannot be ignited by a match or a tinder but requires burning kindling for ignition.

11. Density & Specific Gravity:

Every substance has its own mass and volume. The density of a substance is its mass per unit volume.

$$\text{Density (D)} = \frac{\text{Mass (m)}}{\text{Volume (V)}}$$

= Kg/ml or gms/cm

Water has density 1000 kg/m or 1 gm/cm' of 62.5 lbs/ft Mercury has the very high density of 13.6 gm/cm and therefore 13.6 times as dense as water.

The relative density or specific gravity of a substance is the ratio of the mass of any volume of it to the mass of an equal volume of water.

$$\text{Relative Density} = \frac{\text{Mass of any volume of the Substance}}{\text{Mass of an equal volume of water}}$$

It has no unit, it is simply a number of ratio and It is the same whatever system of units are being used for expressing densities.

12. Vapour Density & Vapour Pressure:

In the case of gases, it is very important to know, vapour density in relation to air because. it gives an idea, as to whether the gas is lighter than air and it will soon distribute itself, in the available atmosphere, forming an inflammable and explosive mixture.

In fire service, the measurement taken with regards to air generally. Vapour density is the ratio of the mass of a given volume of the vapour to the mass of an equal volume of air under the same temperature and pressure.

The vapour pressure of a liquid is the pressure exerted by the vapour of the liquid, at any given temperature at which the vapour and liquid phases of the substance are in equilibrium in closed container.

13. The Transmission of Heat

Heat travels from regions of high temperature to region of lower temperature. This is true no matter how small is the temperature difference. There are three methods by which heat may be transmitted.

(i) Conduction
(ii) Convection
(iii) Radiation

(i) Conduction: Conduction may occur in solids. In conduction, heat energy is passed on from one molecule to the next. In conduction of heat, the molecules vibrate about its mean position and pass on heat energy by colliding with their neighbours. The ability to conduct heat (Thermal conductivity) varies between materials.

(ii) Convection: This occurs only in liquids and gases when a liquid or gas is heated it expands and therefore becomes less dense. The lighter fluid rises being displaced by colder and therefore denser fluid. This in turn becomes heated and so a circulation is set up. Heat energy is carried throughout the fluid by actual movement of molecules until a state of uniform temperature is reached.

(iii) Radiation: Heat may also be transmitted in straight lines by a means which is neither conduction nor convection. Heat from the sun. passes through empty space to warm the earth. Heat from a heater placed at high level in a room can be felt underneath the heater, where neither conduction nor convection can carry it. This method of heat transmission is named radiation' and does not involve any contact between bodies and is independent of any material in the intervening space.

14. Latent Heat

When heat is applied to a container containing water the temperature of water increases and gradually as temperature rises and attains 100°C, water starts boiling. Once water starts boiling the temperature of boiling water remains static at 100°C, though heat is applied constantly. This heat energy is steadily absorbed by boiling water from the source of heat to convert the water from the liquid state to vapour state.

This heat energy which is absorbed by the liquid at its boiling point, to convert from its liquid state to gaseous state, without raising the temperature, is called 'Latent Heat'. This heat is required for vaporisation of the liquid as such this is called "latent heat of vaporisation".

Likewise, the heat required to change the state from solid to liquid at melting point of sub stance without raising the temperature is called as "Latent Heat of fusion".

Similarly, the heat energy released from a substance during change from gaseous state to liquid state or from liquid state to solid state at a static temperature is also called as "latent heat".

Example:

(i) Latent heat of vaporisation of water is 2260000 Joules/kg.

(ii) Latent heat of fusion of water 336000 J/kg.

15. Specific Heat:

Heat energy can be transferred from a place of higher temperature to one at lower temperature. When heat is added to a body the temperature rises.

The thermal capacity (heat capacity) of a body is the heat required to raise its temperature by 1°C. The thermal capacity of various substances vary over a considerable range.

Water has very high thermal capacity (4 2KJ/ kg/C), very few substances have higher value than this.

The specific heat is the ratio of thermal capacity of a substance to that of water.

Thus, the specific heat of a substance may be defined as the ratio of quantity of heat required to raise the temperature of a given mass of sub stance through a given range of temperature to the quantity of heat required to raise the temperature of water through the same range of temperature.

Material with low special heat (Le with low thermal capacity) will heat up more rapidly in a fire situation than those of higher Sp-heat Le Substance, having lower thermal capacity, have higher fire risk.

The Sp-heat of almost all common substances, except water, are less than one. Sp-heat figure are significant in fire protection as they indicate the relative quantity of heat needed to raise the temperature to a point of danger, or the quantity of heat that must be removed to cool a hot substance to a safe temperature.

One reason for the effectiveness of water as an extinguishing agent is that its Sp-heat s higher than that of other substances.

16. Thermal Expansion of Solids

In general, a substance (solid, liquid or gas) expands when heated unless it is prevented from doing so by some external agency, by a change of state or by a change in chemical composition.

When a solid is heated, it expands in all three dimensions and therefore increases in length. and thickness. Frequently, the increase in length is the most important and the determination of expansion in area and volume follows from it. It is found that within normal ranges of temperature, solids which are homogeneous (i.e. uniform in structure) expand uniformly i.e. the expansion of a bar is proportional to the rise in temperature. The expansion also proportional to the length of the bar, but varies with the nature of the substance of which the bar is made.

17. Co-efficient of Linear Expansion

The amount with which unit length of a substance expands when its temperature is raised by one degree is called the co-efficient of linear expansion of the substance. The temperature scale must be stated. Thus, we can say that the co-efficient of linear expansion of a solid is the increase in length of unit length when its temperature is raised by one degree.

For steel the co-efficient of linear expansion is 0.000012 per "C. Thus a bar of steel 1 metre long expands by 0.000012 m for each "C rise in temperature and so on.

For solids, the co-efficient of cubical expansion is three times the co-efficient of linear expansion.

For liquids, only the co-efficient of volume expansion is applicable.

For gases, the increase due to thermal expansion can be measured either as an increase in volume of constant pressure or as the increase in pressure at constant volume.

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CHAPTER -6

CHEMICAL FIRE EXTINGUISHERS

1. **Object :**

Stirrup pumps and quite a few other first aid firefighting appliances are used for extinguishment of small fires. These are known as chemical fire extinguishers. The knowledge of their use, care and maintenance etc, is very essential for the members of the house fire parties, so that in case they come across such appliances during emergencies they will be in a position to use them efficiently for extinguishment of small fires. The object of this lesson is to study the use, care and maintenance of different types of chemical extinguishers.

2. **Introduction:**

The principle of fire extinction consists of the limitations of one or more of the factors (fuel. oxygen and heat) required to continue fire.

The method of extinguishing fire may. therefore, be classified as follows:

(1) **Starvation**: i.e. limitation of fuel.

(a) By removing combustible material from neighbourhood of fire.

(b) By removing the fire from the neighbourhood of combustible material.

(c) By sub-dividing the burning material, when the smaller fires produced may be left to burn out or to be extinguished more easily by other means.

(ii) **Smothering**: i.e. limitation of oxygen. If the oxygen content of the atmosphere in the immediate neighbourhood of burning material can be sufficiently reduced. combustion will cease.

(iii) **Cooling**: i.e. limitation of temperature. By accelerating the speed with which heat is removed from the fires thus reducing the temperature of the burning mass as a consequence than rate at which heat is produced. In due course the rate at which heat is lost from the fire exceeds the rate of heat production and fire dies away.

3. **First Aid Fire Fighting Equipment**

The fire spreads very rapidly. All big fires are caused by the small fires. Therefore, it is essential that the small fires would be attended to immediately, and are not allowed to spread. Different types of equipment may be used to extinguish the fires of different nature at their incipient stages and are known as 'First Aid Fire Fighting Equipment".

This equipment are small in size, light in weight and thus easy to carry and with simple operating procedure.

Different first aid firefighting equipment are based on different principles of extinction as follows:

(a) **Based on cooling principle**: Water in bucket, stirrup pumps, and bucket full water, chemical fire extinguishers of Soda-Acid type, water (stored pressure) extinguishers etc.

(b) **Based on smothering principle:** Sand bucket, sand/soil in gunny bag, scoop and rake, fire beaters, chemical fire extinguishers of Foam, CO., D.P. type etc.

(c) **Based on Starvation principle**: Improvised fire hook, cutting equipment etc.

4. **Portable Chemical Fire Extinguishers:**

(a) Portable Chemical Fire extinguishers are essentially firefighting appliances for use only on fires of certain types in their incipient stages. They are generally sufficiently small in size and light in weight to be carried readily by hand and are then known as 'Hand Extinguishers'.

Larger models of certain types known as Chemical Engines' or 'Trolley Units', may be mounted on a simple two-wheel chassis which is moved by hand on fire.

(b) Generally, Gas or Air Pressure is used as expellant to expel the extinguishing medium from the chemical fire extinguisher. This gas pressure inside the extinguisher may be produced as follows:

(i) Chemically during operation of extinguisher.

(ii) From the inert gas/air.

(a) Stored directly under pressure inside the extinguisher.

(b) Stored under pressure in a cartridge which is placed conveniently inside the extinguisher.

(c) **Types of Extinguishers**

(i) Extinguishers which expel water or dilute chemical such as water (stored pressure) extinguisher. Soda-Acid extinguisher

(ii) Extinguishers which expel 'Foam", such as chemical foam type.

(iii) Extinguisher which expels vapour forming liquid or gas, such as CO, Halon type.

(iv) Extinguisher which expels dry powder. such as a D. P. extinguisher (stored pressure) type.

5**. Classification of Fire:**

(a) **Class 'A'**: Fire involving ordinary car bodacious materials, such as Paper. Wood, Textile etc.

(b) **Class B'**: Fire involving inflammable liquid such as Petrol, Alcohol, Kerosene. Diesel etc.

(c) **Class 'C'**: Fire involving inflammable gas. such as Coal gas, Hydrogen, Methane. Acetylene, L. P. G. etc.

(d) **Class 'D':** Fire involving highly combustible and reactive metals such as Aluminium, Magnesium, Copper. Zinc, Uranium, etc.

6. **Types of Extinguishers**

6.1 Water Type Extinguishers

A. Soda Acid Extinguisher

(i) **Use**: On "A" Class fire at incipient stage.

(ii) **Shape**: (a) Conical (b) Cylindrical.

(iii) **Operating Position**: (a) Upright (b)Turnover.

(iv) **Capacity**: 2 gallon/9 litres.

(v) **Expelling Agent**: Carbon-dioxide which is produced on chemical reaction.

(vi) **Chemical and other substances In use**:

(a) Sodium-bi-carbonate $Na(H)CO_3$

(b) Sulphuric Acid : (H_2SO_4)

(c) Water: Water Soda solution is filled up to an indicating mark in the container of extinguisher.

(vii**) Chemical Reaction**:

Sodium Bicarbonate	+	Sulphuric Acid	=	Sodium Sulphate	+	Carbon dioxide	+	Water
2Na(H)CO	+	H_2SO_4	=	Na_2SO_4	+	$2CO_2$	+	$2H_2O$

(viii) **Extinguishing medium**: Water (mixed with Sodium Bicarbonate and Sodium Sulphate).

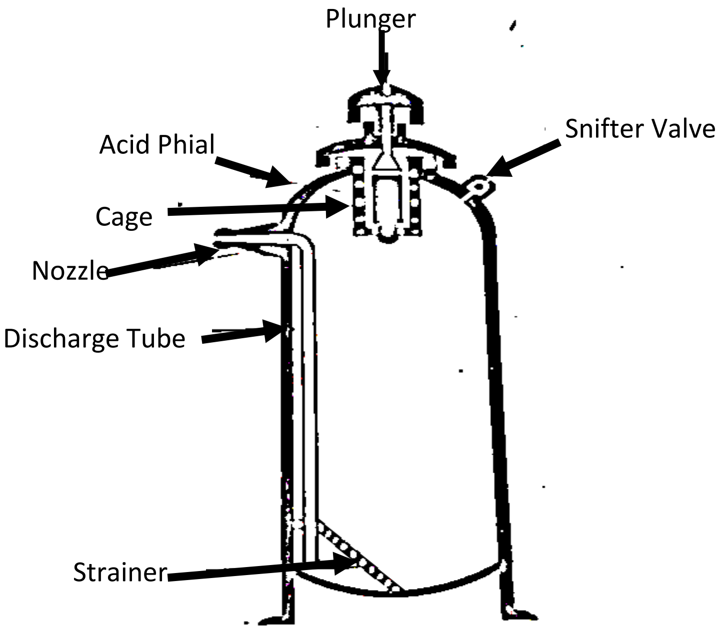
(ix) **Principle of extinction:** Cooling.

(x) **Parts** :

(a) **Outer Container**: This is made of mild steel sheets. The Capacity is about 9 litres. It contains a solution of carbonate or bicarbonate of soda or both in water. There is a nozzle fitted on the container for the discharge of water.

(b) **Inner Container**: This is a suitably shaped metal cage to hold the glass bottle containing sulphuric acid. This container is fitted at the neck of the outer container from inside. It is perforated to allow the acid to mix with the sodium bi carbonate solution when the bottle is broken.

(c) **Cap**: There is a cap made of brass or a metal which can be screwed on at the top of the outer container. There is a plunger rod fitted to the cap which when struck will break the acid bottle thus actuating the chemical reaction.



(xi) **Operation**: The plunger at the top is struck which breaks the acid bottle in the inner container. The acid mixes with the soda-bi carbonate solution in the outer container and the chemical action produces carbon-di-oxide. was in large quantity. Being in a confined space the gas inside the container builds up pressure and forces the water solution to come out through the nozzle in jet form, which can reach a distance of 6 meters. The carbon-di-oxide generated inside the extinguisher plays no part in extinguishment of the fire but acts as expelling agent.

With the extinguisher in hand, approach the fire as near as possible and then operate the same. Direct the jet on the burning material to the heart of the fire disregarding the flames and the smoke.

(xii) **Safety Devices**: Precautions against losses due to expansion-when an upright type extinguisher is left standing fully charged, an increase in the temperature of the room causes the fluid and the air to expand inside the container. Under ordinary circumstances, expansion would force some of the fluid up through the discharge tube and out through the nozzle. The water evaporates and leaves bicarbonate of soda in solid form in the orifice of the nozzle.

If this process is continued, the nozzle would eventually become solidly blocked and would render the extinguisher ineffective.

To prevent this, snifter valve is provided in the plunger rod of the extinguisher.

This is a valve communicating between the air space in the extinguisher and the atmosphere outside and permits the very small quantity of air to escape when the internal pressure rises slightly. A ball rests lightly on the orifice provided in the plunger rod of the extinguisher and allows the air to seep away into the atmosphere. When the extinguisher is operated the high internal pressure lifts the ball firmly against the seating which completely seals the outlet.

Vent Holes: These holes are provided on the plunger cap of the extinguishers. As the cap is unscrewed these holes communicate with the interior of the container and any residual gas pressure or the pressure created inside due to choked nozzle, will discharge through them whilst the cap is still held in position by the threads.

(xiii) **Discharge performance**: The length of the jet should not be less than 20' for the minimum period of 60 seconds. The whole of the content must be discharged within the maximum period of 120 seconds. The jet is expected to reach 35' to 40' although it should not be less than 20'.

(xiv) **Advantages & Disadvantages**:
Advantages:

(a) For first attack on a fire it is most readily accessible firefighting equipment.
(b) Only one person is needed to handle it.
(c) It is most instantaneous in action.

Disadvantages:

(a) Once the extinguisher is actuated the dis charge cannot be stopped midway.

(b) As the liquid discharged is a good conductor of electricity, it should not be used on electrical fire.

(c) At low temperature the chemical reaction is retarded, as well as sometimes the water solution freezes. Anti-freezing solutions cannot be added to prevent freezing, it also affects the chemical reaction.

(d) The liquid ejected contains a chemical (sodium sulphate) which acts chemically on costlier fabrics and damages it, so this extinguisher is not suitable for extinguishment of fires in such fabrics.

(xv) **Care Tests: Maintenance and Standard Tests:**

(a) Extinguisher to be opened up for inspection on acceptance and quarterly to be maintained as follows:

(i) The liquid level should be checked and any slight loss should be made up with water, otherwise a new charge should be used.

(ii) The nozzle, strainer, vent-holes in the cap. discharge tube (where fit ted) and snifter valve should be checked for cleanliness.

(iii) Before the head cap is replaced, the plunger should be checked to see that it operates freely, the washer should be examined and replaced if necessary. The cap then should be tightly screwed to the container to form a gas tight joint.

(iv) No corrosion or damage should be visible either externally or internally.

(b) **Yearly Test:** Check discharge performance once in two year.

(c) **Hydraulic Pressure Test**: Performed once in every 3 years. Outer container should be tested for 17.5 kg. per square centimetre for a period of 2.5 minutes.

(xvi) **Recharging**:

(a) Before opening the extinguisher, the vent hole should be checked in case the extinguisher has become accidentally pressurised. Unscrew and remove the head, keeping the head pointing away from you.

(b) Withdraw the bottle holder detachable.

(c) Thoroughly wash out the extinguisher body and remove any pieces of solid matter, broken glass etc. which may be found in it.

(d) Thoroughly mix the bi-carbonate of soda with water in a clean bucket. Pour the solution into the body of the extinguisher and fill it to the correct level. Do not overfill as this reduces the expansion space above the liquid and may set up dangerous pressure when extinguisher is actuated.

(e) See that plunger works freely. Grease very lightly.

(f) Insert the new bottle of sulphuric acid in the cage. Replace the cage in the extinguisher.

(g) Slightly grease the threads at the tip of the container. Finally screw down the head tightly.

B. **Water (Gas Cartridge) Extinguisher:**

(i) **Use**: On 'A' class fire.
(ii) **Shape**: Cylindrical.
(iii) **Operating Position**: Upright.
(iv) **Capacity**: 2 gallon/9 litres.
(v) **Chemical Used**: Nil.
(vi) **Chemical Action**: Nil.

(vii) **Expelling Agent**: CO_2 Gas stored under pressure in the gas cartridge kept inside the body of the extinguisher.

(viii) **Extinguishing Medium**: Water.

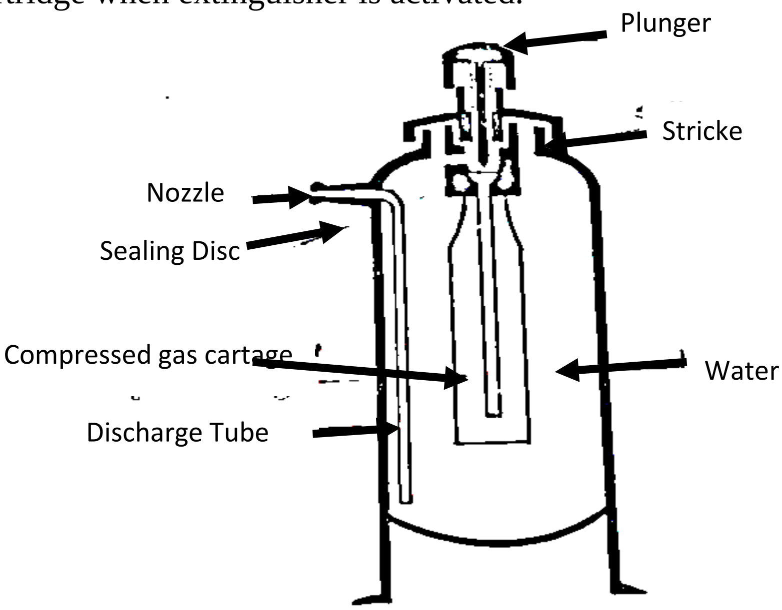
(ix) **Principle of Extinction**: Cooling.

(x) **Parts** :

(a) **Outer Container**: Similar to that of soda Acid Extinguisher but capable of withstanding a minimum internal pressure of 35 bars. It has an expansion space above the surface of the liquid. It has a discharge tube and a nozzle.

(b) **Gas Cartridge**: The cartridge holds the gas under pressure in the region of 35 bars (approx. 35 atmosphere) for low pressure type. The cartridge has a small sealing disc at the tip. The cartridge normally contains about 57 grams of carbon dioxide at just below 35 bars pressure.

(c) **Head cap:** Cap holds the plunger. The knob of the plunger is protected from accidental operation by a safety clip which is removed to strike the knob. The plunger has a pointed striker at its lower and to pierce the sealing disc of the Cartridge when extinguisher is activated.



WATER (GAS CARTRIDGE) TYPE EXTINGUISHER

(xi) **Operation**: Remove the safety clip of e knob of plunger. Strike the knob. Striker of the plunger will pierce the sealing disc of gas cartridge. Gas will come out of the cartridge and would exert pressure on the water. As a result the water will come out of the extinguisher through the discharge tube and the nozzle. Direct the jet of water on to the burning material.

(xii) **Safety Device**:

(a) Vent hole in the cap.
(b) Snifter valve.

(xiii) **Advantages over soda acid Extinguisher**:

(a) The expelled liquid may consist of pure water only.
(b) Extinguisher can be recharged more rapidly.
(c) Discharge performance, precaution against loss of contents by expansion are the same as for soda-acid extinguisher.

(xiv) **Care, maintenance and standard test:**

(a) Extinguisher to be opened up for inspection on acceptance and quarterly to be maintained as follows:

(i) The liquid level should be checked and the liquid topped up if necessary.

(ii) The nozzle, vent holes in the cap. internal discharge tube and snifter valve should be checked for cleanliness.

(iii) The gas cartridge should be weighed and the weight checked against that marked on the cartridge. The cartridge should be renewed if a loss of more than 10% of the contents is recorded. A check should be made to see that the sealing washer is in good condition.

(iv) Before replacing the head cap see that the plunger operates freely.

(v) **No corrosion or damage should be visible either externally or internally:**

(b) **Yearly Test**: Test by discharge once in. five years.

(c) **Hydraulic Pressure Test**: Performed once in every 3 years. Outer container should be tested for 17.5 kg/cm^2 for a period of 2.5 minutes.

(xv) **Recharging**:

(a) Unscrew and remove the head after checking that ventholes are clear.
(b) Unscrew the gas cartridge from its thread under the head.
(c) Wash out the outer container and refill with water.
(d) Make sure that the plunger is completely withdrawn into the head and then screw the gas cartridge into place.
(e) Screw down the head tightly to make a gas tight joint.

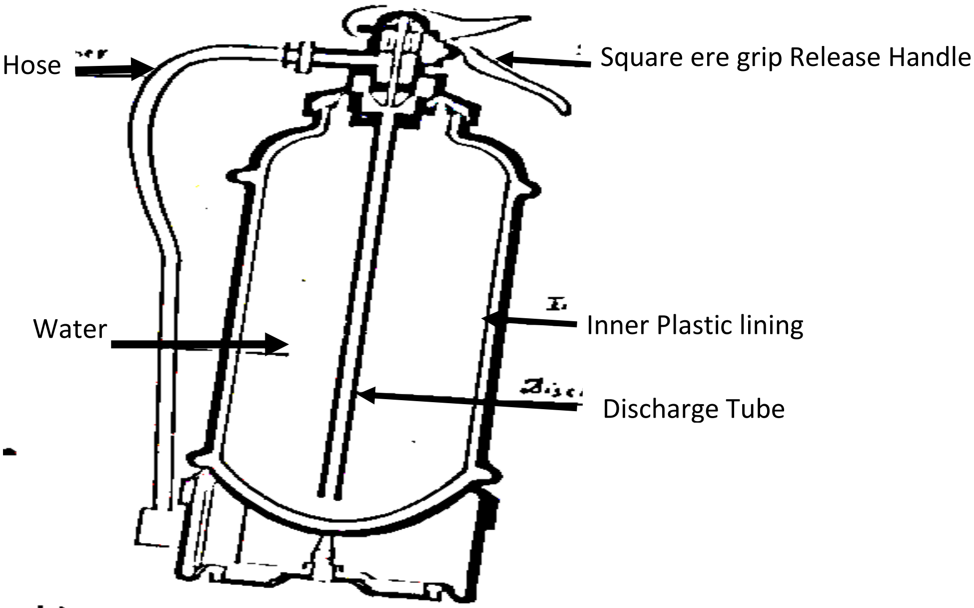
C. **Water (Stored Pressure) Extinguisher:**

In this model, the body is of welded design lined with plastics to prevent corrosion and has a brass screwed cap which contains the valve group.

(i) **Use**: On 'A' class fire.
(ii) **Shape**: Cylindrical.
(iii) **Operating Position**: Upright.
(iv) **Capacity**: 2 gallon/9 litres.
(v) **Chemical used**: Nil.

(vi) **Expelling Agent**: Dry air under pressure at 10 bars.
(vii) **Extinguishing Media** : Water
(viii) **Principle of Extinction**: Cooling
(ix) **Parts**:

(a) Outer Container.
(b) Brass screwed cap with pressure gauge.
(c) Rubber Hose.
(d) Squeeze grip release handle.



WATER (STAVED PRESSURE) EXTINGUISHER

(x) **Operation**: The extinguisher is operated by withdrawing the safety pin, depressing the valve lever and directing the jet by means of the hose. The extinguisher may be rested on the ground during operation and the discharge may be interrupted at will by releasing the valve lever.

(xi) Safety Device: Vent Holes in the cap.

(xii) Advantages over soda-acid extinguisher is same as that of water (gas cartridge) extinguishers.

(xiii) Care, maintenance & standard test:
(a) (i) Examine and verify that the pressure gauge is indicating the internal pressure correctly.
(ii) Examine the extinguisher body externally for corrosion or damage.
(iii) Weigh the extinguisher to check that it contains the correct level of liquid.
(iv) Examine the hose and nozzle and clean if necessary.
(v) Examine the hose for wear and replace if not in good condition.
(vi) Check the operating mechanism & Discharge control for free movement, clean, rectify or replace, if necessary.
(vii) Replace eatery bin as originally fined.
(viii) Refill the extinguisher with clean water

Note:-As this type of extinguisher is pressurised, it can be opened for inspection only after discharge.

(b) **Yearly Test**: Test by discharge once in a two years.

(c) **Hydraulic Pressure Test**: Performed once in every two years. Outer container should be tested for 25 kgs./ cm^2 for a period of 2.5 minutes

6.2. **Foam Extinguisher:**

A. **Chemical Foam**: when Aluminium Sulphate is allowed to react with sodium Bicarbonate in a solution (in water) and a small quantity of stabilizer is added, then a frothy pro duct is obtained which retains its texture for a comparatively long time. This froth is relatively insoluble in most liquids and owing to its light weight floats on the surface of the liquid. This frothy thing is called as Chemical Foam. When foam is applied correctly and in sufficient quantity, it forms a blanket capable of covering the surface of the burning liquid, and this is normally completely effective in extinguishing the fire. We use this on fires involving flammable liquids like petrol, diesel, kerosene oil etc. which can be extinguished in their incipient stage by use of Chemical Foam Extinguisher.

(i) **Use**: On 'B' class fire at incipient stage.

(ii) **Shape**: Cylindrical

(iii) **Operating Position:** Turnover.

(iv) **Capacity**: 2 gal/9 Its

(v) **Expelling Agent**: Carbon-di-oxide which is produced on chemical reaction.

(vi) **Chemicals and other substances used**:

(a) Sodium-bi-carbonate ($Na(H)CO_3$).
(b) Aluminium Sulphate ($Al_2(SO_4)_3$).
(c) Water
(d) Stabilizer-such as Saponin, Red Turkey oil etc.

The outer container holds a solution of about 8% Sodium-bi-carbonate with about 3% of stabilizer dissolved in water.

The inner compartment contains a solution of about 13% aluminium sulphate.

When these two chemicals are mixed a re action is set up which produces carbon-di oxide gas and foam. Gas acts as expellant as well as filling the foam bubbles.

(vii**) Chemical Reaction:**

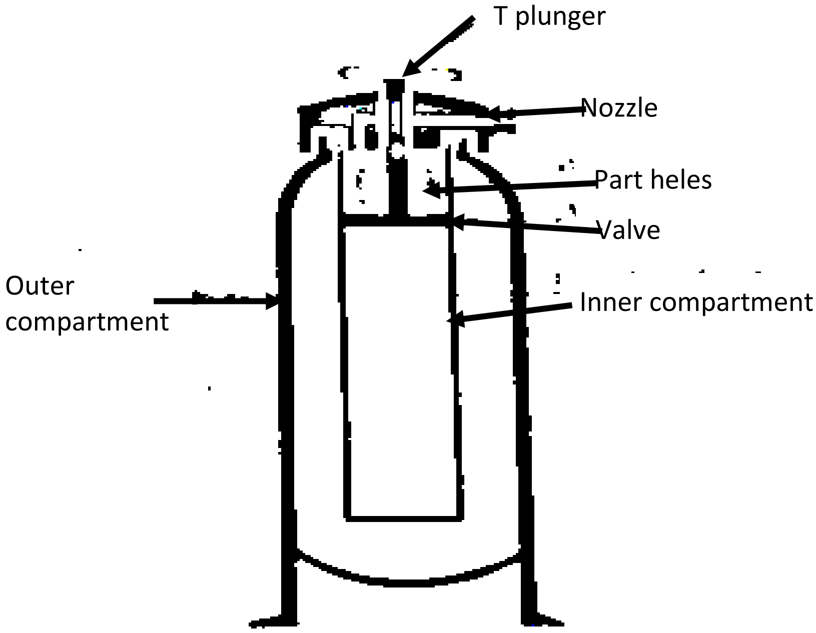
Aluminium Sulphate	+	Sodium Bicarbonate	=	Aluminium Hydroxide	+	Sodium Sulphate	+	Carbon dioxide
$Al_2(SO_4)_3$	+	$6Na(H)CO_3$	=	$2AI(OH)_3$	+	$3Na_2SO_4$	+	$6CO_2$

(viii) **Extinguishing Medium**: Foam.

(ix) **Principle of extinction**: Smothering and partly cooling.

(x) **Parts**:

(a) **Outer Container**: Cylindrical in shape, made of metal sheet, lead coated on the inside to prevent corrosion. Marked with solution level to provide air space above the liquid not less than 5% of the total volume.
(b) **Inner Container**: Cylindrical in shape.
(c) Cap.



Foam Extinguisher

(xi) **Operation**

Lift the spring-loaded plunger and keep it in open position, then invert the extinguisher, thereby both the solution in the containers, get mixed in with each other starting the chemical action which liberates carbon-di-oxide gas in large quantity, which in turn produces foam and discharges it through the nozzle. Do not direct the jet of foam on the seat of flames but direct it on the wall of the container, so that it flows down on to the burning liquid without stirring it up. blankets the surface and extinguishes the fire by smothering effect.

(xii**) Safety Device:** Vent hole.

(xiii) **Discharge performance**:

The jet should reach a distance not less than 20 for a minimum period of 30 seconds and the whole of the charge (foam) shall be ejected within the maximum period of 90 seconds when operated at normal temperature.

(xiv) **Advantages & Disadvantages:**

Advantages:

(a) It coats the burning surface of the substance and excludes oxygen.
(b) It has considerable heat resisting qualities as an insulator and serves to prevent reignition.
(c) Foam floats on most liquids and is then suitable for extinguishing many liquid fires.

Disadvantages:

(a) Foam mixes with certain liquids and renders them unusable.

(b) The use of foam is limited to certain types of liquids only.

(xv) **Care, Maintenance and Standard Test**

(a) Extinguisher to be opened up for inspection on acceptance and quarterly and to be maintained as follows:

(i) During opening care must be taken not to mix the two solutions accidentally otherwise the extinguisher will have to be recharged.

(ii) Check the liquid level in the body and in the inner container. Any slight loss may be made up with water.

(iii) The nozzle and vent holes in the cap should be checked for cleanliness.

(iv) Before the head cap is replace, the plunger, the head cap lever for sealing device should be checked to see that it operates freely.

(v) No corrosion or damage should be visible either externally or internally.

(b) **Yearly Test**: Check discharge performance once in two year.
(c) **Hydraulic Pressure Test**: Should be performed once in every 3 yrs. Outer 24 per square centimetres 2.5 minutes.

(xvi) **Re-charging:**

(a) Remove the head inner container.by unscrewing the
(b) Thoroughly wash all parts, removing any solid matter which may be found.
(c) Thoroughly dissolve the powders supplied in separate clean buckets according to the manufacturer's directions.
(d) Pour the sodium-bi-carbonate stabiliser solution in water into the outer container.
(e) Pour aluminium sulphate solution into the inner container. Any liquid which has been spilt outside of the container should be wiped off. The container should not be filled to the brim.
(f) Carefully replace the inner container into the extinguisher.
(g) If a sealed type is employed withdrawn the plunger to the open position.
(h) Blow through the nozzle to ensure that it is not blocked and check that the vent holes are clear.

(i) Slightly grease the threads.
(j) Screw the cap down tightly.

B. **Self-Aspirating (Mechanical) Foam Extinguishers:**

In this type of extinguisher the foam is produced from a foam solution. The foam concentrate is stored either as a solution in water in the body of the extinguisher, or separately in a her metrically sealed inner container. When the extinguisher is operated the foam solution is expelled by compressed air/nitrogen in the body of the extinguisher or by gas liberated from a small cartridge. The foam is produced in a miniature self-aspirating foam branch-pipe at the end of a short length of hose.

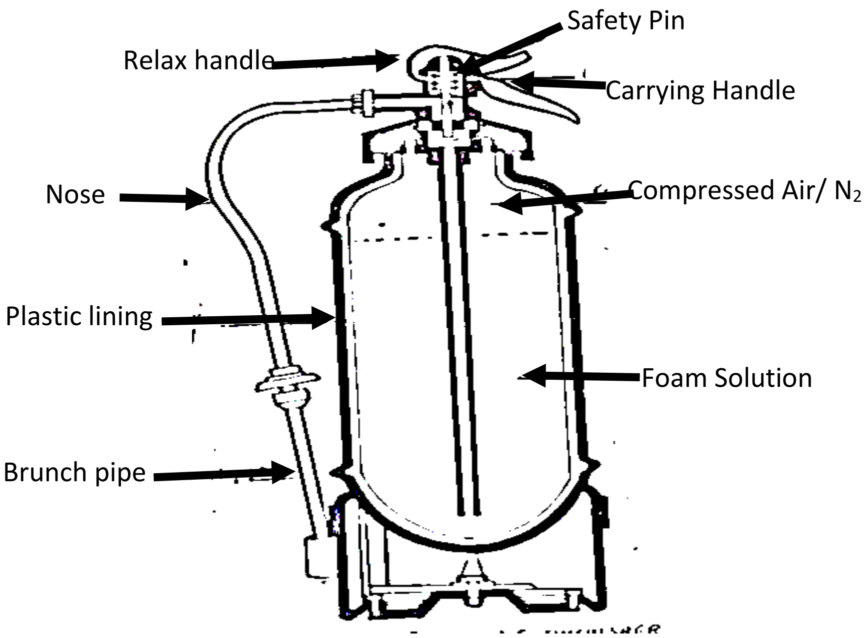
The foam concentrate used may be of following types:

(i) Protein
(ii) Fluoroprotein
(iii) Fluora chemical
(iv) Synthetic

(a) **Stored Pressure Type.**

The stored pressure type is a her metrically sealed container with a plastic lining, which is the same type of container, head cap and valve as used for the stored pressure water extinguisher.

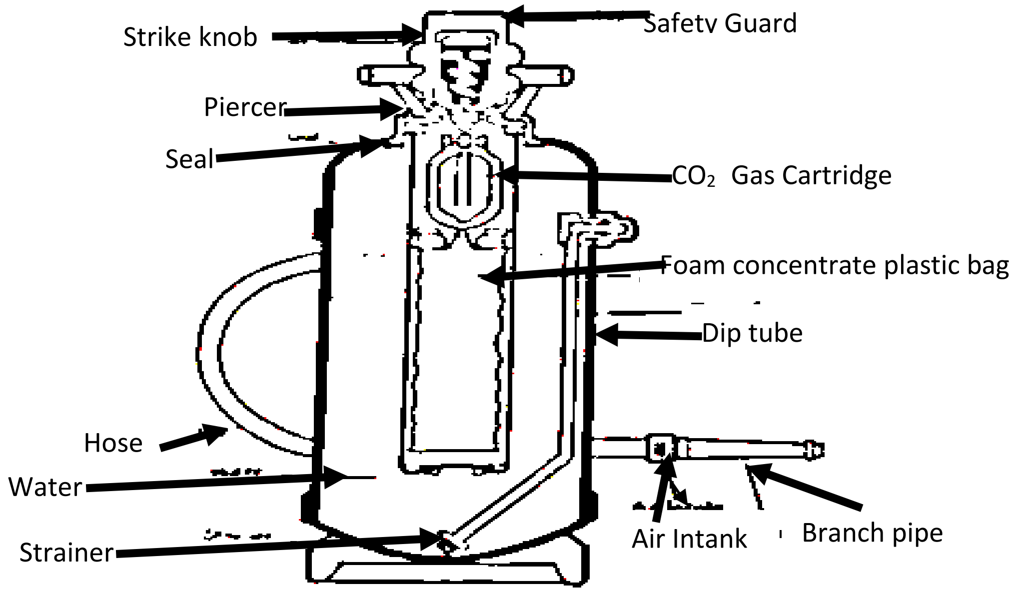
It contain a foam solution and is pressurise to 10 bars with com pressed air/nitrogen operated in the upright position by disengaging the safety pin, removing the branch pipe from its holder and pressing the release handle. Discharge can be halted temporarily by allowing the release handle to return to its normal position.



Foam (Staved Pressure) Extinguisher

(b) **Gas-Cartridge Sealed Foam Solution Type**:

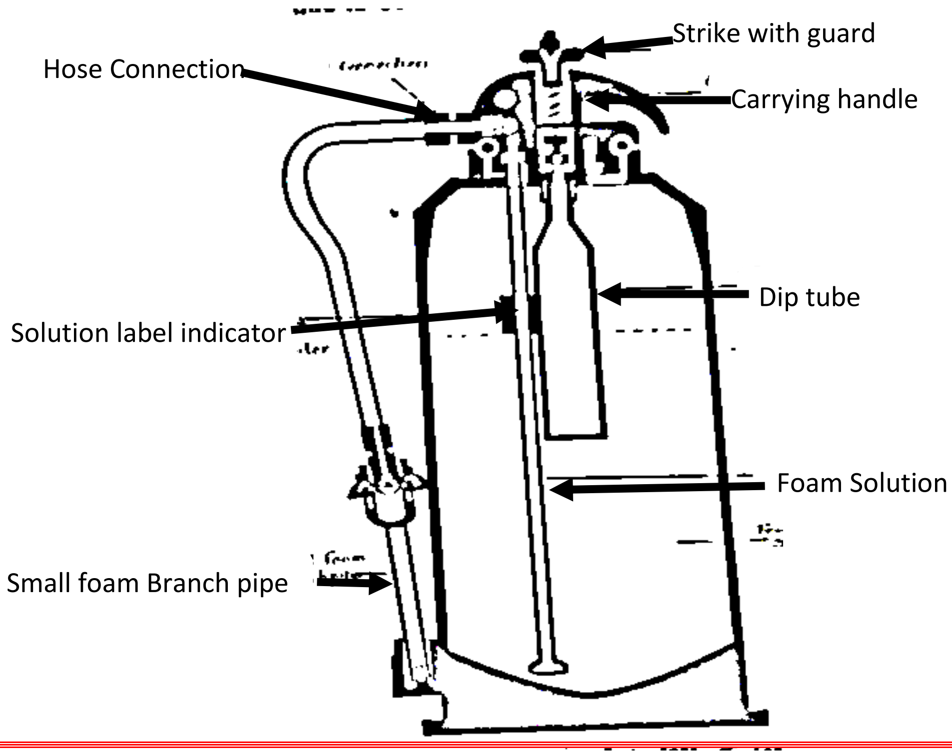
This type contains a quantity of water in an outer container whilst the foam concentrate is contained in a sealed plastic bag which is ruptured on the release of CO: gas from the cartridge. The foam solution is mixed and expelled by the gas up through the dip tube, through the hose and the foam branch pipe. Discharge can only be halted by inverting the extinguisher and allowing the excess gas to escape.



Foam (Gas Cartage) Extinguisher

(c) **Gas Cartridge Foam Solution Type**:

The gas cartridge type of foam extinguisher contain a foam solution as in the stored pressure type, However, in this case, a small cartridge of CO, is included. Operation of the striker released the gas which expels the foam solution via the dip-tube. With this type of extinguisher discharge can only be halted by inverting the extinguisher and allowing the excess gas to escape.



Gas Cartage Foam Solution Type of Frame Extinguisher

(i) **Care, Maintenance and Standard Test**:

(a) Open the extinguisher, check the liquid level, pour liquid in a separate clean receptacle to see if there is any sediment. at the bottom. Reject the charge, if there is sufficient sludge formation.

(b) Examine the extinguisher externally and internally for any corrosion or damage. Damaged or corroded extinguisher should be removed from service.

(c) Corroded gas cartridge should be replaced.

(d) Examine the gas cartridge of mass. If there is loss of more than 10% of original mass, replace it with fully charged one.

(e) Examine the foam generating nozzle, strainer, vent holes, internal discharge tube, sealing washer etc. Replace them, if not in a good condition. Otherwise clean them thoroughly.

(f) Check the operating mechanism for free movement & piercing mechanism.

(g) Clean the hose assembly & check it for any dust sediment at either shank ends.

(ii) **Yearly Test**: Test by discharge once in two year.

(iii) **Hydraulic Pressure Test**: Performed once in every three years. Outer container should be tested for 17.5 kg/cm^2 for a period of 2.5 minutes:

6.3. Carbon-Dioxide Extinguishers:

(i) **Carbon-Dioxide (CO_2):** Under normal conditions carbon-dioxide is a colourless. odourless gas and is a non-supporter of combustion and does not burn also. Its vapour density is 1.5 thus heavier than air. It is relatively non-toxic but inhaled in large quantities can lead to asphyxiation. Inhibitory factor i.e. 'Extinguishing concentration' of carbon-dioxide is 19 to 29%. i.e. if this gas is present in the atmosphere near the fire in the ratio of 19 to 29%, it excludes the oxygen which results in the extinction of fire. This is in gaseous state at normal temperature and pressure but when compressed in cylinders under very high pressure it converts itself into liquid. When released the liquid is reconverted into gas. When carbon dioxide in liquid form is released from a storage cylinder there is an extremely rapid expansion from liquid to gas which produces a refrigerating effect that converts part of the carbon dioxide into 'snow' (i.e. solid particle). This snow which has a temperature of -79° C. soon sub limes i: e. converts into gaseous state and pro duces some cooling effect. Some cooling of the fire may also be effected, but it is the exclusion of oxygen to a point where it will no longer support combustion, which is of primary importance. Expansion ratio of carbon-dioxide is 450:1.

(ii) **Use**: In 'A', 'B' & 'C' class in incipient stage.

(ii) **Shape**: Cylindrical.

(iv) **Operating Position**: Upright.

(v) **Capacity**: 1 kg. to 6 kg. (2 lbs. to 15lbs.).

(vi) **Chemical in Use**: Carbon-dioxide (CO:).

(vii) **Expelling Agent**: Carbon dioxide itself. provides its own pressure for discharge from an extinguisher.

(viii) Extinguishing Medium: Carbon-dioxide.

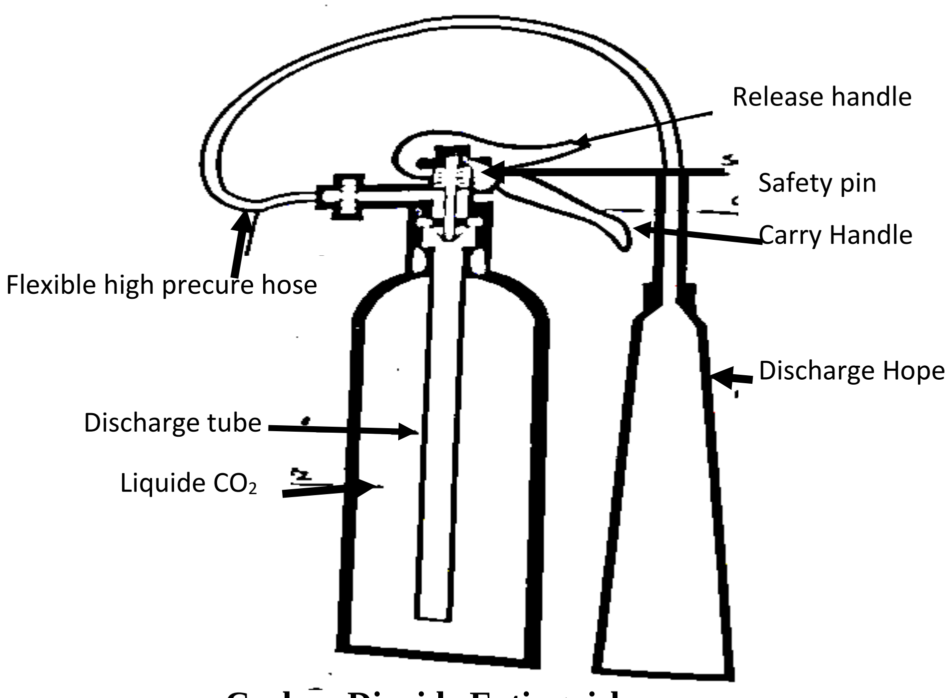
(ix) Principle of Extinction: By diluting and displacing oxygen contents in the air in the immediate vicinity of fire.

(x) Parts:

(a) **Pressure Cylinders**: Carbon-dioxide is retained in a liquid condition in the cylinder under about 51 bars pressure at normal temperature. The cylinder is usually filled to approximately two-thirds by weight of its total water capacity.

(b) **Valve Assembly**: Fitted at the top of the cylinder for releasing the gas when operated.

(c) **Discharge Horn**: Owing to sudden expansion of the discharging gas and its liability to freeze, careful design of the discharge mechanism is required.



Corban Dioxide Extinguisher

The discharge horn- Due to its specific design, stop the entrainment of air with the carbon-dioxide by reducing the velocity of gas and directing the gas on to the seat of the fire.

(d) **Flexible Tube:** Fitted in between valve and the discharge horn. The liquid carbon-dioxide is released from the cylinder through this tube. Expansion starts commencing in this flexible tube.

(x) **Operation**: Remove safety pin and then operate the discharge device.

(xii) **Discharge Performance**: At normal temperature not less than 95% of the contents will be released in the form of a continuous discharge within 6 seconds for upto 3kg. capacity and 9 seconds for capacity of 3kg-to-6kg..

(xi) **Advantages and disadvantages:**

Advantages:

(a) It is extremely rapid in action and its action is independent of atmospheric temperature.

(b) Cleanliness: Being an inert gas. It quickly disperses leaving no trace behind. It has no chemical action under normal conditions and no damage is caused by its use.

(c) It is a non-conductor of electricity. This combined with its cleanliness, makes it very useful in fires involving electronic and electric apparatus.

(d) It may be used in their incipient stages in fires in number of inflammable liquids.

(e) Being a gas it will penetrate into other wise inaccessible places.

Disadvantages:

(a) Total weight of the extinguisher in comparison with the quantity of gas discharged is much more.

(b) There is no visible check on the contents.

(c) They must be sent away for recharging.

(d) It cannot be used on fire involving any material which contains its own supply of oxygen as the material will burn as readily In this gas as in air.

(e) Cannot fight fire from distance.

(f) One extinguisher cannot be used for longer period.

(g) Reignition is always liable to occur unless all the burning material has been cooled below its ignition temperature. Moreover chance of flashback is there.

(xii) **Care, maintenance and standard test** :

(a) Extinguisher to be inspected on acceptance and quarterly and to be maintained as follows :

(i) Check the condition of discharge horn, flexible hose and valve assembly, they should be in good condition.

(ii) The total weight should be checked against that recorded weight when. the extinguisher was put into ser vice. If a loss of weight of more than 10% of the content is detected the extinguisher should be discharged and returned to the supplier for test and recharging.

(iii) The body of the extinguisher to be examined and if there are signs of damage or extensive corrosion the extinguisher should be discharged and returned for test and re charging.

(b) **Hydraulic Pressure Test**: It shall be pressure tested every time the cylinders are sent for recharging at the pressure of 210 kg/cm^3 for a period of 2.5 minutes.

(c) **Yearly Test**: Check discharge performance once in a five year.

6.4. Dry Chemical Powder Extinguisher:

(i) **Dry Chemical Powder:** The normally used fire extinguishing agents are inadequate or dangerous when dealing with metal fires. Chemical dry powders developed now is cap able of controlling or extinguishing metal fires (Magnesium, Aluminium, Uranium etc.). the action on the application of powder is that a crust is formed over the metal by the action: of the heat on the powder. The oxygen in the atmosphere is thereby excluded and a smothering effect obtained. In most cases the crust must be left undisturbed for some time to enable the metal to cool below its ignition temperature.

Modern dry powder extinguishers are very efficient for extinguishing fire in highly inflammable liquids. Dry chemical powder is also capable of dealing with carbonaceous fires.

The composition of the powder itself according to the different proprietary types of extinguisher and the use for which the extinguisher is designed.

(ii) **Use**: In all classes of fires specially in 'D' class in incipient stage.

(iii) **Type**:

(a) Gas cartridge.
(b) Stored pressure.

(iv) **Shape**: Cylindrical.

(v) **Operating Position**: Upright.

(vi) **Capacity**: 1 kg. to 13.5 kg.

(vii) **Expelling Agent**: Compressed air/gas stored in a gas cartridge or stored directly in the cylinder. The method of expelling the powder from the container is by a charge of compressed air or gas which when released, fluidifies' the powder and ejects it via discharge tube and the nozzle.

(viii) **Chemical In Use**: The composition of dry chemical powder varies with different proprietary mixtures.

(a) Sodium Bi-carbonate based (normally used)

(Sodium-Bi-carbonate	-	97%	
(Magnesium Carbonate	-	1%	
(Magnesium Stearate moisture absorption	-	1 ½ %	- Prevent

Tricalcium Phosphate -1/2 % - Assists proper fluidisation of powder and reduce cohesion between particles and wall.

(b) TEC. (Ternary Eutectic Chloride) specially for metallic fire.

(Sodium Chloride-20%) Melts and

(Potassium Chloride - forms a Fuzed skin over the

(Barium Chloride-51%) etc. - burning matter It absorbs heat and cuts off oxygen.

(ix) **Principle of extinction**: Smothering and partly cooling.

Parts:

(a) Outer Container

(b) Gas Cartridge

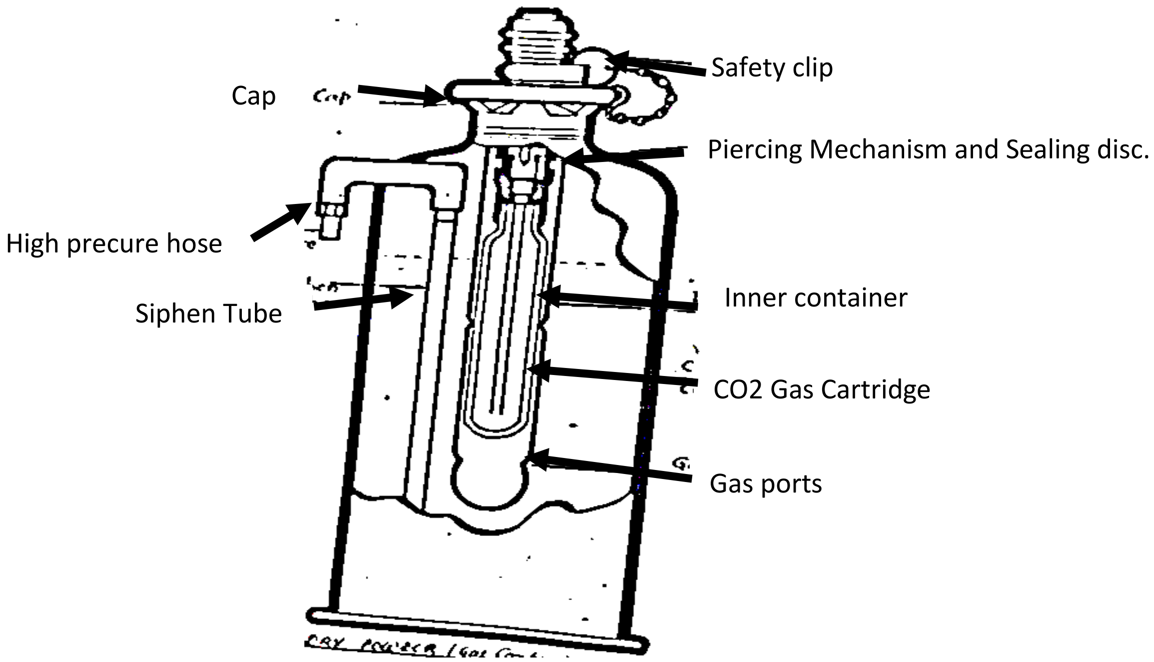
(c) Cap

(d) Powder outlet tube

(e) High pressure hose

(f) Piercing mechanism

(g) Water tight nozzle with squeeze grip control.



DAY POWER (GAS CARTRIDGE) EXTINGUISHER

(x) **Operation**:

Remove the safety clip. Withdraw the nozzle from rubber cap. Depress the plunger. Press the lever of squeeze grip control nozzle. Direct the dry powder to the base of the flame with a fast sweeping motion.

(xi) **Discharge performance**: When fully charged and operated in its normal working position 85% of the contents should be

(a) Within 10 seconds upto 2 kg. capacity

(b) Within 20 seconds over 3 kg. to 5 kg capacity

(c) Within 30 seconds up to 10 kg. capacity

(d) The range of throw will vary from 2-6 meters.

(xi) **Advantages & Disadvantages**

Advantages:

(a) D. P. Extinguisher can be used for all types of fire at incipient stages
(b) D. P. Extinguishers can be used to extinguish fire involving meals like magnesium, Aluminium. Uranium etc.

Disadvantages:

(a) D. P. is not good to be used on electrical equipment and electronic mechanism as the melted powder can damage the equipment.

(xiii**) Care, Maintenance and Standard Test :**

(a) Extinguisher should be inspected on acceptance and quarterly and to be maintained as follows:

(i) Where a discharge control is fitted on the nozzle at the end of the hose this should be operated before opening the extinguisher to ensure that there is no pressure present in the extinguisher.

(ii) Extinguisher should be weighed to check that it contains the correct weight of powder. The weight when fully charged should be recorded at the time of charging.

(iii) Powder should be agitated to ensure it is free from caking.

(iv) The gas cartridge should be weighed and check the weight against the mark on the Cartridge. The Cartridge should be renewed t a loss of more than 10% of the con tents is recorded. Check the seal also.

(v) Hose Nozzle, discharge control. vent hole in the cap etc. to be checked for cleanliness.

(vi) Check, if there is any visible Corrosion externally or internally.

(b) **Hydraulic Pressure Test**: Should be performed once in every 3 years. Outer container should be tested for 25 kg/cm^2 for a period of 2.5 minutes.

(c) **Yearly Test**: Check discharge performance once in a five year

(xiv) **Recharging**:

(a) Before recharging all powder must be removed from the cylinder, hose, nozzle etc.

(b) The extinguisher should be properly dried.

(c) Once a new powder container is opened, the powder should be transferred immediately.

(d) Only extinguishers containing the same type of powder should be opened at any one time.

6.5. **Halon Extinguishers**

The halogenated extinguishing agents are currently known as Halon. Halons are normally stored in liquid form and released in such a way as to vaporise rapidly in a fire zone (in a similar way to Carbon-dioxide).

Their extinguishing capacity depends generally on their influence on the chemical reactions involved in the propagation of flame and such cooling effect as they possess is small and therefore relatively unimportant. Consequently, they are clearly different from water and less efficient in extinguishing fire in wood and other solid materials (Class A fires) where cooling is the main effect required. Similarly, for large fires in burning liquids (Class 'B' fires), particularly in the open, they are inferior to foam because the gas is quickly dispersed. Vaporising liquid (Halons) therefore, find their main application in their rapid knockdown effect in small or incipient fires involving burning liquid. In addition, because they are electrically non conductive, they are particularly suitable or safe to use on electrical equipment as they are non-damaging to electronic apparatus.

Normally, the halons used in fire extinguishers are chlorobromomethane (CBM-CH_2 CI Br), bromochlorodifluromethane (BCF-CF_2 CI Br.) and bromotrifluromethane (BTM-CF_3 Br) etc. Halon extinguisher containing CBM BCE or BTM are stored pressure types the pressure is generally supplied by the use of Carbon dioxide or Nitrogen.

Advantages:

(a) It may be used where clean agent (non residual) is required.

(b) It may be used where live electrical or electronic circuit exists.

(c) It can be used for flammable liquids or flammable gases.

(d) It can be used for surface buring flammable solids, such as thermoplastic

Disadvantages:

(a) It cannot be used on fuels which contain their own oxidising agents, such as gunpowder, cellulose nitrate, organic peroxide etc.

(b) It cannot be used on reactive metals such as sodium, potassium, magnesium.

As for the restriction on release of Halon in atmosphere because of ozone layer depletion. property it need not be necessary to refill/ operate Halon 1211 type portable fire extinguishers within any stipulated period. However, as regards the pressure of injections gas i.e.. dry N_2, it should be checked up for the adequate pressure on the pressure gauge and.. the contents by weighing the fire extinguishers.

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CHAPTER -7

STIRRUP PUMP-CONSTRUCTION, USE, CARE AND MAINTENANCE

1. Object:

After an Incendiary Bomb attack a large number of small fires may be started simultaneously. For extinguishing these fires by water, stirrup pump is the best first aid firefighting equipment. The object of this lesson is to study the use of Stirrup Pump, its care and maintenance and drill.

2 Introduction:

The Stirrup Pump is an excellent piece of first aid firefighting equipment essentially designed for use on small fire. It is capable of making very effective use of limited water supplies. The pump would prove to be very useful in localising and controlling fires. It can be used in emergency by two people and even by one. The normal Stirrup Pump team however should be of four.

3. Construction

The pump is of very small construction. There are only three moving parts, viz :-

(i) The plunger tube, to the bottom of which is fitted the piston.

(ii) The metal ball which acts as the non-return valve in the piston.

(iii) The metal ball which acts as the foot valve in the metal strainer of the base of the barrel.

In the bottom of the pump is a strainer, which can be unscrewed and taken out, if necessary. for cleaning. The pump is provided with not less than 8 metres (=26 feet) length of half inch bore rubber tube to which a dual-purpose nozzle is fitted for getting a jet or spray by working its slide and the nozzle held horizontally at a height of 1.5 metres (= about 5 feet) from the ground, the jet will hit the ground at a horizontal distance of not less than 9 metres (29% feet) from the nozzle. The consumption of water will be about 1 to 1% gallons per minute, and if spray is used, the range of fine spray will be about 15 to 20 feet, and water consumption % gallons per minute.

4. General Uses:

Stirrup pump can be used to extinguish any small fire for which water is suitable. Spray may be used on small oil fires to cut off oxygen and for cooling the surroundings of scene of fire.

5. Testing:

Stirrup Pump should be tested with water preferably once a week. There are only a few things which can go wrong, and if a fault develops it is probably one of the following: -

(i) Rusted ball valves: The strainer at one end of the pump barrel and the pump handle at the other should be removed and plunger pulled out at the lower end. The ball valves are then accessible and the rust can be removed with a pocket knife or emery paper

(ii) Ball valves stuck to the seating- They can usually be freed by pushing a pin or piece of wire up through the strainer.

(iii) Choked Strainer: This is easily cleaned out with a pin or a piece of wire.

(iv) Choked hose nozzle: This should be cleaned by unscrewing the nozzle and cleaning out the holes.

6. Care and Maintenance:

(i) No strong disinfectant or chemical sprays should on any account be passed through the pump, as they are likely to cause corrosion and clogging of the barrel and deterioration of the delivery rubber tubing.

(ii) After emptying, the hose should not be left loose, it should be properly coiled and attached to the pump by the strap or the string.

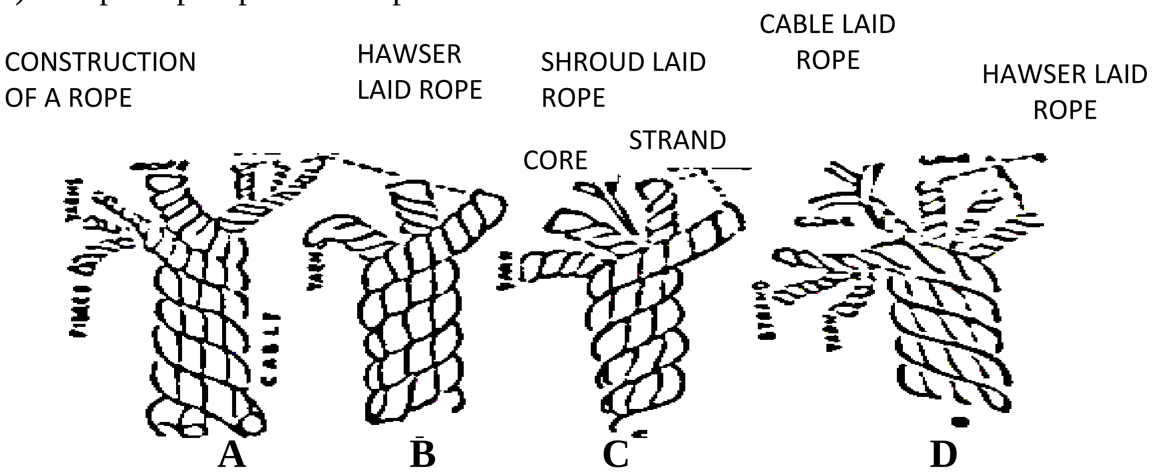
(iii) When not in use, the pump should preferably be hung on a wall bracket about 5 feet from the ground.

(iv) If water leaks from the top of barrel. when a pump is in use, screw down the gland collar a little tighter to stop the leak. If the leak does not stop, unscrew the gland collar and repack with soft cord soaked in oil.

(v) Lubricate the inner surface by pouring a small quantity of lubricating oil into the pump through the wire mesh at the foot valve working the pump full strokes.

(vi) After drying the plunger rod, apply grease all over the inner surface.

(vii) Keep the pump in a cool place.



Construction of Ropes

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CHAPTER-8

DUTIES OF HOUSE FIRE PARTY MEMBERS & DRILL

The actions and movements of a specific member of the House Fire Party, using a stirrup pump have been laid down in the stirrup pump drill. It enables training and practice to be carried out on a standard line. Each member of the party is well conversed with his own duties and that of the other members. The stirrup pump drill also facilitate to give clear cut idea of the actions of each member and avoid ambiguity resulting in a chaotic condition leading to failure in firefighting.

Normally the house fire party comprises of four members but in compelling circumstances wherein there may be shortage of manpower. the House Fire Party has to function with three members.

Hence hereinafter the details of duties of the specific members of the house fire party and the drill is considered as under:

(a) When there are four members in the house fire party, and

(b) When there are three members in the house fire party.

(I) **Details of duties for a house fire party of four members:**

No. 1: Party leader. Makes reconnaissance. Selects position for pump. Goes forward with nozzle to deal with fire. Gives orders "Water on", "Water Off" and "Knock off and Make up" as required.

No. 2: Operates pump. Gives order "Change Round" and is relieved by No. 3 and 4 when desired.

No. 3: Assists in running out the hose. Keeps in touch with No. 1 with No. 4. maintains water supply and when required relieves No. 2

No. 4: Assists No. 3 to maintain the water supply. In the case of long carry bring water supply to a prearranged point from where No. 3. takes them forward to the pump. Relieves No. 2 when required.

(II) **Duties for house fire party of three members:**

No. 1: Party leader. Recce the area. Selects position for pump. Goes forward with nozzle to deal with fire. Gives orders "Water on" "Water Off" or "Knock off and make up" as required.

No. 2: Operate pump. No. 3 relieves him when desired.

No. 3: Assists in running out the hose. Maintains water supply and relieves No. 2 as necessary. Keeps in touch with No. 1.

(III) **Drill for the house fire party of four members:**
No. 1 is the leader of the team.

(a) **When moving to attack a fire**:

No. 1 carries out a reconnaissance.

No. 2 carries the pump.

No. 3 carries bucket filled with water.

No. 4 carries bucket filled with water.

(b) **On the order from No. 1:**

(i) "Get to Work" No. 1 goes forward with the nozzle (uses discretion for carrying shields or taking cover).

No. 3 and 4 places the buckets where ordered by No. 1.

No. 3 assists No. 1 in running out the hose and returns to No. 2.

No. 2 places the pump in the bucket and pumps a few strokes to fill the hose.

No. 4 maintains the water supply with the assistance of No. 3.

If No. 1 is not in sight No. 3 goes forward from time to time and keeps in touch with him.

(ii) "Water On" On this order: No. 2 pumps and on the order of.

(iii) "Water off" No. 2 stops pumping. When No. 2 requires to be relieved from pumping he gives the order.

(iv) "Change Round" No. 2 then takes over the duties of No. 4 No. 4 of No. 3 and No. 3 3 of No. 2. Pumping must not stop during the changeover.

(v) "Water Off-No. 2 stops pumping but all equipment is left in position. This order is given by No. 1 to enable him. further recce the area.

(vi) "Knock Off and Make Up"-No. 2 clears the hose by pumping after removing the pump from the bucket and all hands assist in coiling and securing the hose and making up the gear. They return to their position.

(IV) **Drill for the House Fire Party of three members:**

The party consists of three persons who should be numbered 1 to 3. No. 1 is the party leader.

(a) **When moving to attack a fire:**

No. 1 carries out a reconnaissance.

No. 2 carries the pump.

No. 3 carries bucket filled with water.

(b) On the order from No. 1:

(i) "Get to Work"-No. 1 goes forward with the nozzle (uses shield or any suitable cover for protection) No. 3 places the buckets where ordered by No. 1 and assist him in running out the hose. He then returns to No. 2 and maintain the water supply and relives No. 2 at the pump when required, when order. "Change Round" is given. He also keeps in touch with No. 1. No. 2 places the pump in the bucket and pumps a few strokes to fill hose.

(ii) "Water On"-No. 2 pumps.

(iii) "Water Off" No. 2 stops pumping

(iv) "Knock Off and Make up"-Hose is cleared by pumping after removing the pump from the bucket, gear is made up, the hose being coiled and secured. They return to their position.

Conclusion:

The Stirrup pump drill no doubt lays down the routine when fighting a fire. However the situation at the scene of fire may demand and dictate variation which will be implemented by the leader of the House Fire Party considering the compelling circumstances at the scene of fire.

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CHAPTER-9

FIRE WATHCERS AND CARING SYSTEM

Members of House Fire Party will act as "Fire Watchers". They will watch for the fall of incendiary bombs and the fires caused by them. This enables the house fire party to deal with the incendiary bombs as soon as they fall. Thus, the fires are controlled and localised before they spread and turn into conflagrations.

(I) **Arrangements of Duties of House Fire Par ties as 'Fire Watcher'.**

1. The duty of these parties is to watch for the fall of Incendiary bombs and to deal with as many of the bombs as possible as soon as they fall so that fires may be dealt with at the earliest stage and conflagration prevented.

2. The way in which fire watching as distinct from firefighting may be arranged depends to some extent on local circumstances. In daylight hours no fire watching in streets and residential areas is ordinarily necessary. Arrangements should be made to cover the whole of the period during which lighting restrictions are in force and the object of such arrangements should be:

(a) to ensure that the party on duty goes into action without delay should necessity arise.

(b) to avoid fatigue which would result from an undue number of persons being kept awake at night when no enemy attack is in progress.

3. When there is no air raid warning no fire watching need be performed but watchers should readily be available to take up their duties. When action warning is sounded or when there is gun fire, or enemy aeroplanes are about to drop the bombs they must be prepared to detect incendiary bomb attacks. In both cases the rest of the party can remain indoors and may be in bed. The important consideration is that at least one person should be awake during the blackout period, whether there is an air raid warning or not so that the alarm can be given as required.

4. When a watcher considers that there is imminent danger of an incendiary bomb attack in the neighbourhood e.g. when he sees that bombs have fallen in the neighbourhood, he should warn three other members of the party to stand by for action. If they are not properly dressed they should do so but they need not turn out until they hear short blasts on a whistle which indicate that incendiary bombs are actually falling in the neighbourhood.

5. The other member of the party, on hearing the whistle should dress and take their place in accordance with a pre-arranged scheme. Every person should know what action he or she should take in an emergency on the whistle signal. Thus, it should be for one person to note where bombs are falling and direct the personnel available accordingly.

6. In the absence of incendiary bomb attacks on a particular locality the only duty to be carried out by members of parties is that of watching or being prepared to watch. The members of the fire parties, when not on watching duty should be available to deal with incendiary bombs.

7. It may often be possible to arrange for one person to act as watcher for more than one section of a street, and summon the available personnel in each section in an emergency.

(II) **Notification on fire watching:**

The Central Government or the State Government may by general or special order make provision:

(a) for requiring the occupiers of any pre mises to which the order applies to make and carry out such arrangements as may be specified in the order with a view to securing that fires occurring at the pre mises as a result of hostile attack will be immediately detected and combated.

(b) for requiring the occupiers of several premises jointly to make and carry out such arrangements as aforesaid for all those premises, and in particular for requiring that they shall take turns of duty at specified premises and perform such fire prevention duties as may be allotted to them under those arrangements.

(c) for empowering any authority, in such circumstances as may be specified in the order, to make and carry out such arrangements as aforesaid, including a joint arrangement as respects any pre mises to which the order applies, and where it carries out such arrangements to recover from the occupiers concerned the expenses of so doing.

Explanation: In clause (b) of this sub rule" fire prevention duties" include the duties of keeping a watch for the fall of incendiary bombs, taking such steps as are immediately practicable to combat a fire caused by such bombs or otherwise and summoning such assistance as may be necessary, and also includes the duty of being in readiness to perform any such duties as aforesaid.

(III) **Caring system:**

House Fire Party members have to take certain care of important points in firefighting. These points are listed below in the form of DO's and Don'ts. They together form the caring system. It is as below:

(a) **Fire Fighting Hints**: Some important points in firefighting are listed below in the form of DO's and DONT's.

(i) DO keep ample supplies of water:
YOU CAN'T HAVE TOO MUCH.

(ii) DO keep all fire-fighting equipment in good order and ready for action.

(iii) DO get to know as much as you can about the layout of buildings in which you might have to fight fires.

(iv) DO make certain that no one is lost or trapped in building which is on fire.

(v) Do get in as close as you can to a fire when you fighting it.

(vi) DO make sure you aim for the heart of a fire when you direct a jet on it.

(vii) DO use any cover available when directing a jet on to incendiary material.

(viii) DO make quite sure that all fires are really out before you leave the scene of the fire.

(ix) DO keep close to walls, where floors and stairs are strongest when moving in a damaged or burning building.

(x) DO see that the gas is turned off at the main before firefighting starts, it is practicable to do so.

(xi) DO break a panel near the lock when you need to force a door.

(xii) DO make sure you always know.

Where fires should be reported, and in what circumstances where the nearest emergency water supplies are.

(b) **Firefighting Hints DON'T:**

(i) DON'T lose your head. whatever the circumstances.

(ii) DON'T forget to ask for reinforcements in fighting fire before the fire gets out of your control.

(iii) DON'T be caught unawares in a burning building from which you don't know more than one way out.

(iv) DON'T admit air to a fire by opening doors or windows before it is safe to do so.

(v) DON'T let phosphorus get dry.

(vi) DON'T go empty handed into a burning building, except to save life.

(vii) DON'T go alone into a burning building, even to save life if you can go as one of a pair.

(viii) DON'T direct water or foam on to live electric wiring.

(ix) DON'T switch on electricity during fire-fighting unless it is safe to do so.

(x) DON'T let anything unnecessary delay your attack on a fire, even by second.

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CHAPTER-10

FIRE EXTINGUISHING AGENTS

Class A, B and C fires are normally controlled and extinguished by standard fire extinguishing agents. These agents are in general use by fire departments and industries concerned with fire extinguishment. Despite the advances in technological knowledge and the contributions of natural scientists to fire extinguishment by various means, water is still the most widely used and most efficient extinguishing agent.

1. **Water**

Water is relatively cheap, and it is much more easily procurable and available than are any other known extinguishants. Some of the physical properties that make it our best extinguishing agent should be understood.

(i) At ordinary temperatures, water is a stable liquid and is not easily decomposed. (Some of the combustible metals do have the potential of decomposing water into its components of hydrogen and oxygen and then using the released oxygen for support of their own combustion).

(ii) Specific heat is defined as the number of Btu needed to raise the temperature of one pound of a substance 1°F. In the case of water, one Btu is required. No other substance has as high a specific heat. (Kerosene, for example, has a specific heat of 50). This means that more Btu, or units heat, will be required to raise the temperature of water, say 100°F. than will be needed to raise the temperature of any other substance the same amount. The latent heat of vaporisation of water presents an even higher heat absorbing capacity. To convert one pound of water at 212°F requires 970.3 Btu. This is the latent heat of vaporization. To convert one pound of water, at 62°F requires 150 Btu. To convert water at 212°F to steam at 212°F requires 970.3 Btu. Total Btu absorbed per pound of water in this process is 1,120.3. In this lies the potential of water for fire extinguishment. The most efficient means of the extinguishment is the removal of heat from the combustible material. Heat, we know is a form of energy measured in Btu. No other extinguishant compares with water in heat-absorbing capability.

(iii) In the process of converting from a liquid, at 212°F to steam at 212°F, water increases in volume 1,700 time the expansion is so rapid that the steam will tend to replace smoke, heat, and fire gases as well as the air needed for combustion. The steam then will tend to help smother the fire by reducing available oxygen.

(iv) Water may dilute certain flammable materials that are water soluble to a point where extinguishment is effected. Thick, viscous liquids, such as heavy fuel oil, will tend to froth up when struck with water. This emulsification also can aid extinguishment.

There are limitations and some hazards to the use of water as an extinguishing agent. Its ability to conduct electricity poses the problem of fire in electrical equipment. The reactivity of water with materials such as magnesium and sodium also preclude its use in fires involving these chemicals. Sodium and other elements that are in the same periodic grouping as sodium (group 1), and magnesium and other elements in group 2 are particularly hazardous when struck with water. The highly flammable gas hydrogen is released in the reactive pro cess and ignition or explosion can result.

But even in the ordinary class A fire, there are limitations to the effectiveness of water. Water in its liquid state maintains a certain cohesion of its own that retards its deep penetration into most materials. The viscosity of water, however. is such that it will tend to run off rather than remain as a cover and a smothering agent on the surface of the burning material.

To overcome these handicaps of water, chemical agents can be added to change its basic characteristics. Wetting agents will reduce the surface tension characteristic so that it will flow more readily and penetrate more deeply into piles of combustible that are packed, baled, or stacked. Wetting agents can also be put to good advantage in the overhaul and final extinguishment of stubborn deep-seated fires, wetting agent solutions may be combined with foam for oxygen exclusion and also for penetration resulting in heat absorption.

Where there is a need for "thicker" water to prevent runover can be added that will aid water in forming a thicker blanketing film. This thicker layer can absorb more heat and also act as a smothering agent. Thicker water plays an important role in forest fire fighting.

Aqueous film forming foam (AFFF) is a more recent example of what can be accomplished with water combined with an additive. The additive in this case consists of active fluorine chemicals that, in solution with water, "float" on top of the flammable liquid. Water released from the foam bubbles does not sink, but spreads over the surface and aids in cooling the burning fuel. Very fast knock down of flammable liquid fires has been accomplished more rapidly with this film-forming foam than with conventional foam. The additive is compatible with the bicarbonate-base dry chemicals and is used as a twined attack team on flammable liquids, aircraft crash fires in particular. A unit with dual containers, one of potassium bicarbonate dry chemical and the other of "Light" water, has separate hoses and nozzles in each container that form an integral unit that can be led out together. Each nozzle can be triggered separately or simultaneously. The liquid has been called "Light" water because of its characteristics.

"Slippery" water is another newly developed water. A special chemical dissolved in water reduces friction loss in hose lines to such an extent that water flowage is increased 70 per cent. Nozzle reach is said to be doubled. The fire department can therefore use a smaller diameter, more manoeuvrable hose than the standard sizes now used and obtain equal flow. New York City is experimenting both with a pumper carrying this additive and with 1%-inch hose replacing the conventional 2½ inch hose.

2. **Carbon Dioxide :**

Carbon dioxide has a long history as an extinguishing agent, being used primarily for flammable liquid fires and electrical equipment fires. Carbon dioxide, CO: is non-combustible and does not react with most substances. It is a gas, but it can be easily liquefied under pressure and is normally stored under such a condition. It provides its own pressure for release and blankets the fire area when released in sufficient amounts. Being heavier than air, it replaces the air above the fire and smothers it. CO_2 is mildly toxic, as stated in the discussion of fire gases. It can induce unconsciousness in the person trapped in a 9 percent concentration.

Carbon dioxide is a non-conductor of electricity and it is this attribute that makes it a valuable aid in controlling the electrically energized equipment fire.

The principal property of extinguishment possessed by CO_2 is its smothering or air replacement, capability. One pound of liquid) CO_2 will vaporize to 8 cubic feet of gas and displace an equal volume of air. It does possess some cooling properties, but they are minor when compared with those of water. When released as a liquid. CO_2 expands to a gas so rapidly that much of it is converted into a "snow" at a temperature of 110°F. As this "snow" changes to a gas, some heat is absorbed from the fire area and some cooling results. The latent heat of CO: "snow" is 246.9 Btu per pound. Compare this heat with the latent heat of one pound of water-1.120 Btu from water at 32°F to steam at 212°F.

There are some disadvantages and precautions to be considered in the use of CO: as an extinguishant. There is a possibility of a rekindle from hot embers after the carbon dioxide gas has been dissipated and no longer affords a smothering effect. This is the reason that water may have to be used on the deep-seated electrical fire after the power current has been shut off.

Carbon dioxide has been used successfully on flammable liquid fire and, in particular, on air-crash fires where a quick knock-down is needed. Here, too, the possibility of rekindle must be considered CO: cannot be used successfully in those chemical fires, such as cellulose nitrate that generate their own oxygen supply. The same, of course is true of any extinguishant that utilizes a smothering action. Certain metals, such as sodium, potassium. magnesium, titanium, zirconium and the metal hydrides, are highly reactive with carbon dioxide and will decompose to, negating the smothering action.

3. **Foam:**

Foam is considered to be the best extinguishant for flammable liquid fires that cover a large area. Because its action of blanketing the fire area, it can be flowed on in progressive steps until total extinguishment is obtained. The coherent blanket formed extinguishes by cooling. Foam must float on top of a flammable liquid to be effective as a smothering agent. In those cases where the blanket cover is broken only small patches of fire will result which can be recovered to effect extinguishment again. Care must be exercised to ensure that the blanket is not widely broken by a water stream or an incompatible dry chemical. This requirement predicates a foam that is stable in its basic formula.

There are two common types of foam, chemical and mechanical.

Chemical foam is generated by the chemical reaction of two chemicals in water. One of the two chemicals is an alkaline salt solution, such as aluminium sulphate, the second is usually sodium bicarbonate with an added foaming agent and a stabilizer. The chemicals can be added to the water from two separate sources, or the chemicals may be premixed in a two-in one container.

Mechanical foam (air foam) is generated by introducing a small proportion of the foaming agent into water and then mixing it turbulently with air. The degree of mixing will determine the characteristics of the foam blanket-watery or viscous. Water temperature is not as a serious factor as it is in the chemical foam. The foaming agent can be protein base or a synthetic type. The liquid concentrate is normally found in two concentrations, 3 per cent or 6 per cent. The 3 per cent is mixed with 97 per cent water, and the 6 per cent with 94 per cent water. This foam has a low expansion ratio and expansion may be from 6:1 to 10:1.

The foam blanket prevents formation of ignitable vapours, offers protection against heat radiation, retards toxic gas spread, and blocks oxygen from reaching the burning liquids. The water in the foam has a cooling action. Through a careful application of water spray, water in the foam lost to the heat of the fire can be replaced, but this must be done carefully to avoid the possibility of dissipating the foam blanket. Mention has already been made for the double benefits of a compatible foam-dry chemical and used in multiple attack.

Because of the water content, foam cannot be used on an electrical fire or on those chemicals that react with water.

4**. High-Expansion Foam**

A method has been long sought to extinguish those fires beneath grade level where ventilation is difficult. Research in England for an extinguishant for mine fires brought on development of high-expansion foam, a detergent product.

Expansion rate is over 100: 1, in most instances 1,000: 1. High-expansion foam is nothing more than bubbles mechanically generated by the passage of a large volume of air through a net or screen which has been wetted by an aqueous solution of the foaming detergent. The generated bubbles are blown through a large diameter collapsible tube to the fire area and they quickly achieve total flooding of any con fined space. Vapours, heat and smoke are displaced, heat radiation and transmission are blocked. The water in the foam, here too. absorbs some of the heat of the fire.

Total flooding may be blocked by partitions that stop the flow to the desired area. In other instances, open doors or windows permit the foam to flow from the fire area. It can be used above grade as well as in sub-grade areas. It is important that the necessary air for foam generation is not drawn from the fire building. The heated air, smoke and gases of the fire will cause a sharp reduction in the volume and possible physical disruption of the blanket.

It is possible for fire fighters to walk about in the foam-filled area, but there is also the possibility of their becoming "lost" and dis oriented. Backup water lines may have to be used if foam is dissipated before total cooling and extinguishment are achieved.

5. **Dry Chemicals**

Dry chemical extinguishing agents are dry chemicals in a finely ground state, varying somewhat according to the purpose for which they are intended. Dry chemicals used in the extinguishment of class B flammable liquids, class C flammable gases and electrical fires were originally of sodium bicarbonate with additives, such as metallic stearates or silicones. Both sodium and potassium are in group 1 of the periodic table and have one electron in the outer orbit. Potassium, however, is more active than sodium. After success was attained with sodium mixtures as an extinguishing agent, experiments were conducted using potassium mixtures as the agent. Because of the greater reactivity, potassium proved to be a better extinguishant than sodium on the class B and C fires.

A multipurpose dry chemical extinguishant is also in use. Ammonium phosphate is the base powder with other additives mixed in. The multipurpose dry chemical can be used on class A as well as class B and C fires. On class A fires, the chemical melts upon striking the hot surface, becomes sticky, and adheres to the material.

Dry chemicals are stable at normal or low temperatures. A temperature of 140°F is said to be at the top limit for storage purposes.

The dry chemical requires an expelling agent to propel it from its container. The pressure of non-flammable gas expels the dry chemical, rapidly filling the discharge area with the chemical. The fine particles are non-toxic, though visibility is impaired and breathing is very difficult within the discharge area.

Extinguishment was at first thought to be caused by smothering and some cooling. The released CO_2, it was believed, aided in extinguishment by a cooling process. However, tests revealed that 5 pounds of chemical was as effective in extinguishment as 10 pounds of CO_2. This finding stimulated more research on the basic fire-triangle the chain breaking reaction hypothesis. The free radicals of combustion are prevented from reacting with one another by the reaction with the dry chemical. The chain of combustion is broken.

There are limitations to the use of dry chemicals. When expelled, they dissipate, and oxygen is again available. The fire can rekindle if an ignition source or hot embers remain. While they are effective in electrical fires, dry chemicals can be harmful to electrical contacts: and relays. Also, they are not effective for fires involving materials that generate their own oxygen supply.

Dry chemicals do prove particularly effective on flammable liquid fires and especially on aircraft crash fires because of the quick extinguishment attained. The inherent danger is the rekindle possibility when the dry chemical dissipates. To overcome this hazard, foam can be used in conjunction with the dry chemical proved incompatible with mechanical, air foam. breaking the foam cover down and destroying its effectiveness. A foam-compatible dry chemical was then formulated. In conjunction with foam, it has proven particularly effective for air craft crash fires. (Refer to the section on "Light" water and its compatibility with potassium base dry chemicals).

6. Halogenated Agents A halogenated extinguishing agent is formed by the introduction of a halogen into an organic compound (Carbon). The halogens, the chemicals in group 7 of the periodic table of the elements, are chlorine. fluorine, bromine, iodine, and astatine. One of the most successful of the halogenated agents is bromotrifluoromethane (trade names are Halon 201 or Dupont freon 1301). The chemical of in $CBrF_3$.

Extinguishment appears to be obtained by a chemical chain breaking reaction which stops the combustion process. The chemical reaction theory is as follows:

A bromide radical, Br, in the agent reacts with the fuel. In this chemical reaction, hydrogen bromide, HBr is one substance formed.

$$R\text{-}H + Br \rightarrow R + HBr$$

The HBr in turn reacts with the hydroxyl OH radical found in the normal combustion pro cess. Water vapour and bromine, Br is the end product.

$$OH + HBr \rightarrow H_20 + Br \text{ radical}$$

This free bromine radical reacts with more fuel to remove hydrogen to form HBr, which, again in turn, reacts with the OH radical. Thus, the chain reaction of combustion is broken by the removal of H and OH. The halogens are toxic. but the concentrations encountered are more irritating than lethal.

7. **Dry Powders**

Magnesium, titanium sodium, potassium, and several other metals, when burning, are capable of generating their own oxygen supply. Fires in these metals, known as class D fires, are very difficult to extinguish. All are very reactive with water, and little success is obtained with other generally accepted extinguishing agents.

Special extinguishing agents, mostly dry powders, are used for these specific fire hazards. While chemical in themselves, these agents are classified as dry "powders" to differentiates them from dry chemicals used on most class B and C fires, but ineffective on these fires. These special dry powders are not effective on all of the combustible metals, some powders being limited to a specific metal. Control, rather than extinguishment is the best that can be obtained with some powders.

In some cases, the powder or liquid, is applied by means of a standard-type extinguisher. In other cases of class D fires, the powder may be shovelled over the burning metals. These means of control or extinguishment for the particular combustible metal will normally be found stored on the plant site rather than carried as a standard piece of equipment by the responding fire department.

G-1 powder, a trade name extinguishant, is a mixture of granulated graphite and an organic phosphate that must be shovelled onto the burning mass. The organic phosphates vaporize and tend to exclude air. The graphite offers some smothering effect plus removal of much of the heat.

G-1 Dry powder to be used in an extinguisher with a gas as propellant additives to a sodium chloride base formula make it free flowing and capable of being expelled from the extinguisher. In use, the heat of the fire causes solidification of the fine particles into a unified mass that smother the flame.

Both G-1 and Metals are now toxic and non-combustible. While there is some variance in degree of effectiveness, both can be classified as controlling or extinguishing agents of magnesium, sodium, potassium, titanium. lithium and zirconium.

TMB liquid(trimethoxy-boroxine) can also be used in an extinguisher as a controlling or an extinguishing agent on magnesium, zirconium or titanium, fires. It is a flammable liquid in itself.

It has been observed that burning magnesium is an one sense two fires. The first is a fire of vapours that burns quite hot, over 5000 F. and with a white-hot flame. The second fire is a cooler and slower fire on the metal's surface. TMB liquid controls the white-hot fire by retarding vaporization in a smothering action. The TMB liquid first ignites in its own fire, then forms a smothering coat of boron oxide. Once the white-hot fire is controlled. water spray is capable of controlling the second, cooler surface fire without the violent reaction normally encountered when water is used on a magnesium fire. This technique is being used on aircraft fires.

Other industries using combustible metals also quite frequently have other powders that can be shovelled or thrown on the burning metal for control, if not extinguishment. Some of these agents are foundry flux asbestos talc or graphite powder and soda ash. The user of the material has the responsibility of having some means of control for that particular combustible metal a hand.

Accepted standard extinguishing agents are now in practical use in various ways. Most familiar to the average individual are the port able extinguishers kept in various occupancies as the first line of defence against fire. Fire code requirements list the type and number deemed necessary for the various structural and occupancy factors at the specific site. Sizes of the various extinguishers vary, depending on expected use and type of extinguishment. They range from a 2%-gallon water pump, to a 40-gallon wheeled foam extinguisher, to a wheeled 750-pound refrigerated carbon-dioxide unit. In the, selection of the proper type and size of extinguisher, consideration is given to the specific combustible hazard and the expected severity of the fire potential. These conditions are then matched with the characteristics and capability of the extinguishing agents

The modern, well-equipped fire department will carry, or have access, to agents suitable for the average fire it will encounter. Class D fires can present special problems. The property owner must assume added responsibility for fire protection when this class of fire is possible. The quantities of agents carried for Class B & C fires may be limited, but the fire ground commander should have a backup supply available. He should have a dry chemical unit and a foam generating unit at hand. Proper airport protection requires a foam crash unit or a twinned "light" water and dry chemical unit.

Building codes, insurance underwriters, and just common sense dictate that certain occupancies and hazards will have fixed fire protection systems that can be automatically activated and placed in service before portable systems can be put in use of the fire service can res pond. A common first line of defence is a sprinkler system. Other systems use carbon dioxide. dry chemical, foam or the halogenated agents. Again, hazard and severity determine the type and method of protection.

Some representative installations are:

(i) Carbon dioxide systems for surface flammable liquids for equipment where damage from the extinguishing agent must be minimized, and for protection of electrical installations.

(ii) Dry chemical systems for flammable liquids and electrical installations.

(iii) Foam systems for flammable liquids where reignition is possible, for example, large outdoor storage tanks for gasoline.

(iv) Halogenated agents as protection against flammable liquid fire potentials. in particular, used by the aircraft industry as an aircraft-engine fire extinguisher in a fixed installation.

8. **Summary**

Fire extinguishment can take place by elimination of one of the four known factors involved in combustion. The basic methods of doing this are:

(i) **Cooling**: Reduce the temperature of the burning substance below its ignition temperature.

(ii) **Smothering**: Prevent the source of oxygen necessary for combustion to take place from reaching the seat of the fire.

(iii) **Removal of Fuel**: Remove substances not yet ignited from the fire area.

(iv) **Rupture of Chain reaction**: Introduce another substance into the fire area that will react chemically with products of combustion and break-up the chain reaction feeding combustion.

Because of the varying nature of the fire itself. fires have been grouped into four general classes:

Class A Ordinary combustible materials.
Class B Flammable liquids.
Class C Inflammable gases.
Class D Combustible and reactive metals.

There are various extinguishing agents available, many suited for a particular classification of fire that requires its own method of extinguishment.

Water is by far the cheapest, most plentiful, and best extinguishing, agent available. Its extinguishing power lies in its ability to cool by absorbing the heat energy of the fire. Water converted to steam by the generated heat not only has cooled the fire, but the steam tends to smother the fire by blanketing out oxygen.

Certain limitations to water its inability to penetrate readily and the fact it runs off a sur face quickly can be overcome by specific additives, Its reactivity with combustible metals and its conductivity of electricity forestalls its use in fires involving these substances.

Carbon dioxide (CO), is a gas that liquefies under pressure and extinguishes by smothering and light cooling. As a non-conductor of electricity, it is useful on the class C type of fire, and also in smothering the class B fire.

Foam extinguishing agents are of several types. Chemical, mechanical, and high expansion foams are examples, chemical foam is the reaction of dry chemicals and water, mechanical foam, the mixing of a liquid foaming agent. water, and air, high-expansion foam is a detergent type that creates mechanically generated bubbles by the passage of air through a net or screen holding the solution. Foam is useful on flammable liquid fires, as it blankets the area and separates the fire from the oxygen source. Some cooling also takes place. High expansion foam can be used for total flooding of a confined fire area.

Dry chemical in a finely ground state, expelled by a gas, nitrogen or CO: blanket the area with a fine powder and extinguish by smothering. There is no cooling effect and there is a danger of rekindle from heated embers when the chemical dissipates. The chemicals also react in a chain-breaking reaction to retard combustion, which is useful on class B and class C fires.

Halogenated agents contain chlorine, bromine and fluorine, the group 7 elements of the periodic table. Extinguishment is by the chain breaking reaction. The toxic gases are released, the principal use is in fixed installations.

Dry powders are the special powders used in the class D combustible metal fires. Some specific trade names are G-1 powder, Met-L-X and TMB liquid. These extinguishing agents are used in portable extinguishers and in fixed protection systems that are automatically activated when fire occurs.

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CHAPTER-11

HOSE

1. Introduction

Very often fire may take place far away from the source of water, which could be utilised for fighting fire Fire engines may not be able to approach the fire spot it fires occur at places where there is no easy access. Water may also have to be conveyed to higher floors of a building for fighting fires. Water may be required to be conveyed under high pressure. To overcome this problem, Firemen must always therefore carry with them the required number of various types of hoses and hose fittings before they arrive at the site of fire. We shall. therefore, study in this precis a hose in details.

2. Types of Hose

Hose is one of the most important pieces of equipment used by the Fire Service. It may be divided into two main groups:

(a) Delivery Hose: Where water passing through it, is at pressure above that of atmosphere.

(b) Suction Hose: Where water passing" through it may be pressure either below or above that of atmosphere.

The first group may be sub-divided into:

(i) Unlined Hose, woven from vegetable fibres.

(ii) Non-percolating hose, consisting of a jacket woven from vegetable fibres or combination of both vegetable and synthetic fibres and having a rubber or pasting lining.

(iii) Hose for Hose-reel, normally of rubber with fabric re-enforcement.

The second group includes the various types of armoured hose, constructed to withstand external pressure.

3. Characteristics of Hose

The following are the main characteristics essential for a good fire-fighting hose:

(i) Flexibility: For easy handling and without kinking when in use and to be made up into a smooth roll whether wet or dry, without any flats

(ii) Durability: Wearing qualities to be as high as possible and the materials used particularly in the warp must have high resistance to abrasion

(iii) Resistance to rot: Vegetable fibres are liable to be affected by mildew or rot and these materials when used should be given rot-proofing treatment. Until recently, hose was given a zinc chloride treatment known as "Burnettising, but more effective preservative agents are now available and burnettising with zinc chloride has been superseded by the use of an agent usually based on pen tachlorophenyl laurate. Hose may be given this rat proofing treatment during manufacture, or the yarn may be treated before being woven.

(iv) Change in length and diameter: Increase in length and diameter when under pressure indicates that the materials are stretched. Unlimited stretch would tend to weaken the hose and bursts, particularly of the weft, would occur, moreover, lengthwise stretch or extension cause hose to snake when under pressure. The limit of extension of unlined hose at a pressure of 12.0 kg/cm^2 is 6% of the length and the increase in diameter of the 70 mm size hose is limited to 2.4 mm.

As nylon and ethylene are used extensively in jackets on non-percolating hose, a large increase in diameter (6 mm for 70 mm) hose is permitted to allow for the greater stretch properties of these materials..

(Even with these limits it will be seen that the extension in 30 m of hose may be as much as 1.8 m. This increase in length emphasises the inadvisability of straightening out charged hose. Should a length burst and require to be changed the couplings of the burst length would be so far apart. that a new length cannot be connected up).

(v) Frictional loss: A rough internal surface increases the resistance to the flow of water through hose; the surface should therefore be as smooth as possible in order to reduce to the minimum loss of pressure through friction. The maximum permissible loss of a 30 m. hose of 70 mm, size with a pressure of 7 kg/cm' at the inlet is 1,8 kg/cm^2.

(vi) Weight: The weight of hose is important. not only from the point of view of handling at fires and drills, but also as regards stowage on appliances. The 1.S.L. specifications require hose to be as light as possible without sacrificing durability. The maximum weight limit laid down for 70 mm, unlined flax canvas hose is 470 grams, per meter and for the non-percolating 70 mm. hose is 865.5 grams per meter.

The use of synthetic materials and light weight linings has enabled manufacturers to produce a good quality hose having a weight of 510 grams per 914 mm. (per yard).

(vii) Percolation: Excessive loss of water is likely to affect the quality of the jet and hamper firefighting operations. It may also cause damage to buildings and stock of commodities through which the) hose line passes. The loss of water for any 3.5 meters of 70 mm, hose shall not exceed 13.5 litres during the 6th to 10th minute, and 6 litres during the 15th to 19th minute after reaching maximum pressure.

(viii) Repairable: It is also essential that a hose should easily be repairable by simple means, as length of hose which is initially good may develop leakage or even burst later on due to use.

4. Unlined Hose

Materials-Flax, Hemp, Cotton, Jute and Ramie are used in the manufacture of unlined hose. Synthetic fibres have also been tried:

(i) Flax: Received the first choice as this fibre satisfies all the requirements mentioned under characteristics. It has the lowest, strongest and most flexible fibres in addition to the advantages of its strands swelling and thus becoming water tight when saturated with water.

(ii) Hemp: Makes a very stiff hose and one which is subject to rapid deterioration. However, when soft hemp of the best quality is used as weft along with flax. warp, a hose of fair quality can be made.

(iii) Cotton: This is light and flexible but not water-tight. It can only be used in the manufacture of jackets for non-percolating hose.

(iv) Ramie: This fibre available from China, East Africa, Egypt or Assam makes a first-class unlined hose, but only when the fibre has been de-gummed, and if necessary, further processes to such a degree of purity that it may readily spun. It is probably the strongest vegetable fibre, but it is difficult to obtain. The costly, processing adds to the cost.

(v) Synthetic Fibre: Because of their lack of absorbency, it is not possible to produce a water-tight hose of sufficient flexibility. They are however being used extensively in the manufacture of non-percolating hose.

(vi) Construction: The fabric of canvas hose consists of two sets of yarns running at right angles to each other, those running lengthwise being called the 'Warp' and those running crosswise the "Weft".

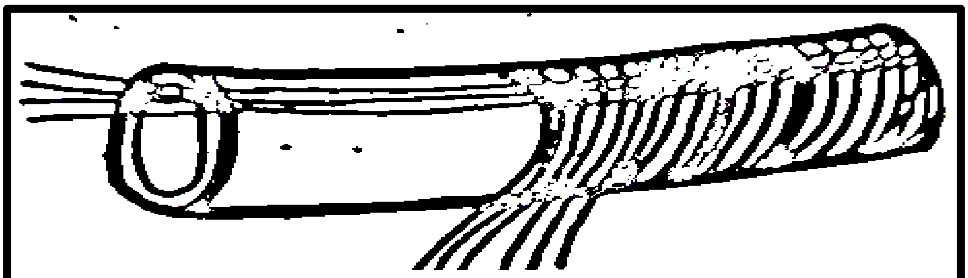

Fig: Sketch showing ‘Warp’ & ‘Weft’ threads

The weft generally consists of 10 to 24 strands or plies, twisted together, and the warp from 3 to 9 strands twisted together. The warp threads are those that give it durability to resist wear and tear, while the weft thread resist the tendency of water pressure to burst the hose, for this reason the weaving is so arranged that the "Warp" threads are on the outside, and they can be clearly seen when looking at the hose.

Hose is woven in two ways, viz. "Plain" and "Twill". In plain woven hose the warp threads are woven under one and over one, throughout the fabric. This type is normally used for unlined hose. In twill woven hose, the warp threads are woven on the principle of over two and under one; this weave is more pliable and is usually used for lined hose. It is utilised particularly with heavy rubber linings so as to obtain maximum flexibility. However, due to the introduction of light weight linings, the need for the flexibility of twill woven hose is less important, and mostly hoses are now plain woven.

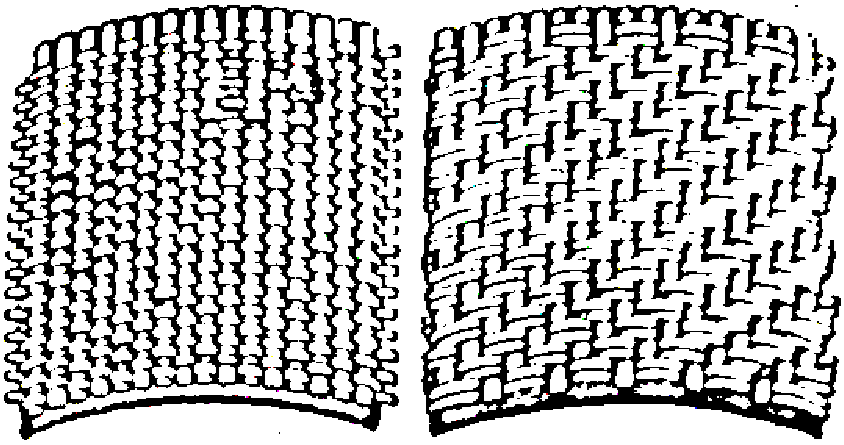

Fig: Left "Dassin" wolve Right:" Twill" Wearer.

Hose is woven on either flat or circular looms. The former type is generally weaker at the selvedge or longitudinal creases and consequently hose woven on circular looms has now entirely superseded the hose woven on flat looms.

5. Non-Percolating Hose

The term non-percolating is now used to describe all types of non-porous delivery hose including rubber-lined and the many combinations of hose manufactured from synthetic materials.

Rubber and synthetic materials are now used to produce light weight rot-resisting hose that is both flexible and durable.

(i) Materials used: Apart from vegetable fibres, flax and cotton, synthetic fibres like Nylon and Terylene in various combinations are used for making jackets. The materials used for making these jackets non-percolating may be either rubber or plastic. The rubber is usually in the form of calendared sheet, extruded rubber or latex and in some cases the latex is reinforced with cotton.

(ii) Nylon: A synthetic rot-resisting fibre. light in weight and of great strength with a low degree of absorbency. Under pressure the stretch is more and so its use is confined to the weft. If used as the warp. it will result in undue "snaking"

(iii) Terylene: Also a synthetic rot-resisting fibre of light weight and great strength with low absorbent qualities. It resists stretching and so may be used for both warp and weft. Used as the warp, "snaking" under pressure is greatly reduced.

6. Hose-Reel Hose

A non-percolating delivery hose of small internal diameter, normally 19 mm carried on a drum, which has to be flexible, but at the same time should not flatten unduly when coiled on. It is used for taking a hose line quickly inside buildings using the available water supply carried on the fire appliances.

Construction: It consists of a rubber tube or lining reinforced by wrapping with layers or plies of rubberised woven fabric applied spirally. An outer cover of abrasion-resistant rubber is then applied and the whole thing vulcanised together.

7. Causes of Decay

It is important that every fireman should know how to look after the hose in his care and how to keep it in first class condition. Much of the damage caused is avoidable and every opportunity should be taken to impress on personnel the necessity of taking care in its use. The causes of decay may be listed as:

(i) Abrasion
(ii) Mildew
(iii) Shock
(iv) Rubber acid
(v) General

(i) Cause and Prevention of Abrasion

Cause: Dragging of hose is the main point for consideration. Abrasion is likely to take place more readily and rapidly when the hose is wet. It should never be pulled around a corner where it may scrape against a wall. The vibration of a pump will bring about severe chaffing at the point where hose touches the ground after leaving the pump delivery. Abrasion can also take place at other points of contact e.g., sills of windows, parapets, roof corners etc, and should be suitably protected. Firemen should always be taught to lay out hose without dragging it.

The question of abrasion is intimately connected with the methods of "making-up" hose. The different methods are as follows:

(a) The Roll or Coil: Normally preferred, since with instantaneous couplings, the female coupling may be held with both hands and then the hose rotated to run it out Rolled hose should be stored on edge and not in fat position.

(b) Dutch Roll or Roll on the Bight: This method of making up helps to reduce abrasion. Hose should never be made up in a Dutch Roll when it is wet as the tight folds provided by rolling it from the bight are likely to damage the fabric.

(c) Flaking: Its principal advantage is that it permits running out of hose as fast as a man can move, but is subject to risk of serious damage due to dragging, which can be avoided by carrying the hose on the shoulder and allowing it to pay out as the man moves away. The objection to flaking, however does not apply to hose carried on hose-laying vehicles as there is little likelihood of dragging when laid out from these vehicles, Hose should never be flaked when wet as undue strain is brought about at the bends.

(d) Figure-of-Eight: Its chief advantage is that it avoids the tight bends of flaking and the hose can be run out equally well. but takes more space. This method is the best for storing Rubber-Lined Hose.

Prevention:

(a) Do not drag a hose, wet or dry. It may be the easy way but the wrong way.

(b) Protect hose by placing old hose or hose bandage at the first point where it touches the ground after leaving the pump delivery, and at all other points of contact e.g. sills. parapets, corners etc.

(c) Use proper hose ramps where a hose line crosses a road. (d) Hold the hose aloft parapets or sills by using crutches or other methods of suspension.

(e) Change relative position of rolls in lockers periodically to prevent chaffing of edges due to movement of appliance.

(ii) Cause and Prevention of Mildew Cause: Mildew is a fungus which, given suit able conditions of moisture and heat, lives and grows in the cellulose of natural fibres, like flax and cotton. Hose insufficiently dried, or stored in damp state together with lack of ventilation provides the conditions which promote the growth of mildew Synthetic materials are not affected by mildew, but the fungus may grow on them if damp and dirt are present in bad cases, could be recognised by its characteristic "Mouldy smell"

Prevention:

(a) Proper drying of hose.

(b) Adequate ventilation without exposure to direct sunlight.

(iii) Cause and Prevention of shock Cause: Rolls of hose thrown roughly to the ground, or allowing water to flow too rapidly without giving sufficient time for the hose to take the strain are causes of shock. Use of hand-controlled branches (shutting off suddenly can also bring about shock).

Prevention:

(a) Proper training.

(b) Flow of water into hose and increase of pressure to be gradual so that series of pressure waves in between two kinks will not lead to a burst.

(iv) Cause and Prevention of Rubber Acid Cause: Rubber lined hose stored without being properly drained results in pockets of water turning acid. The acid is formed by the action of a micro-organism on the sulphur used for vulcanising the rubber and consists of dilute Sulphuric acid. As the water evaporates through slow drying, the acid concentration increases. Hose jackets contaminated by rubber acid may have yellowish or brownish stains.

Prevention:

(a) Draining the last drop of water before drying.

(b) Proper drying of Hose.

It should be noted that with the high standard of hose maintenance prevalent today, the formation of rubber acid is unlikely although the possibility should not be overlooked. Further, the composition of rubber for lining hose is chosen now-a-days with a view to prevent, as far as possible, the formation of Rubber Acid, and this is a requirement of the specification.

(v) General:

Hoses are liable to damage by contact with acid, alkaline, oils, tars and paints etc, and hoses should be stored well away from these substances. Care should also be taken when working at oil installations and industrial under takings to ensure as far as possible that hose has the minimum contact with the above. Substances should not be allowed to remain on the appliance.

8. Operational Misuse of Hose:

By operational misuse it means, misuse at fires and at drill ground. The points mentioned earlier leading to the causes of decay should be borne in mind and all steps to prevent damage should be taken, viz., prevention of abrasion, stop mildew etc as best as possible.

Storage

(i) Roof of the store room should not be of metal, as it encourages condensation of moisture in wet days

(ii) Wooden racks are preferable to metal ones; wooden racks are to be protected with ant rodent paints.

(iii) Adequate ventilation without direct exposure to sunlight.

(iv) Ideal temperature for the store room is 60°F. But direct exposure to heat over 100°F will damage the fabric and lining.

(v) Hose should be stored in Rolls standing on edge.

(vi) Adequate space to be left between hoses, coiling, floor and from the back wall.

Stowage

(i) Hose lockers on appliances should be opened daily for allowing proper ventilation.

(ii) Chaffing of edges of rolls due to movement of appliance is a common cause of damage. To avoid it. felt-lining or similar sort of material may be used in the side walls of hose lockers and in between hoses or the relative position of rolls in locker changed periodically.

(iii) Sharp edges of couplings should be filed and polished with fine emery paper.

(iv) On return from fire, hose lockers must be wiped dry before stowing fresh hose.

9. Care of Hose

The following general points of care of hoses will assist in prolonging its life:

(i) New hose when received should be removed from its packing and the coils loosened.

(ii) Hose which is unused for long periods should not be allowed to remain on the appliance.

(iii) If recommended by manufacturer. Rubber-lined hose should have water passed through it from time to time to keep the lining in good condition, after which it should be thoroughly drained and dried.

(iv) Rubber deteriorates at high temperature and so rubber-lined hose should not be exposed to hot dry air nor stored in the Sun's rays

(v) Great care should be taken of rubber lined hose especially when cooling down after serious fires, as the hose is often stretched over debris fallen into the building, and as the brick stones etc. retain heat for a long time, the outer covering is liable to scorching thereby weakening it and shortening the life of the hose.

(vi) Hose known to have been contaminated with acids or alkalis should be thoroughly washed immediately with clean water.

(vii) When making up hose into a roll, the female coupling should not be doubled down on the hose too tightly and the first coil should be somewhat loose. This will prevent the coupling edge cutting into the hose.

10. Standard Test Delivery Hose:

All delivery hoses and hose reel tubing’s should be tested to a minimum pressure of 10.5 kg/cm^3 (a) every twelve months. (b) after every fire in which it is used. In the case of delivery hose, a 12.5 mm nozzle at the branch should be used and in the case of hose-reel hose, the hose-reel nozzle should be used. If a 12.5 mm nozzle is not available. then the smallest suitable nozzle which will allow the requisite pressure to be obtained, should be employed.

The pressure should be built up gradually to allow the hose to take the strain. Any leaks should be marked in indelible pencil and the hose sent for repair. All couplings should be inspected and tested by marrying with standard couplings. At the same time, defective washers replaced and the lugs of the instantaneous couplings lightly lubricated and adjusted, if necessary.

Acceptance Test

During Firefighting internal pressures may be as high as 105 kg/cm^2 and shock pressure may be even higher. Actual length of hose be tested to a pressure of 21 kg/cm^2.

11. Suction Hose

As mentioned earlier, Suction Hose is one that is designed to withstand both internal and external pressure and as such is used exclusively between the water supply and the pump 10 m of suction, made up in lengths of 2.5 or 50 m is normally carried on appliances. The diameter wit however, depend on the rated output of the pump which normally are 75, 100, 125- or 140-mm diameter.

A. Construction

The principal feature is that it should possess sufficient strength to withstand without collapsing the pressure of the external air when a vacuum has been created inside. It should also be strong enough to resist the maximum hydrant pressure normally encountered and at the same time possess the maximum of light ness and flexibility compatible with this strength. The nominal length of each hose is the length measured over the coupling after they have been fitted. The bore is the nominal diameter with a tolerance of usually + or - 1.6 mm.

Two main types of suction hoses are in general used in the Fire Services.

(i) **Partially Embedded Suction Hose:** This is usually built from a tough rubber lining in which is a partially embedded spiral form tempered galvanised steel wire. This embedding is so arranged as to provide a full water way built up from several layers of canvas and rubber into which also is embedded similar spiral wiring, the two spirals lying in such a way that each turn of one lies midway between the two turns of the other. The complete wall is consolidated by vulcanising

(ii) Smooth bore or fully embedded suction hose: This has a thick internal rubber lining in which a spiral wire is fully embedded. The wall is then built up in the normal way with plies of fabric and rubber as for the partially embedded type. The advantage in this type is that the internal surface offers less resistance to the flow of water than the partially embedded type. Further, the spiral wire cannot be forced from its channel as is sometimes likely when partially embedded hose is subjected to high internal pressure. The disadvantage, however, is that collapse of the inner lining is possible under vacuum causing complete obstruction of the hose. While under test, lack of adhesion of the lining will be revealed as a blister. Also, it is less flexible than partially embedded hose.

Suction hose must be constructed to with stand a pressure of 10.5 kg/cm but the actual acceptance pressure test is reduced to 8 kg/ cm so as not to dislodge the internal wire of partially embedded hose.

B. Care of Suction Hose:

The hose should be washed after use with clean water. The interior of the hose, the coupling threads and the joint washer examined for damage. The coupling nut should be lubricated as required. No dressing should be used which might cause the rubber to perish.

On modern appliances it is usual to provide special tunnels for the storage of suction hose. Where it is carried externally, it should be protected from damage resulting from men standing on it or clambering over it when mounting the appliances.

Suction couplings should be treated with care as distortion may cause air leaks. The couplings should never be dropped or dragged along the ground and the correct size of wrench should always be used for tightening the joints in cases where the universal type of wrench is not in use.

C. Standard Tests Suction Hose:

Suction hose is normally tested quarterly, at the same time as the quarterly vacuum test of the pump. After verifying that air leaks are present in pump or suction by means of the dry vacuum test, the leaks are located in the suction hose on the following way:

The length of suction hose is connected to a pump and placed under Hydrant pressure, care being taken to shut off the vacuum gauge. All blank caps are removed from deliveries. One delivery is opened to allow air to escape. The delivery is then shut down gradually and hydrant pressure applied to the suction hose: pressure is not allowed to exceed 3.5 kg/cm^3 Any leak will be indicated by water oozing out, and steps should be taken to rectify it.

d. Soft Suction

Where delivery hose is employed on the intake side of a pump it is known as a "Soft Suction" These lengths are coupled up to the pump inlet either by means of the collecting head or a suction hose adaptor.

Soft suction can only be used with a pressure fed supply, where hydrant pressures and flows are good. 10 m suction is generally used instead of the standard hard suction for the following advantages:

(i) It is capable of withstanding considerable higher internal pressures than standard suction hose.

(ii) Pump operator alone can easily handle it.

(iii) Two or more pressure supplies can be connected to the pump through a collecting head.

(iv) It is easy to run out and convenient to stow on the appliance.

(v) It is cheap, good parts cut from a condemned length of delivery hose are frequently used.

Normally lengths of 5 m to 10 m are carried on the fire appliance for this purpose. On certain appliances, two 5 m length of 90 mm, rubber lined hose are carried for use as "Soft Suction".

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CHAPTER 12

HOUSE DRILL

Aim: The aim of this precis is to enable the trainees to understand the words of command used in the hose drill and the actions they have to perform on those words of command.

Man Power: Any number, depending on the availability of equipments.

Equipments: As required.

PRELIMINARY WORDS OF COMMAND	ACTION
In a Single Line Fall in"	All concern will form a single line tallest to the right and shortest to the left.
Squad-Attention"	All concern will come to attention position.
"Right Dress"	All concern except right hand marker will come one step forward, raise their right hands up to the shoulder of man on their right & will dress in straight line with right hand marker and will look to the right
"Eyes Front"	All concern except the right hand marker will come to attention position and look to front.
"Squad Stand at Ease"	All concern will come to "stand at ease" position.
Squad Attention"	All concern will come to attention position,
'Squad Number"	All concern will number from right. The right marker will call "ONE" the next "TWO" and so in succession to the left.
Squad from the Right in Series Number	All concern will count from the right. Right marker will call "ONE" and next "TWO" and so on upto "SIX" and every 7th person will count "ONE" and so on.
"Crews Number"	Number 'ONE' of the first crew will call "ONE" No. 1 of second crew will call "TWO" and so on until all crews are numbered.
"Squad Stand at Ease"	All concern will come to stand at ease position.
No. 1 Crew Attention Remainder Stand Easy"	Only No. 1 crew will come to attention position whereas remaining crews will come to stand easy position.
"No. 1 Crew Attention"	No. 1 crew will come to attention position.
"Litting a Roll of Delivery Hose by Numbers". "By No. one"	The crew members will advance their left foot, bend left knee and steep sufficiently so that they can place the right hand on the male coupling of the roll of delivery hose with right hand fingers and at the same time left hand on the underside where it touches the ground.
"By No, two"	The roll of delivery hose will then be lifted vertically with the help of one hand, place on the right shoulder so that male coupling is on top of the roll and points to the front. the right hand still placed on the top of hose holding in firmly and left foot takes back to original position. the left hand still holding the underside of the roll of delivery hose.
"By No. three"	the left hand removed to normal position.
"Keeping a Roll of Delivery Hose by Numbers"	
By No. one	All members of the crew will take the left hand under the hose.
By No. two	A crew members will take left leg forward, bend down and keep the hose on the ground but still right hand on male coupling and left hand under side of the roll of delivery hose.

By No. three	All crew members will take both hands and left leg back so as to come in attention position.
"Un Rolling of a Hose" Crew Unroll (Stationary)	All the members of crew hold the lugs of hose roll to their level of breast and rotate it so as to unroll the roll of delivery hose.
Crew Unroll (Running)	All the members of the crew hold the lugs of unwinding roll and move forward unrolling the hose and female coupling will be put down on the grounds, standing in attention position in front of it and taking male coupling.
"Under Running and Rolling up a Delivery Hose" "Get to work"	(a) On these words of command members of crew will take half left turn in front of the female coupling, double up to a male coupling and stand on the left hand side of the hose facing it. (b) Holding the male coupling with right hand, he raises it so that water in it drain towards female coupling. At the same time with left hand he drains off water up to a certain length of hose. Male coupling is put on ground and folded once. With alternative hand (under hand) he drains off the water from the hose till he reaches female coupling. (c) Positioning himself in front of a female coupling, he holds two lugs thereof and roll the hose for 4 or 5 times thereafter he may proceed with rolling in one of the two ways: (i) Continue in the same fashion as above. (ii) By pressure on the lugs go on rolling the hose at a fast speed. At the end tightens the rolls (this method requires practice).
"Connecting and Disconnecting a Delivery Hose	(a) The first member of the crew lifts a hose roll and carried it a few paces unrolling a roll of delivery hose. At the same time second member carrying a hose roll follows him. First member now completes the unrolling of a hose and he holds the cool of female coupling of his hose with right hand and stretches out his left hand. palm taking behind. The second member then slows down, holds the inner lug of female coupling of the roll of hose on a shoulder with his left hand, removes right hand from the top of the roll of hose, holds the outer lug and then rotates the lugs, lowers the male coupling a couple of feet. The member immediately holds the male coupling of the roll of hose from the second member, with his outstretched left hand and connects it with the female end of his roll of hose that had just run out. (b) the crew faces the hydrant takes the hose between his knees near the male couplings, thus facing the female couplings of the hose to be disconnected. Then the lugs of female couplings pull apart by hands. which will automatically disconnect the male coupling he is holding bet ween his knees. Then he rolls, carries and keeps a roll of hose as per previous drill and stand two paces rear of hose in stand at ease position
"No. 1 Crew Attention	The members of the crew will come to attention position.
"No 1 Crew Fall out"	Each member turns to left and doubles up.

CHAPTER NO. 13

HYDRANT AND HYDRANT GEARS

1. **Introduction**

Water is the best available means of controlling fire. So, in the cities, which are fed by the piped water supply, hydrants are installed on water mains for making the water available to the fire service personnel for fighting fires. A fireman is, therefore, required to be conversant with the hydrant and the hydrant gears.

The term 'Hydrant' which is believed to be a derivation from the Greek word 'Houdon' means. water, and is applied to a special fitting on water mains for use by the Fire Services when required for firefighting purposes. It allows the fireman to connect his hose or stand pipe to the water main and also to control the flow of water as he requires. It essentially consists of (a) a short length of flanged pipe connecting to the water, or (b) a valve or device for turning 'on' and shutting off the flow of water, or (c) an outlet terminating a fire service connection.

2. **Classification**

Broadly, however, these may be divided into the classes according to their position relative to ground level. When below the ground, they are known as (a) Ground Hydrants, and when above the ground level, they are known as (b) Pillar or Post Hydrant.

In the past the lack of standard had been a cause of most inconvenience, but in recent times certain standardisation in respect of outlets etc. are being followed, since the introduction of the LS.S.

3. **Essential Requirements**

The requirements for a standard hydrant are as follows:

(i) Round threaded outlet with 2½" (63mm) diameter.

(ii) Delivery capacity not less than 450. G.P.M. (1800 Litres P.M.) at a constant running pressure of 25 lbs./in? (1.75 Kg./sq. cm.) at the hydrant inlet.

(iii) Spindle should be either eccentric or square and to be turned clockwise to close; and anti-clockwise to open.

(iv) Cast iron parts of the hydrant are to be coated with anti-rust painting.

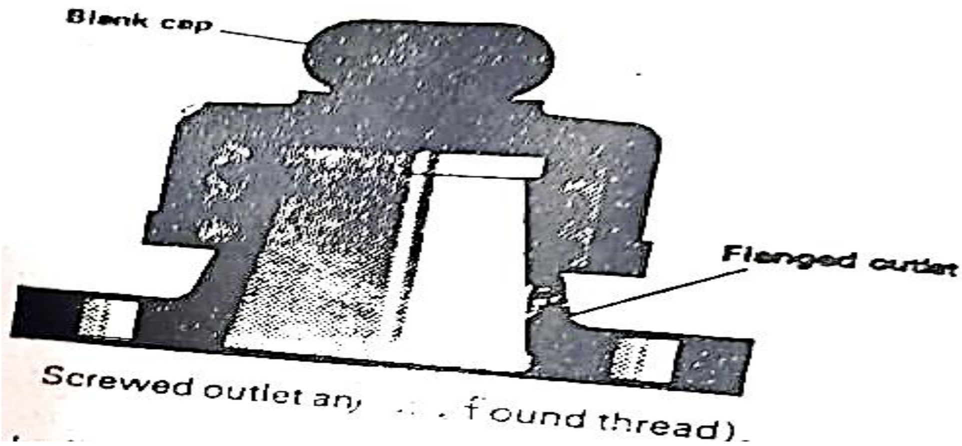
(v) Hydrant should be either provided with a lid if housed in box or otherwise fitted with a cap at the outlet as a measure of protection against being blocked.

(vi) Hydrant boxes 8% x 13% for sluice valve hydrant and 9" x 15" for screw, down hydrant and the depths of frame should be 4% and 6" for footpath and road work respectively.

(vii) Hydrant should be marked either "Fire Hydrant" or "F.H."..

4. **Description**

(a) **Ball Type Hydrants**: This type was once in wide use but now it is being gradually replaced. It does not possess a normal type of valve but consists of an outlet against which a hard wooden ball is held in position by the pressure of water in the main. There are two castings the lower bolted by a flange to the upper end of the junction pipe on the main, the upper having a connection for the stand pipe and acting as a seat for the ball that forms the valve, both castings are bolted together with a leather or rubber washer in between.



The ball is of hard wood, covered with Gutta Percha or vulcanised rubber and when the hydrant is not in use the ball is forced by the water pressure in the main against the underside of the upper casting, where it fits tightly. To obtain water from this type of hydrant the ball must be forced down against the water pressure and for this purpose a special type of stand pipe equipped with necessary means for effecting this is employed.

This type is simple and cheap, but hydraulically inefficient, since spindle and ball cause considerable obstruction to the flow of water on the contrary when the pressure will fall a little, the hydrant will be subjected to water wastage, ball having not tightly sealed at the outlet and permitting leakage.

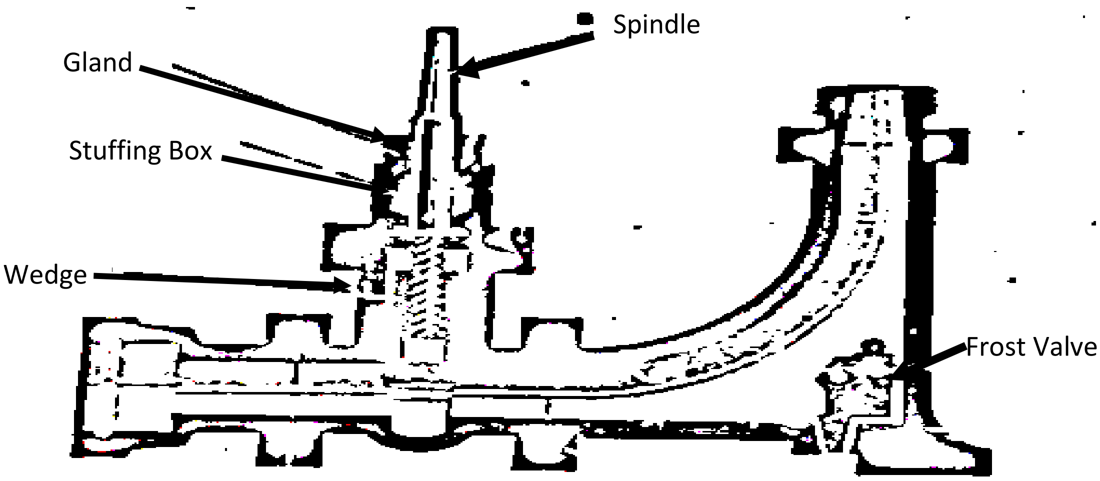


Fig: Section through topical wedge – gate valve hydrant

(b) **Screw Down Type Hydrant**: This is probable the commonest type, being found in one or other of its many forms in most parts of the country. It is attached directly to the main, which is provided at the chosen point with a vertical branch having a flange to which the hydrant is bolted. A mushroom type valve closes on a seating in the base of the hydrant body just above the inlet flange. The valve may have, a leather/rubber or gun metal face, while the seating is of gun metal. The valve is attached to the lower end of the screwed stem and is lifted from its seating by the rotation of a hollow spindle into which the stem screws till it is clear of the water way. The cover to the hydrant body carries a stuffing box and gland through which the spindle passes. The outlet is bolted to the upper end of a bend leading from the valve seating.

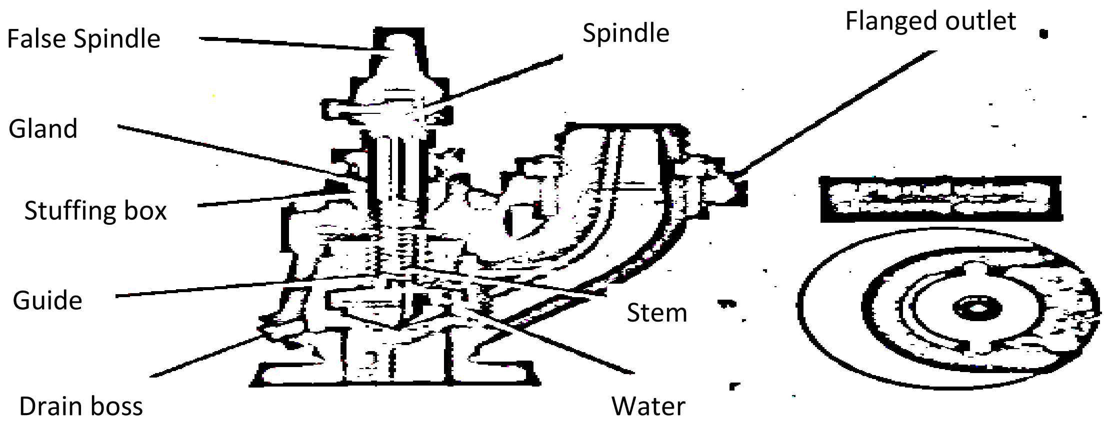
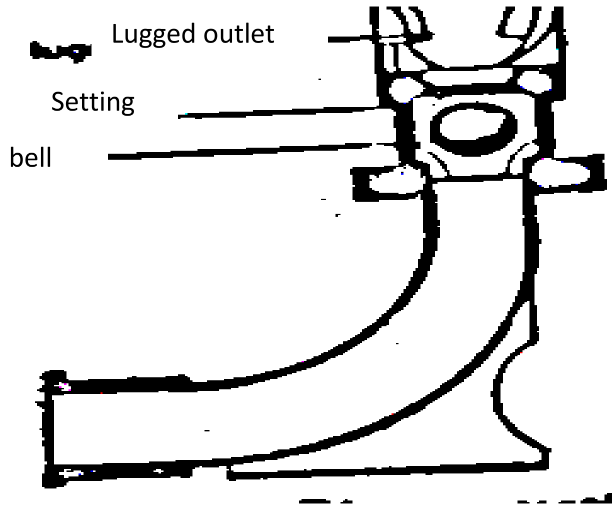


Fig: a screw down type hydrant

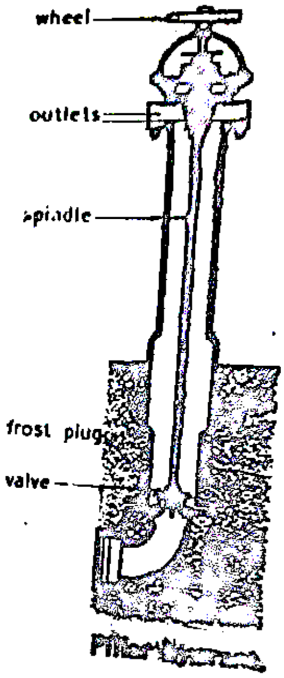
(c) **Sluice Valve Type Hydrant**: This type hydrant is not placed above the main, but alongside it on a short branch, the water flowing horizontally past the valve and not vertically as in the screw down type. It consists of three mains castings, the inlet piece which is connected to the pipe, the sluice valve itself, and the duck foot bend leading to the outlet. The opening and closing of the water way is effected by means of a gate on wedge, having gun metal faces, which seats on corresponding faces, in the body of the valve. Rotation of the spindle raises the wedge till it is clear of the water way. The spindle passes through the valve cover by means of the usual gland and stuffing box.

This hydrant is hydraulically very efficient. and when the valve is open gives a full water way with a negligible loss of pressure.



(d) **Pillar Hydrant**: The Pillar hydrant com bines in permanent form the ground hydrant and the stand pipe; it stands usually between 3 ft. and 4 ft. high and provides an accessible means of directly connecting a hose. It is made of cast iron, and usually of cylindrical shape, the hydrant is fitted with an internal valve at the base, which is controlled by a key or by means of a long connecting spindle. The Pillar hydrant carries one or two outlets for the connection of hose and may also serve in addition, to supply water for drinking purposes. In the latter case, a separate press-button or other type of valve is supplied by means of a small by-pass pipe within the pillar.

The types of Pillar hydrant to be found are nearly as numerous as those of Ground Hydrants, but they may commonly be found on private premises, such as in factory yards. etc.



5. **Component Parts of Hydrants**

The component parts of hydrant for general study may be enlisted as follows:

(i) Metal pipe connecting the outlet with the main:

(ii) Valve assembly for operating the hydrant on and off;

(iii) Outlet, may be threaded or instantaneous:

(iv) Blank cap for protecting the outlet:

(v) Cast iron box, in the case of ground hydrant and cast iron cylindrical hollow post. in the case of pillar hydrant:

(vi) Cast iron spindle top:

(vii) Frost valve where frost is commonly apprehended.

6. **Hydrant Gears and Equipment:**

The term hydrant gear, refers to a number of tools and fittings which a fire-fighting appliance has mostly to carry to meet the indispensable or casual need that may occur in respect of working from some particular hydrant. The gear may be enlisted hereunder as :-

i. Hydrant Box key or Hydrant cover key:
ii. Hydrant key (may be double ended or single ended):
iii. Spindle top. Adaptors (Eccentric and Square):
iv. Tommy bar (For turning the Hydrant Key):
v. Hydrant Outlet. Adaptors;
vi. Hydrant Extension Piece.
vii. Stand Pipe.

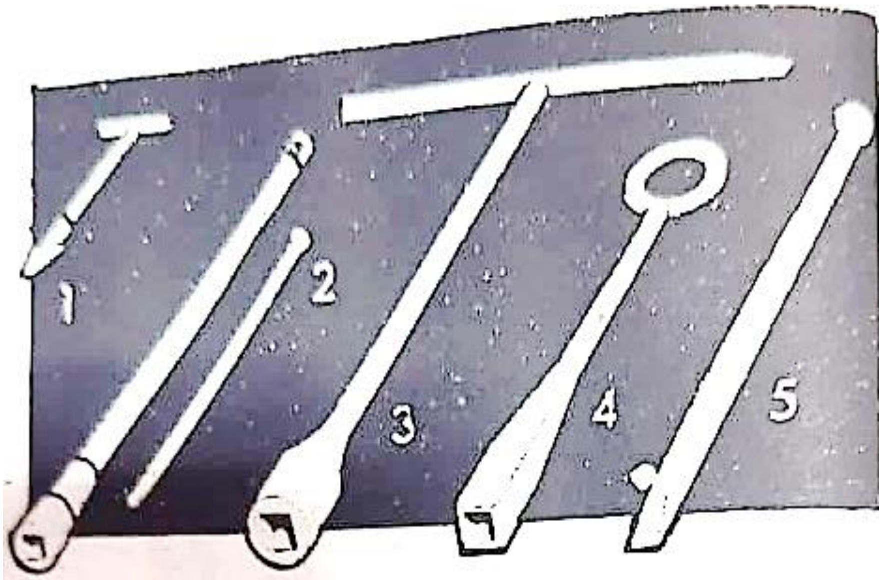


Fig: Small gear in connection with Hydrant: (1) Hydrant cover key (2) Combination set (3) Water Iron (4) Hydrant key (5) Hydrant bar.

7. **Operation of Hydrant**

(a) Open the hydrant valve slowly.

(b) Allow some water pass of to ensure that no dirt or filth is left inside that might block or clog the flow at later stage.

(c) When closing, close the valve slowly to prevent water hammer and a possible brust main.

(d) After use, see that the hydrant valve is properly closed so that no water leaks out; that the pit is left clear and in condition in which frost will not damage it, that the frost valve works (where frost valve is present).

(e) The valve of a hydrant should not be operated, unless standpipe or hose is first connected.

(f) The standpipe or hose must be disconnected from a hydrant in which no water is available or from which the flow had failed until the valve has been shut. This will obviate the danger of the valve being left open with unfortunate consequences when the supply is restored.

(g) Blank cap on outlet if it is there or Box lid if it is a ground hydrant must be restored. to position, when the service is over with hydrant.

8**. Marking, Testing, Care & Maintenance**

(a) Attention should be given to the proper marking of hydrant so that they can be found in all conditions of weather or light: tablet are to be cleaned at each. inspection. A hydrant should be marked either "Fire Hydrant" or "F.H.".

(b) **Testing**: At one of the inspections during the year, each hydrant should be tested in the following manner, using a stand pipe for the purpose:

(i) The Standpipe should be fitted to the outlet to ensure that the thread or connection is in good order.

(ii) Using a blank cap on the standpipe. or a standpipe with valve in the head which is kept shut, the spindle should be fully worked in the case of a sluice valve hydrant. In each case the hydrant should be opened to its full extent and then closed again.

(iii) To ascertain if the hydrant is charged after fully operating the valve, the blank cap should be removed, or the valve in the stand pipe head opened, and the valve should be partially operated to release small quantity of water through the hydrant. Care should be taken to direct the water into road way in order to avoid damage to adjacent property. This test should be carried out during frosty weather.

(iv) Frost Valve: Care should be taken to see that frost valve (where fitted) is in satisfactory working order.

(v) After each inspection or test, and when hydrants have been used at fires, hydrant pit should be left empty and clear.

(vi) Hydrant should be inspected at least twice a year or where circumstances permit, four times a year. Attention should be given to pits, frames, covers and surface paving round the edges of the frames. A hydrant should not be reported in good working order unless all details in connection with it are complete and in order.

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CHAPTER-14

HYDRANT DRILL

Aim: The aim of this precis is to enable the trainees to understand the words of com in Hydrant Drill and the actions they have to perform on those words of command.

Manpower for Drill: Three men/Four men.

Equipments: 3 lengths of delivery hose. Hydrant connection, hydrant key and a branch with nozzle.

PRELIMINARY WORDS OF COMMAND	ACTION
In a Single Line Fall in (Ek katar me Line Ban)	All concern will form a single line, tallest to the right and shortest to the left
Squad-Attention" Squad Savdhan)	All concern will come to attention position.
"Right Dress (Dahine Sall	All concern except right hand marker will come one step forward, raise their right hands upto the shoulder of man on their right, will dress in a straight line with right hand marker and will look to the right.
Eyes Front (Samne Dekn)	All concern except the right hand marker will come to attention position and look to front.
Squad Stand at Ease" (Squad Vishram)	All concern will come to "stand at ease" position.
Squad Attention (Squad Savdhan)	All concern will come to attention position.
Squad Number (Squad Ginti Kar)	All concern will number from right. The right marker will call "One" the next "Two" and so on in succession to the left.
Squad from the Right in Three Number (Dahine se ex se Teen Tak Ginti Kar)	All concern will count from the right.
"Crew Number (Crew Ginti Kar)	Right marker will call "ONE" and next "TWO" and so on upto "THREE" and every 4th person will count "ONE" and so on.
"Squad Stand at Ease"(Squad Vishram)	Number "ONE" of the first crew will call "ONE", No. 1 of second crew will call "TWO" and so on untill all crews are numbered.
No. 1 Crew Attention" (Remainders Stand Easy)	All concern will come to stand at ease position.
(No. 1 Crew Savdhan Baki Aram Say)	Only No. 1 crew will come to attention position whereas remaining crews will come to stand easy position.
Drill: "No. 1 Crew For Hydrant Drill 2 Paces behind the Equipments Fall in" (No. 1 Crew Hydrant Drill Ke Liye Saman Ke Pichhe Do Kadam Line Ban)	The members of the crew called out take one step forward, turn smartly to the right and at the double "fall in" in one line, two paces behind the hydrant with length of rolled hose and the branch with nozzle kept near the feet on the ground in front of No. 1, a length of rolled hose near the feet on the ground in front of No. 2 and a length of rolled hose and the hydrant connection and the ground in front of No. 3.
"Attention (Savdhan)	Crew comes to "Attention" position
"BY Number" (Ginti Kar)	Crew calls out numbers from the right as 'One' and 'Three'.

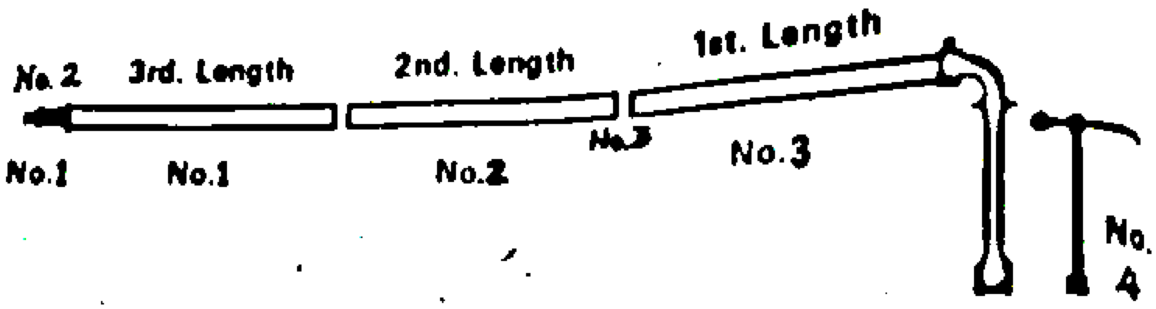
Orders given and actions taken as mentions above pertains to Drill only and not to operational call. The work on an operational call being on the only order “Get to Work” and the position taken as mentioned below:

"Get to Work" (Kam Shuru Karo)

No. 1 tucks the branch with nozzle under belt with the nozzle pointing the left, takes up the third length of rolled hose vertically on his right shoulder
holding the same with his right hand, runs up two paces behind No. 2, and after lowering the male end of his length near the place where No. 2 has ended his length of hose. so as to allow No. 2 to collect the same by his out-stretched left hand, lays it out towards the fire, connects the branch at the end of this length and gives the signal or message "Water On" by a loud shout when ready, to No. 2 who is half, way behind. He there after mans the branch with the help of No. 2 to extinguish the fire.

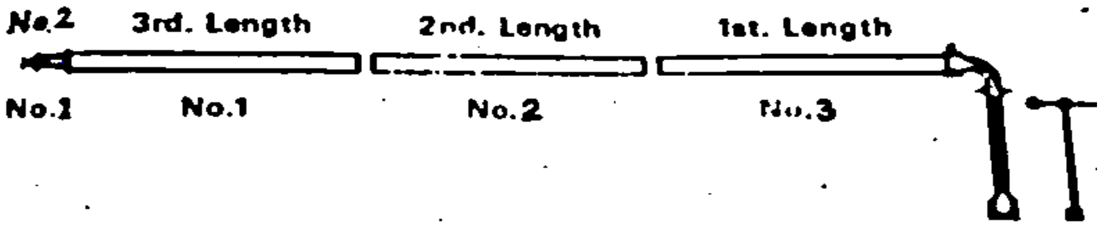
No. 2 takes the second length of hose in vertical coil on his right shoulder holding the same with his right hand. runs up two pace's behind No. 3 to collect the same by his out stretched left hand, lays out towards the fire, waits and couples the end of the third length lowered to him by No. 1. He removes kinks from the laid out hoses and awaits signal or message from No. 1 at the branch for "Water on" and passes the same on to No. 3 at the hydrant and then joins No. 1 to help in manning the branch at the fire. He latter on acts as a messenger between No. 1 at the branch and No. 3 at the hydrant.

No. 3 takes the first length of hase in vertical coil on his right shoulder holding the same with his right hand, runs up to hydrant. lowers the male end of the length of hose close to the hydrant and lays out the full length of hose towards the fire. couples up the female end of length of hose with him with the male end of the second length of hose lowered to him by No. 2. doubles back, takes the hydrant connection and the hydrant key in his hands, runs up to the hydrant, ships the hydrant connection to the hydrant, couples up end of the first length of hose left near the hydrant by him to the hydrant connection, engages the hydrant key to the spindle of the hydrant and waits for further instruction from No. 2. He then operates the hydrant on the spindle as per



"Water off" (Pani band karo)	At the order "Water Off from the officer-in-charge No. 1 directs No. 2 to No. 3 with this order when No. 3 will close the hydrant on the spindle with the hydrant key.
"Knock off & make up " (Sara line band karo aur saman lapeto)	At this order, No. 3 closes the hydrant on the spindle, disconnects the first length of hose from the hydrant connection and unships the same. from the hydrant and returns on the gears, No. 2 Un-couples the two pairs of delivery couplings between the three length of hose and No. 1 disconnects the branch from the third length of hose and tucks it under his belt The 3 men thereafter proceed to under run and make up the lengths of hose and return the same. They then "FALL IN" 2 paces behind the hydrant. No. 1 reports to the Officer-in-charge when all gears are makeup.
"No.1 Crew fall Out" (No. 1 Crew Line tor)	At this order, the crew will smartly turn to the right, take a regulation pause and then break off (at the double join with the rank on the left)

N.B. The crew may consist of three or four members. In case of three members crew, No.3 carries hydrant connection and hydrant key in addition to a rolled of hose and No. 2 works as a messenger. Where as in case of four members crew. No. 4 carries hydrant connection and hydrant key and No. 3 works as a messenger.



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CHAPTER-15

PUMPS-TYPES, CONSTRUCTIN, PRIMERS

1. Introduction

Water is the best available fire extinguishing media on account of its highest thermal capacity (power of absorbing heat). It is also cheap and available in plenty. For applying the water effectively in the form of either jet, spray or fog on the fire, we need some external energy to drive the water to the seat of fire. This machine which drives the water with force is known as pump. We shall, therefore, study in this precis the pumps used for fighting fires.

2. **Definition of a Pump**

A pump is a machine for transmitting energy to a liquid generally for the purpose of driving the liquid from one place to another over a distance or for lifting the liquid from a lower level to a higher level.

3**. Essential Requirements of a Pump for Fire Fighting**

The pump as required for firefighting, should be (a) Reliable. (b) Portable, (c) Capable of delivering water in quantities, and (d) Capable of subjecting water to pressure. It should also be able to utilise Atmospheric Pressure.

4. **Types of Pumps**

The different types of pumps are:

I. Reciprocating Pump or Positive Dis placement Pump.

(i) Force pump like hand pump.

(ii) Lift pump like those used for wells, and

(iii) Bucket & Plunger Pump like the Stirrup Hand Pump.

II. Rotary or Semi rotary Pump (Gear type pump i.e. Oil Pump in Petrol Engine, Hose Reel Pump).

III. Centrifugal Pump (Pumps where centrifugal force is used for giving energy to the fluid).

5. (i) **Force Pump**

Construction: The force pump is the simplest type of pump. It consists of a solid plunger which moves up and down in a cylinder fitted with inlet and outlet valves.

Operation: Water is drawn in on the upward stroke and discharged on the downward stroke.

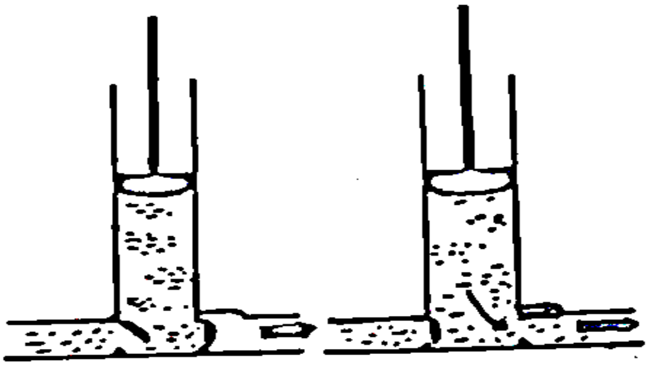
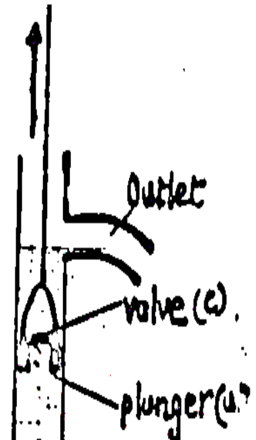


Diagram showing operation of Single Action Force Pump.

Limitation: This elementary type of force pump is not suitable for firefighting as the jet given by it is intermittent or pulsating. This pump is known as a single acting force pump. To overcome the limitation of this pump double acting force pump and single acting force pump with air vessel may be used.

(ii) **Lift Pump**

Construction: It consists of a hollow plunger which moves up and down in a cylinder. The plunger is fitted with a inlet valve through which water can pass freely in one direction but not return. The cylinder is fitted with an inlet valve below and an outlet above which may or may not be protected by a valve.



Operation: On the first stroke, as the plunger (a) moves upwards the inlet valve (b) opens and a quantity of water is drawn into the cylinder, the plunger valve (c) remaining closed.

On the second stroke, as the plunger (a) moves downwards, the inlet valve (b) shuts, the plunger valve (c) opens and water pass through the plunger into the upper portion of the cylinder.

When the plunger rises again on the next stroke, the water con not return as the valve (c) is closed, and is consequently expelled through the outlet (d) more water being at the same time drawn in through the inlet valve (b).

Limitation: The limitation of the lift pump is the intermittent flow of water. Several devices have been used to overcome the limitation and maintain the steady flow of water.

Use: the lift pumps are used for wells.

(iii) **Bucket and Plunger Pump**

Construction: The Bucket and Plunger pump is a combination of both lift and force pumps. It consists of a cylinder fitted with an inlet valve and sometimes with an outlet valve and a hollow plunger with a valve.

The plunger has mounted on it a trunk or column which work in the same way as the nor mal plunger rod.

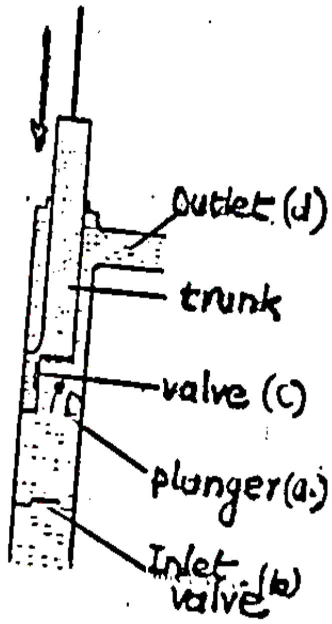


DIAGRAM SHOWING THE OPERATION OF BUCKET AND PLUNGER PUMP

Operation: At the first stroke the plunger (a) moves upward and draws water through the inlet valve (b) which opens. At the second stroke the plunger (a) moves downwards, the inlet valve (b) closes, the plunger valve (c) opens, the water passes through the plunger (a) into the above portion of the cylinder, some portion of the water is expelled through the outlet (d) and some remains in the cylinder.

At the third stroke the plunger (a) moves upwards, the plunger valve (c) closes, the remaining water in the upper portion of the cylinder also moves up along with the plunger (a). some of the water which moves up passes out through the outlet (d) and the fresh water enters into the cylinder through the inlet valve (a) at the same time.

In this pump the water passes out at each upward and downward stroke, and a continuous action is achieved although the pump is not double acting.

The best example of the bucket and plunger pump is of the stirrup pump.

II**. Rotary Pump**

Construction: It consists of projections (e.g. gears or driven wheels) which move round in a partially cylindrical chamber.

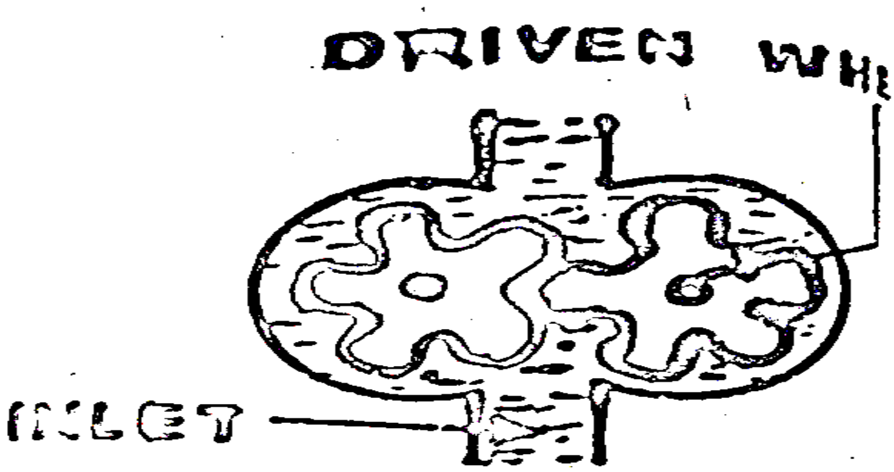


DIAGRAM SHOWING OPERATION OF ROTARY GEAR TYPE PUMP

Operation: The pump operates by means of projections (gear or driven wheels) which move round in such a way as to pick up water at one stage of their travel and discharge it at another.

The Rotary pump thus maintains the continuous flow of water.

Limitation: It is unsuitable for pumping the large quantity of water as the portion of the water drawn into the pump is carried back into inlet between the gears. Wear and tear between the projections (gears or driven wheels) and the cylinder will further increase this unavoidable slip of water into the inlet.

Use: It is widely used with hose reels and in petrol engines.

III. **Centrifugal Pump**

The Centrifugal Pump is the type most widely used for fire fighting purposes. It has no valves. pistons, or plungers and does not work by dis placement. It makes use of natural law known as centrifugal force for the transmission of energy to a liquid. The simplest type consists of an impeller rotating in a volute casing. The water is led into the centre or eye of the impeller where it is caught by the vanes and discharged by centrifugal force into the casing at high speed. The Volute casing is gradually increasing in area, and the velocity energy imparted to the liquid by the impeller is changed into pressure energy. When the water is thrown by the impeller away from the centre or eye, a vacuum is created and more water is drawn in thus ensuring constant flow.

a**. Single stage pump**

Here a single impeller is rotating in a volute casing.

b. **Multi-stage pump**

Here two or more impellers are delivering water through diffuser vanes instead of through a single volute. The diffuser vanes act as separate volutes and serve the same purpose. Multi-stage pumps are generally meant to ensure greater efficiency or for building high pressures with a slower running engine.

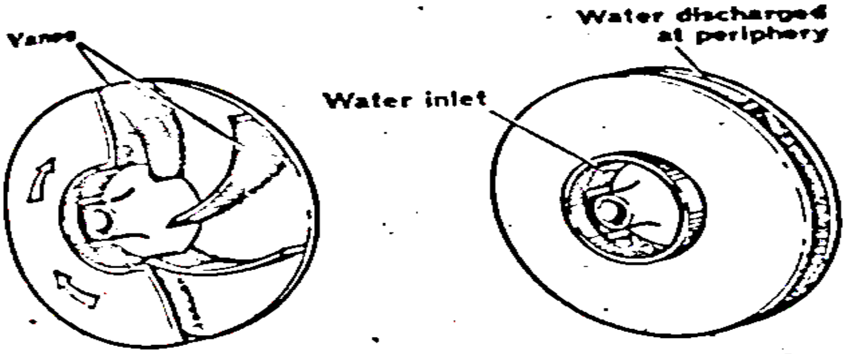


Fig. Sketch showing the construction of a typical impeller.

c. **Impellers**

These are in the form of circular discs with two shrouds joined together with vanes bet ween them and with an opening in the centre called the 'eye'.

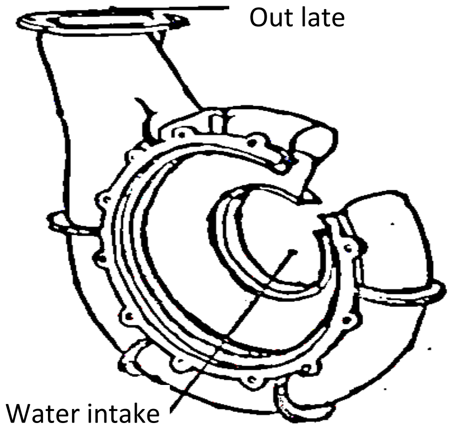


Fig: Sketch showing construction of typical value

d. Volute

The volute is a progressively expanding spiral casing so designed to convert velocity energy to pressure energy.

e**. Gland Packing**

The purpose of the Gland Packing is to seal off the passage through the pump casing through which the shaft from the engine passes to the impeller. The packing generally consists of graphited cotton or asbestos flax in split rings with staggered joints. Gland packing must not be adjusted or tightened to a point where water will cease to weep. This is to be done only when the pump is delivering water at 100 lbs. pressure per sq. in, when there should be a drip of 30 drops per minute. This is to provide the necessary lubrication and to dissipate the heat generated. In such cases, provision is also made for greasing.

This is now being superseded by a new-type of seal using new synthetic materials which require no adjustments. Seals of this kind are known as Mechanical Seals and there is no weep from them while pumping. It consists essentially of two parts kept in contact by a spring, one part fixed in the casting and the other on the shaft.

f**. Advantages of a Centrifugal Pump**

(i) The pump is small and compact.
(ii) It ensures a constant flow of water.

(iii) It is capable of handling large quantities of water.
(Iv) Its discharge can be stopped without stopping the engine.
(v) It is adjustable to the internal combustion engine by direct drive.
(vi) It has less number of moving parts (an impeller on the shaft).
(vii) It has no valves.
(viii) It is easy to maintain.
(ix) It is best suited for handling positive and fluctuating feeds.

g. **Disadvantages**

(i) Efficiency is lower than the reciprocating pump.
(ii) It requires a separate priming device.
(iii) It is not good for deep lifts.

5. **Cooling Systems**

Most engines are water-cooled from a by pass on the delivery of the pump. There are two systems.

(a) **Direct cooling** : A small quantity of water is by-passed direct from the pump to the water jacket in the cylinder block. After circulation through the engine, the water is discharged to waste via the overflow in the header tank. Filters are provided to prevent the entry of foreign matter.

Disadvantages:
(i) Anti-freeze cannot be used .
(ii) Choked filters will cause water boiling with consequent danger.
(iii) Possibility of impurities entering the cooling system and causing leakage.

(b**) Indirect Cooling**: The water in the header tank and in the cylinder, block circulates in a closed circuit. The water by-passed from the pump passes through the filters and through the cooling coils in the header tank before running to waste.

Advantages:
(i) Anti-freeze can be used in the header tank.
(ii) Cooling water can be maintained at a fairly constant temperature.
(iii) Impurities cannot block the passage in the engine.

6. **Priming devices**

Priming devices are used with centrifugal pumps to exhaust air from the suction and pump casing and so enable atmospheric pressure to force water up to the pump entry.

The different types of primers are as follows:

(i) **Reciprocating Primer** : Reciprocating force pumps usually arranged in pairs or as a single piston double acting pump.

Advantages:
(a) Simple to operate.
(b) Positive in action.
(c) High efficiency.
(d) Operates at low engine revolutions (1000 to 1500 revolutions per minute).

Disadvantages:

(a) The bulk of this type primer.
(b) The number of working parts liable to wear and tear.

(ii**) Exhaust Ejector Primer**: This type of primer operates by the force of the exhaust gases from the engine.

Advantages:

(a) Simple in operation.
(b) Less subject to damage by mis handling.

Disadvantages:

(a) Less efficient than reciprocating primer.
(b) Back pressure acts on engine at high revolutions.
(c) High engine revolutions cause wear in the water tight glands in the pump casing.

(iii) **Rotary Primer (Sliding Vane):** The rotary primer extracts the air from the suction and pump casing by positive dis placement.

Disadvantages:

(a) Slight wear between the vanes, and the casing destroys the air-tightness of the pump.
(b) The vanes have a tendency to stick in their slots.

(iv) **Rotary-Water Ring Primer**: This is a primer automatic in action.

Advantages:

(a) Large exhausting capacity.
(b) Extremely rapid and effective priming.
(c) No skill required in operation (automatic).
(d) Suitable for working from low water levels.

(v) **Water Seal Primer**: This is yet another type of "Self primer".

Disadvantages:

(a) Priming is comparatively slow.
(b) The maximum lift is limited.
(c) The need to keep the pump full of water, creates frost problems during winter.

Of these, the Rotary (Sliding Vane) and Water Seal primers are now not widely used.

Particular attention should be paid to cleaning and lubrication of primers. After use, the reciprocating primer oil sump cock should be opened to drain away any water that may have accumulated, after allowing it to settle.

If the primer is of the rotary type, it should be run for a short time to eject all water.

7. **Getting to work from open water without primer**

Where a pump is serviceable except for some defect in the priming system which cannot be remedied on the spot, and is required for lifting purposes, the following methods can be adopted, provided that the lift is not abnormally deep:

(a) Use of a second pump.
(b) Use of Blank Cap.

(c) Use of Collecting Head.
(d) Use of Foot Valve.
Of these methods, the first one i.e. with the use of a second pump is the best.

8. **Standard Tests**

All pumps should be subjected to the following tests:

a. Monthly Output Test: For this test, the pump is to be set up at an open source of water supply with a lift as near to, but not exceeding 3 m (10 ft) and using one length of hose per delivery. The pumps should be run for at least 15 minutes and any pump found incapable of sustaining the pressure indicated below should be made the subject of report.

(i) Portable Pump 60 GPM/275 L/min	One delivery with ½ " nozzle 40 lbs per sq. in./4.2 Kg./cm^2
(ii) Light Pump 150 GPM/680 L/min	One delivery with 1" nozzle 100 lbs / sq. in./7 Kg./cm^2
(iii) Large Pump 450 GPM/1800 L/min	Two deliveries with 1" nozzle 100 lbs. per sq.in./7 Kg./Cm^2
(iv) Large Heavy 750 GPM/3400 L/min	3 deliveries
(v) Extra Heavy 1000 GPM/4500L/min.	4 deliveries, 1 $^1/_8$ " nozzle/ 30 mm. nozzle.

b. **Monthly Vacuum Test**: This is to be carried out immediately after the output test when the gland packing is fully saturated. All lengths of suction to be connected to the inlet of the pump with the blank cap in position at the end of the last length, but leaving the blank caps off all deliveries. The compound Gauge Cock should be left open and the primer run at priming speed for not more than 45 secs. Priming should cease after obtaining 24 ins./60 Cm. or more of vacuum and the com pound gauge needle should then be watched. If the needle falls to 10 ins./25 Cm. in less than one minute an excessive air leak is present. Steps should then be taken to rectify the leak.

c. **Six-monthly Deep Lift Test**: All pumps should be subjected to a deep lift test as follows, but with the proviso that if a pump passes satisfactorily the monthly output and vacuum tests, the deep lift test may be dispensed with.

(i) Pumps with a capacity greater than 200 g.p.m./ 900 1/min at 100 lbs/sq. In/7 Kg per cm	20-24 t/7"m -7.3 m.
(ii) Pumps with a capacity bet- ween 100 & 200 g.p.m/400* & 900 l/min.	17-20 t/7'm-7.3m.
(iii) Pumps with capacities between 100 g.p.m./450 1/min	10-12 tt/7'm.

"Indicates I.S.I. Specifications.

It may be noted that when working on a deep lift, the output will be substantially below its nominal output.

9**. Servicing a pump on return from a fire**

(i) Petrol, oil & water to be checked.
(ii) Pump should be flushed thoroughly with clean water.
(iii) All grease cups and grease guns to be replenished.
(iv) Cooling water filters to be cleaned.
(v) Water from reciprocating primer to be drained.
(vi) If the primer is of the rotary type, it should be run for a short time to eject all water.

(vii) All body and paint work to be washed.
(viii) Tyre pressures to be checked.
(ix) All gears washed, checked and restored.

10. **Practical pump operation**

The following points are worth remembering while operating a pump:

I. Checking up of petrol, oil and water.
II. Pump to be kept as close to water supply as possible.
III. Pump to be placed on the side of the road.
IV. Pump should be placed on a made-up surface
V. Hand brake to be engaged.
VI. The weight of the engine to be taken off the springs by securing the jacks properly and ensuring that the pump is level.
VII. If basket strainer is used, internal strainer should be removed.
VIII. Kinks and sharp bends in suction to be avoided and to be protected from chaffing.
IX. Strainer to be properly submerged.

Causes of failure of water when working from hydrant or pressure fed supply

(i) Failure of the supply itself i.e. fractured main or burst of soft or hard suction bet ween pump and supply.

(ii) Choked strainer (either in stand pipe or internal strainer).

(iii) Over running of water supply (when working with soft suction, the hose flat tens and shuts off the supply).

Causes of Increased delivery pressure whilst at work

(i) Blockage of hose (due to fallen debris, kinks in hose line, vehicle, standing on hose lines, blocked jet or when hand controlled branch is in use).

Causes of reduction of delivery pressure whilst at work

(i) Reduction of flow in supply to pump.
(ii) Burst length of hose.
(iii) A hand controlled branch when in use, being further opened up.

11. **While working from open water**

a. ***If a Pump Fails to Prime***

(i) Strainer not submerged.
(ii) Faulty suction joints.
(iii) Pump filler cock or drain plug loose.
(iv) Air leak in suction or damaged washers.
(v) Defective gland packing.
(vi) Cooling by-pass open.
(vii) Leak in lead to gauges.
(viii) Choked strainer.
(ix) Defect in pump casing.
(x) Priming Valve turned off.
(xi) Mechanical defect in priming system.

b. **Causes of loss of Vacuum whilst at work**

(i) Strainer not adequately submerged.
(ii) Loose suction joint.
(iii) Leak in suction.
(iv) Fault in pump casing.
(v) Leak in lead to gauges.
(vi) Packing gland too loose.

c**. Pump fails to prime and register high vacuum reading**

(i) Blocked strainers.
(ii) Faulty suction hose (when it is liable to collapse).

d. **Pump registering a decreased vacuum reading whilst at work**

(i) A rise in level of water (tidal water).
(ii) Less water is being pumped.

e. **Pump registering an increased vacuum reading whilst at work**

(i) A drop in the level of the static water.
(ii) Pumping more water.
(iii) One or other of the strainers getting blocked.

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CHAPTER NO. 16

TRAILER PUMP DRILL

Aim: The aim of this precis is to enable the trainees to understand the words of command used in the trailer pump drill and the actions they have to perform on these words of commands.

Manpower for drill: Six Men.

Equipments: One trailer pump, two suction hoses, three pairs of delivery hoses, one strainer, two wrenches, one guideline and two branches (Short).

PRELIMINARY WORDS OF COMMAND	ACTION
"In A Single Line Fall In (Ek Katar Me Line Ban)	All concern will form a single line tallest to the right and shortest to the left.
Squad antion (Squad Saadhan)	All concern will come to attention position.
"Right Dress (Dahine Saj)	All concern except right hand marker will come one step forward. raise their right hands up to the shoulder of man on their right, will dress in straight line with right hand marker and will look to the right.
"Eyes Front"(Samne Dekh)	All concern except the right hand marker will come to attention position and look to front.
"Squad Stand At Ease (Squad Vishram)	All concern will come to "Stand at ease" position.
Squad Attention (Savdhan)	All concern will come to attention position.
"Squad Number (Squad Gint Kar)	All concern will number from right. The right marker will call "One". the next "two" and so on in succession to the left.
"Squad From the Right In Sixes Number (Dahinese Ek Se Chheh Tak Gint Kar)	All concern will count from the right. Right marker will call "ONE" and next "TWO" and so on upto "SIX" and every 7th person will count "ONE" and so on.
"Crews Number (Crew Gini Kar)	Number ONE of the first crew will call "ONE", No. 1 of second crew will "TWO" and so on until all crews are numbered.
"Squad Stand at Ease (Vishram)	All concern will come to stand at ease position.
"No: 1 Crew Attention Remainders Stand Easy (No 1 Crew Savdhan Baki Aram Sey)	Only No. 1 crew will come to attention position whereas remaining crews will come to stand easy position.
Drill	
No. ………..Crew Three Paces Behind The Pump Fall In " (No Crew Pump ke Pichhe Teen Kadam, Line Ban)	The members of the crew called out, take one step forward, turn smartly to the right and at the double No. 1 of the crew will take 3 paces from the right side of the pump at behind and will turn on right and stop. The number six will say "Up" at this command all crew members will turn up left and will take dressing from centre. No. 6 will be in line with the No. 1. delivery outlet and No. 4 (right) delivery out and thereafter once again No. 6 will say "Up" and all members will come to the "Stand at Ease" position.
"Attention (Savdhan)	Crew comes to attention position
Number (Ginti Kar)	The men call out their number starting from the left hand man as "One" "Two". "Three" and so on. No. 6 should be the motor driver/pump operator.
"Close Up" (Ghera Lagao)	Each member of the crew doubles up to the position as shown in the below diagram (by arrows), No. 1, 2 and 3 turn half left with No. 1 in front and Nos. 2 and 3 following him in the order, and Nos. 4, 5 and 6 turn half right and double to the off side of the trailer pump with No. 6 in the front and Nos. 5& 4 following him in that order. No. 1 at the near side draw bar and Nos. 2 & 3 along the near side mudguard Nos. 4 & 5 along the off-side mudguard of the trailer pump and No. 6 at the off side draw bar

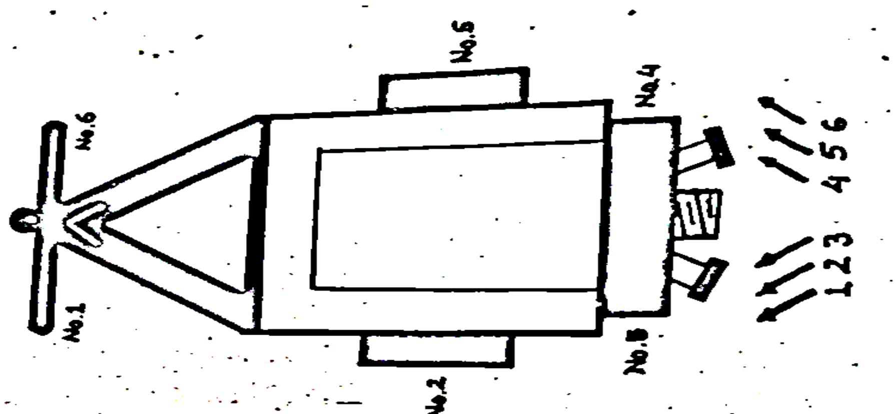


Fig: "Close Up" Position in Trailer Pump Drill

Working" from Open water/Hydrant. Single/Double Suction Single/Double delivery/Three Lengths Each No... Crew. Get-To-Work" Khule Pani Se/Hydrant Se Kam Karane Ke Liye. Ek/ Do Suction Se. 3 Hose Ka Ek/Do Delivery Line No. CREW, Shuru K2.0).	Nos. 1 & 6 take the first length of suction to the inlet eye when No. 6 with the suction wrenches, removes the blank cap and they connect it. Nos. 4 & 5 take second length of suction, connect it to the first length when No. 6 assisted by No. 5 tightens all joints. No. 4 then collects the strainer and guideline, secures the suction and strainer with the guideline and assisted by No. 5 lowers to the strainer with the manila line in the water and No. 5 makes the loose end of the manila line secured to a firm object. No. 1 tucks the branch and carry one and length of delivery hose and Nos. 2 & 3 each takes one length of delivery hose. No. 3 lays out the first length from the left hand delivery of the pump while Nos. 2 and 1 in that order lay out their lengths of delivery hose from the first length onwards. No. 1 connects the branch and with the help of No. 2 continues to man the branch. No. 2 acts also as messenger and No. 6 remains at the pump. No. 2 as message passes "Water on & Water off" signals or messages with right hand raised above head straight to No. 6 at the pump. Use of second delivery:-If a second delivery or second line is to be brought into use. No. 3 will tuck the second branch under his belt and Nos. 4. 3 & again No. 4 will lay out the required length of hose in that order. No. 3 will man the branch at the second line with the assistant of No. 4 and No. 4 also will act as a messenger at the second line and No. 5 remains at the pump. No. 5 will operate the pump/hydrant as required by No. 6 and generally assists No. 6 at the pump as shown in diagram.
"Knock Off and Make Up" (Sara Line Band karo-Aur Saman Lapeto) "Fall Out" (Line Tor)	No. 1 sends back No. 2 to inform No. 6 with the message 'Knock off and make up', while No. 3 sends back No. 4 to inform No. 5 with the message "Knock off and make Up". Thereupon each member of the crew will make up whatever gears/suction or delivery hoses after under-running, he had laid out or used. However. No. 5 and No. 6 will make up hoses of second length and third length respectively of second delivery instead of Nos. 3 and 4 who had laid them. When all gears, hoses made up, the crew will fall in. 3 paces behind the pump and No. 1 reports to the Officer-in-charge.
"Fall Out" (Line Tor)	At this order, the crew will smartly turn to the left, take regulation pause (approx. two seconds) and then break off.

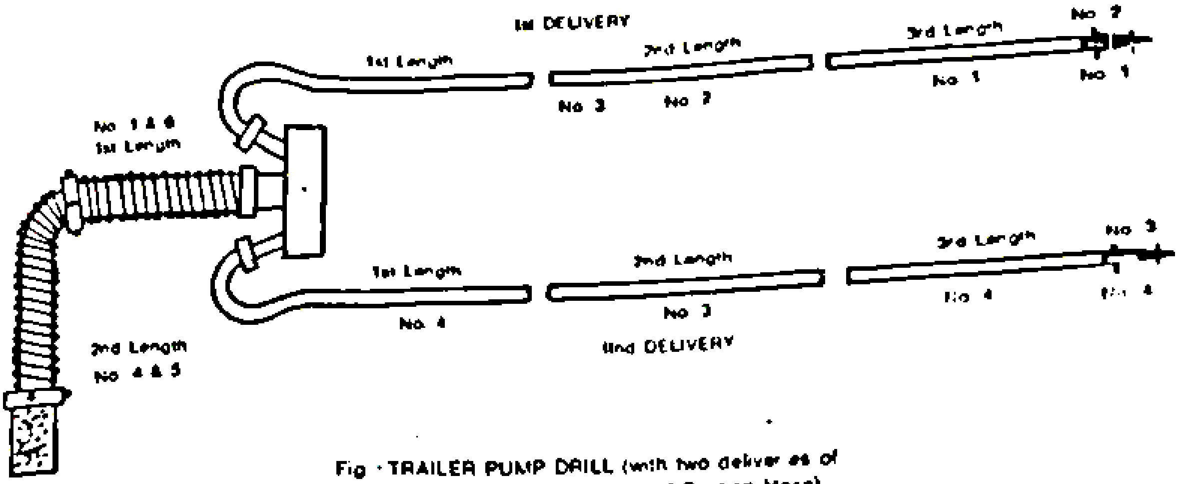
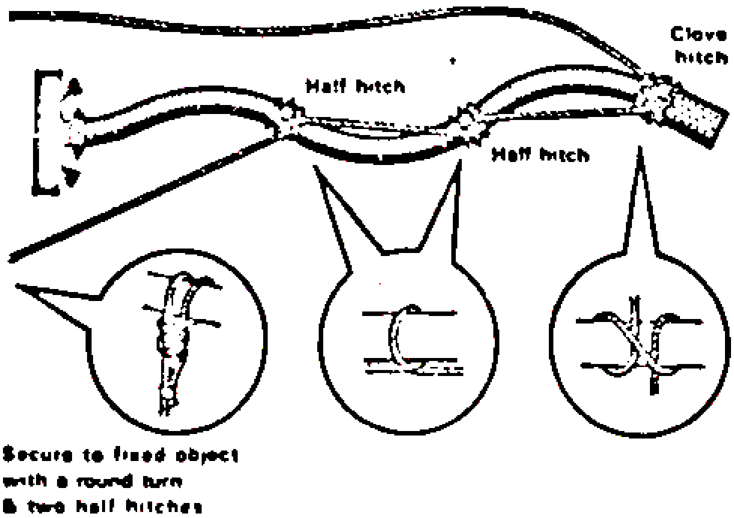


Fig · TRAILER PUMP DRILL (with two deliver as of 3-lengths of each & 2-lengths of Suction Hose) (Working from open water)



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CHAPTER 17

BUILDING CONSTRUCTION

1. INTRODUCTION

A fire officer while extinguishing a fire and / or effecting a rescue from burning or fallen buildings, comes across the different members of construction in a building. i.e. walls, stairs, floors, roofs etc, and the various types of materials used in such construction. It is therefore, essential for him to acquire a first-hand knowledge about the general principles of construction and the effects of heat or sudden cooling by water when hot, of the various materials used in such constructions and the stress and strain they are subjected to.

2. DEFINITION OF SOME TERMS.

Some of the common terms relating to the elements of structure and building materials when involved in a fire, are as follows: -

(a) Fire Resistance: The term fire resistance is a relative one and normally refers to elements of structure only. It means that an elements of structure will resist fire for a specified time when specified heat is applied.

(b) Incombustibility: An incombustible material is one which neither burns nor given off inflammable vapours when heated upto 7500 C.

(c) Combustibility: Any material which is just below the standard of incombustibility, is termed as combustible material.

3. Building materials & their behaviour in a Fire

Following materials are generally used in the construction of buildings: -

(a) Timber

(b) Brick

(c) Concrete

(d) Stone

(e) Glass

(f) Metals

(g) Plastics

(h) Building boards.

(a) Timber: Timber has a low thermal conductivity and this factor combined with its production of a protective skin of charcoal in fire, reduces the rate of combustion, much, however, depends on whether it is hard or soft wood, its cross-sectional area and its chemical treatment if any.

(b) Bricks: Bricks generally have a very low thermal conductivity and nearly approach fire proof stage if all stones and foreign materials are removed from them (9" X41/2 X3" – size) and to baked at 9000C to 12500 C.

(c) Concrete: consists of gravel broken-stone, brick or clinker or other hard materials, mixed with sand, cement and water. It consists of three constituents viz. Coarse aggregate, fine aggregate and matrix. Where it is reinforced with steel member, it is called reinforced concrete. In a fire, concrete is rapidly dried and contracts between 4000c and 5000c with the result that it cracks. At about 8000c the cement begins to decompose. It may slake the lime causing rapid expansion which often results in collapse of the structure.

(d) Stone: Stone in general is a good heat insulator but inferior to brick when subjected to heat owing to its tendency to spall and split into pieces and specially when a jet of water is applied suddenly.

(e) Glass: Glass when heated, tends to crack easily because of its low thermal conductivity and uneven expansion. It behaves well when reinforced with wire meshing or metal strips as in wire glass or electro-copper glazing. (1/4" thick-glass & copper have the same rate of expansion).

(f) Metals: Metals used in a building are (i) Cast Iron. (ii) Wrought Iron, (iii) Steel and (iv) Lead and Zinc.

(i) Cast Iron: While fighting a fire in a building having cast iron structural members, it is wise to avoid playing a jet of water directly on them because the rapid cooling may cause these members to suddenly contract and thus cause cracks.

(ii) Wrought Iron: When exposed to heat, wrought iron members normally loose shape and get distorted.

(iii) Steel : Steel loses two-thirds of its strength when heated to over 6000c.

(iv) Lead and Zinc : These metals melt easily and allow the fire to spread quickly. These may, therefore, cause serious burns to the fire fighters while working under panels or fittings of these metals.

(g) Plastic: Plastics are of two types viz. Thermo-Plastic and thermo-setting plastics. In general, all thermo-plastics are inflammable whilst thermo-setting plastic are fire resisting.

(h) Building Boards: The types of building boards that are commonly used are as follows (Used for lining walls, ceilings and for constructing partitions) :-

(i) Fibre board

(ii) Plaster board

(iii) Asbestos board

(iv) Plywood board

(v) Plastic board

The fire resistance of building boards mainly depends on the material used, their thickness and finally, in their method of erection.

4. Fire Resistance of Materials employed in Building Construction

When different materials are exposed to or come in contact with fire, the time taken for complete collapse or disintegration, and the rate of spread of flame through the material vary in each case:

(i) The factors which largely affect these variations are the nature of materials, that is whether it is combustible or not:

(ii) The ignition temperature of the material if it is combustible.

(iii) Size, particularly the thickness of the material.

(iv) The intensity of fire to which the material is exposed, and

(v) The physical load stresses which act on the structural component of which the concerned material forms a part. It therefore follows the rate of growth and intensity of fire in a building, and its consequent collapse or resistance to fire, depends upon the nature, quantity and distribution of combustible materials used in its construction and of those which are housed in it.

Every combustible material gives out heat while burning. The amount of heat given out depends upon the nature of the combustible substance and its quantity. This means that the amount of heat given out by equal quantity of different combustible substances may be different. The total weight of combustible material is, therefore, not a sufficient criterion for assessing the fire-hazard and it is customary to express the total heat that can be liberated in terms of Kcal/m2, the area being the floor-area of the building.

Further, the elements of structure of any building must be designed for strength and fire-resistance consistent with the fire-load of the building. So that the building is able to withstand physical collapse because of a possible fire. For this, it is necessary to assess the fire-resistance of locally available building materials under varying fire and structural loads.

5. Fire Resisting Walls:

These walls are of two types, e.g. one between adjoining properties and the other sub-dividing property.

The former is a type of wall that is owned jointly by two parties. It must be a fire-resisting one so that fire from one side may not communicate to the other side. Naturally, it must have no openings in it, which can spread the fire. It is known as a separating wall or party-wall.

The latter type of wall may have, on the other hand, doors and other openings in it to afford communication with their other parts of the buildings in which it divides. These openings are however, required to be protected. It is known as Division Wall.

6. Symptoms of Building Collapse

The following are the probable symptoms of building collapse:

i) Falling or spalling of pieces of mortar, stone, etc., from the wall.

ii) Horizontal cracks are more indicative of danger than vertical cracks.

iii) Cracked or dropping arches over doors and their openings.

iv) Sagging floors or beams or gaps appearing between the edges of floors and walls.

v) Displacement of steel or cast-iron pillars, supporting joists or beams.

vi) Bulging of wall.

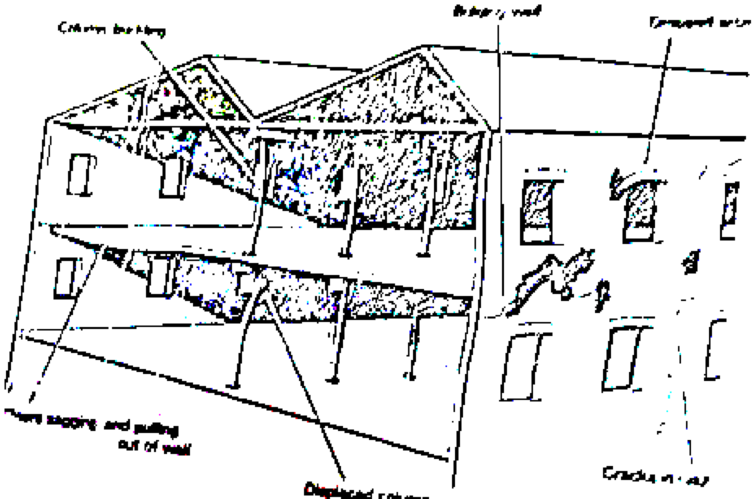

Fig: Diagram showing (greatly exaggerated) some of the more usuals ions pf collapse in building

7. Element of Structure

The major elements of structure are walls, floor and roof. Other important members are arch and lintel, beams and columns, doors and windows, staircase etc.

A) Wall : Walls may be either load bearing or non-load bearing. In case of framed building all the load of the structure is borne by the frames, and therefore, the wall in such buildings are not required to carry any load and are consequently thinly built. The internal walls may be thinner working merely as “partitions” and reaching only upto the ceiling.

in a non-framed building, however all the load of the structure must be borne by the walls themselves and as such there must be of thicker construction, sufficiently strong for carrying the loads overhead.

i) Load Bearing Walls: Load bearing walls are, therefore, those external or main walls which carry some load of overhead structure in addition o to their own load. These walls are also often termed as traditional or masonry walls.

ii) Non-Load Bearing Walls: These are often termed as partitions, but the non-load bearing walls extend upto and touching the ceiling. Sometimes taking a small load in addition to its own, while the partition walls are never such. The walls in a framed type building are mainly no-load bearing type.

iii) Fire Walls: Fire walls are those which run the entire height of the building upto 1 meter above it. These walls though of heavier construction, usually 30” – 35” thick minimum, plus plastering on both sides do not carry any load other than their own and their sole purpose as the name suggest, is to divide a large floor area into smaller ones, and resisting the spread of fire from one side of it to the other.

iv) Cavity Walls: It consists of two brick walls held together by metal ties and separated by an air space. This type of wall is mainly used as an external wall in a building exposed to weather and the object is to prevent rain penetrating to the inside face of the walls.

Behaviour of Load Bearing Wall in a Fire

Strength of a wall to withstand the stress of fire mainly depends upon:

i. Its thickness in relation to its height.

ii. Its height in relation to its support walls, i.e. cross walls, which are built into it thus imparting strength to the load bearing wall.

iii. Any lateral pressure exerted by expansion of the steel joints thus throwing it out.

iv. Levering action by the collapsing of joists built into the wall.

v. Uneven expansion factor between the exposed and the unexposed sides. In case of fire, the exposed side of this heated, expands and because of this uneven heat expansion factor, leans out at top. A jet played at the middle of the wall in such a case may hasten collapse.

B) Wall Openings: For the purpose of fixing doors, windows, etc. opening are required to be provided in the wall.

i) Arches & Lintels: Wherever such opening are provided provisions are made for carrying the load of the wall above the opening and transmitted to the both sides of the opening. This is done by either a lintel or an arch. In case of a lintel, a simple beam of either wood, concrete or cast iron is placed on the walls, spanning across the opening.

in case of arch which may be either flat or curved, it comprises of rectangular or wedge-shaped blocks, in such a manner that each member compresses its neighbour and the load overhead is transmitted downwards and outwards to the extremities. It is, therefore, clear that in the case of arch, there is always a sideways thrust and if removed, i.e. falling of any one of the members will lead to collapse of the whole arch.

ii) Doors and Windows: The behaviour of doors and windows in a fire depends upon:

a) The material used and also its thickness, in case of timber doors and windows, the thinner they are and the thinner their frames, the lower resistance, Wooden door frame for openings in external walls are formed out of 4”x3” timber.

b) In case of metal doors or windows, although, these are themselves non-combustible, they will help spread of fire by conduction, radiation and also by flames passing through the gaps caused by buckling under stress of heat.

C) Columns and Beams: Columns and beams (Joists) perform the important function of supporting the floor or roof above. A column is a vertical member carrying part of the load overhead, and thus, in reality, is like a load bearing wall, where large uninterrupted space is required columns are avoid load bearing walls. It is, therefore, clear that columns are meant to withstand vertical load only and any great eccentric load may overturn the column if not rigidly, fixed at foot. Their behaviour in a fire, depends upon the materials of which they are constructed and their thickness in relation to the height. Materials normally used are – reinforced concrete, timber, cast iron and steel. Bare, i.e. unprotected steel or cast-iron column are potential sources of danger in a fire.

Beams are horizontal members as opposed to vertical members, i.e. columns. Beams span horizontally between walls, or between columns or between a column and wall, so that they can carry the load of the upper floor or roof above and transmit same on to the walls or columns supporting them. Timber, reinforced concrete or steel are the materials normally used. Since the strength of beam depends on its depth, the beam is always placed on its edge, and in case of a steel beam the thickness of its wall on the central part is reduced to the minimum, with flanges at top and bottom, in the shape of “T” or “I”.

(i) Flitched Beam: This type of beam consists of two narrow wooden beams bolted together to a central wrought or cast-iron bar to make a single unit.

(ii) Behaviour in a fire: Behaviour of timber and R.C. beams, if of sufficient thickness, is quite satisfactory. Behaviour of steel beams unless encased properly, is most unsatisfactory. In case of any fire of intensities the beam will not only expand and throw out the walls they are built into, but will also loose quickly their tensile strength to a great extent, and sag and twisting, thus causing collapse of the floor they are supporting.

D) Floors : Floors are laid out to cover kutcha earth in case of ground floor and to support their own weight and also all superimposed loads in case of upper floors and transmit same to the walls or columns supporting the floor. Floors are either of wood or concrete, the latter being the modern tendency. The behaviour of a timber floor in a fire, obviously is most unsatisfactory because the floor compromises of high combustible timber boards. The concrete floor which is more often of reinforced type behaves quite well, although in a fire some spalling of it may take place.

E) Roof: Roof is designed from structural point of view to carry its own load only and transfer it to the side-walls providing protection against weather.

Basically, roofs are of two types – flat and pitched.

In case of flat floor – it is laid same as a floor either of wood, cement concrete or slabs of stone. In case of wooden floor, it is covered with metal sheets e.g. lead, zinc, galvanised iron and in case of cement concrete or stone slabs, paved with cement or china mosaic. The cement concrete roof with cement covering is most fire resisting. Where roof covering, other than cement or china mosaic is used e.g. metallic sheets, or asphalt the same adds to the hazard in case of a roof fire.

F) Staircase: Of all the types of staircases, reinforced concrete staircases are the best, particularly when such a staircase is enclosed on three sides by brick walls keeping only the front side open, this type of staircase does not become smoke-logged and makes fire-fighting much easier. Timber staircases often result in a complete burn out of the treads and risers. Cast iron and steel staircases are liable to crack, buckled or get distorted.

a. Main features of a well-designed staircase

The main features are: -

i. It should be built of fire resisting materials.
ii. The head of the stair be ventilated to prevent mushrooming.
iii. All doors on the stair should be fire resisting and self-closing.

b. **Vertical opening-flue effects of lift wells, stairwells etc**.

Lift wells, stairwells, chimneys and such other vertical opening cause a flue effect and help the spread of fire from floor to floor. They offer a passage for warmed-up air which the adjacent cold and heavier air pushed up, and with this warmed-up air, goes a rush of burning material, flame and partly consumed gases, all ready to set fire to more fuel in the floor above, whilst the fresh oxygen in the cold air down below intensifies the fire thus already attacking all the fuel it can get.

8. Exposure Hazard

This hazard normally exists under the following conditions.

i. When the adjoining buildings are of non-standard construction.

ii. When the party walls are of unsatisfactory nature.

iii. When the number of building are in close proximity.

a. Means of external ignition

i. Flames or hot gases

ii. Burning brands.

iii. Radiant heat

iv. Inflammable liquids.

b. Method of reducing exposure hazards

i. Better arrangement of premises

ii. Provision of fire resisting shutters

iii. Provision of wired glass of electro-copper glazing

iv. Provision of hardwood and fire-resisting doors.

v. Provision of skylights with wire-netting

vi. Provision of drenchers.

9. Types of Collapse

i. Lean to Collapse: When floors drop on one side and hang to the wall on the other, a "lean-to-void" is formed. They are often large and are relatively easy to reach.

ii. Flat Collapse: Occasionally, when the walls spread outwards, the floor falls straight down, often it is stopped by furniture and shallow flat void is formed at the bottom. This type of void is extremely hard to reach. It is often dangerous.

iii. "V" Shaped Collapse: Usually floors of normal dwelling houses are not so constructed to take heavy load and this may therefore bend or break at the centre of joint span. The floor or roof then falls in the form of "V". Voids are formed on either side.

iv. "A" Shaped Collapse: Sometimes the centre of floor holds up and both sides collapse forming an "A" shaped void. These voids are more difficult to reach.

v. Pancake Collapse: The weakening or destruction of bearing walls may cause the floors and possibly the roofs to collapse one on top of the others, into a lower floor or the basement. Persons may be trapped between the layers of these.

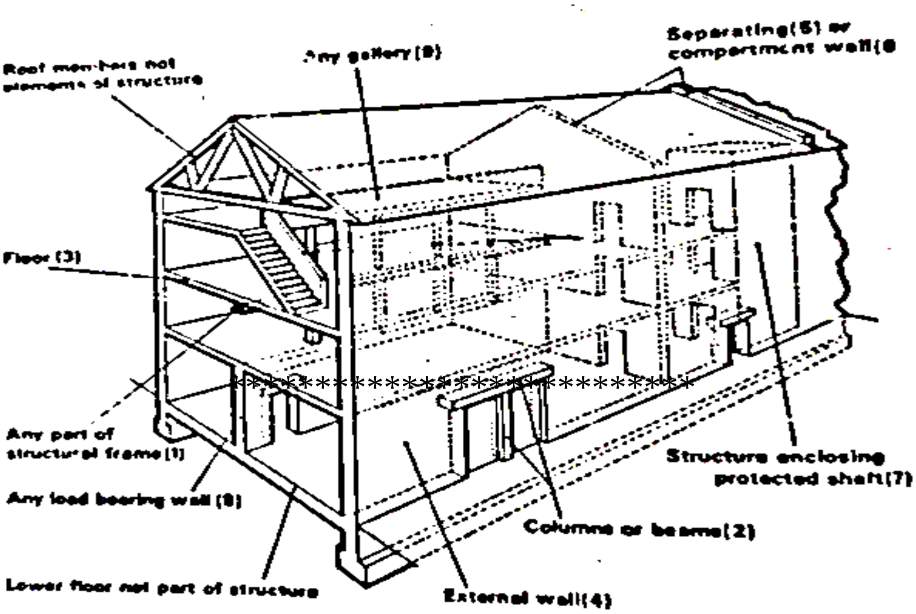

Fig. Sketch showing the various elements of structure of a building.

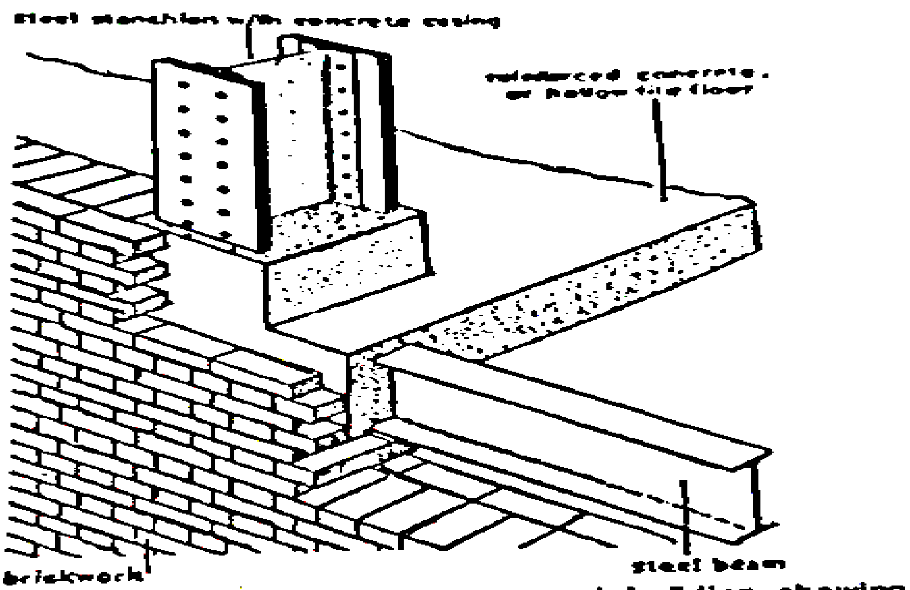

Fig. A portion of a steel-framed building showing concrete encasement of steelwork and brick panel walls.

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CHAPTER 18

BUILDING MATERIAL AND FIRE HAZARDS

1. **Introduction**

All building codes recognise several types of building construction. These have varying degrees of fire resistance. Most building codes, although there are some variations, classify five standard types of building construction. (The code used in Western States does not classify in this manner).

(i) Fire-resistive
(ii) Non-combustible
(iii) Heavy Timber
(iv) Ordinary
(v) Wood frame

These five standard types of building construction are defined in National Fire Protection Association Standard No. 220. Minimum performance standards are also established.

Older codes carried the classification of "fire proof building" but fire in many buildings ranked as fireproof gave vivid evidence that no structure is truly untouchable by fire. A fireproof building will contain combustible contents and some combustible components, such as wood trim, doors, and perhaps panelling. Given those structural members previously listed as fire proof were subject to some reaction if exposed to sufficient heat. For these reasons, the "fire proof" classification has been amended to "fire resistive"

2. **Fire testing of building construction and materials**:

In discussing types of building construction and building materials, a fire-resistance rating in terms of hours of resistance has been given. These ratings can be one hour, two hours, or many hours of resistance before the materials succumb to the effects of the fire. A natural question then arises: What are the criteria used to determine this rating?

In 1918, a conference of representatives from eleven technical sources met to formulate a rate-of-temperature-rise curve that would be indicative of the temperature reached at the normal fire. Many factors had to be considered. and of course, any standard derived would tend to be an "average", since many fires show a much smaller temperature rise and some fires exhibit a faster rise and higher temperatures.

Professor Ira Wool son, consulting engineer of the National Bureau of Fire Underwriters (NBFU), had a strong influence on the determination of the characteristics of the standard time-temperature curve. This curve is now used as the standard for testing building materials and components.

Some points on the time-temperature curve were judged to characterise the average fire and were established as the standard to be used in the testing of materials.

Heat of 1000°F at five minutes, which is above the average ignition temperature of the average room content.

Heat of 1300°F at ten minutes, which, it can be seen, is a very rapid temperature rise in the first ten minutes. At the end of ten minutes, average combustibles have been heated up enough for flash over to occur if sufficient oxygen is present. This fact indicates the importance of time to the firefighter and the need to arrive at the fire scene before the building and its contents can reach those temperatures. The first few minutes are critical. The fire may out speed the response.

Heat of 1550°F at thirty minutes, showing that the temperature rise has now levelled off some what, although it will continue to rise. Material that has not ignited at this time and at this temperature is said to have, at a minimum, a half hour fire-resistance rating.

The NFPA, the American Society for Testing and Materials (ASTM), and the Underwriters Laboratories, Inc. have published similar texts detailing the standard methods of fire testing of building construction and materials. The materials of components to be tested are subjected to controlled temperatures that follow the time-temperature curve for a duration of time equal to the specific period that the material or components are to be rated, or until the materials ignite.

The test specimen, under the time-temperature condition necessary for acceptance, must bear working loads and stresses to which the material will be subjected in field use. In addition, walls, floors, and roof must be able to retard the flow of heat through them so that cotton waste on the exterior side cannot be ignited by flame or gases, or so that the temperature rise on the unexposed side will not be more than 250°F.

An additional required test may be the application of a hose stream on a test specimen that has been subjected to the time-tempera true factor of one-half the rating period. Because of rapid cooling, there is possible structural failure of some materials that are struck with a hose stream even though they apparently can withstand the fire-endurance restrictions.

Observations on the completed tests will include structural behaviour or change in the tested material such as deformation, cracking. spalling (chipping or scaling), and smoke production.

3. **Types of construction**

With the understanding of how materials are tested and classified, a discussion of the five standard building types, as defined in NFPA Standard No. 220, is worthwhile.

Table 7-1 Fire-Resistance Rating of Structural Members in Hours Recommended in Fire Administration Report Standard No. 220.

Structural Members	Classification	
	3-hour	2-hour
Bearing walls or bearing portions of walls, exterior or interior (all bearing walls and bearing partitions must have adequate stability under fire conditions in addition to the specified fire-resistance rating).	4	3
Non-bearing walls or portions of walls, exterior or interior, must be non-combustible (NC). Fire resistance may be required in such walls by conditions such as fire exposure. location with respect to lot lines, occupancy, or other pertinent conditions.	NC.	NC.
Principal supporting members, including columns, trusses, girders and beams for one floor or roof only.	3	2
Principal supporting members, including columns, trusses, girders, and beams for more than one floor or roof.	4	3
Secondary floor construction members, such as beams, slabs and joists not affecting the building's stability.	3	2
Secondary roof construction members, such as beams, purlins, and slabs not affecting the building's stability.	2	1 ½
Interior partitions enclosing stairways and other openings through floors (One-hour non-combustible partitions may be permitted under certain conditions).	2	2

I. **Fire-Resistive construction:**

Fire-resistive construction requires that all structural members, such as walls, partitions, columns and floor and roof construction, are of non-combustible materials with fire-resistance ratings not, less than those specified in Table 7-1.

A clear understanding of these requirements is not possible without a definition of the term "non-combustible". The word has been applied to materials that will not ignite and burn when subjected to fire. It is well again to point out that this fire-resistive quality does not negate the possibility of structure failure the material is subjected to fire. Steel brickwork, and concrete, all non-combustible materials, provide the skeletal structural strength of the fire-resistant building. Yet they can fail structurally if exposed to sufficiently high temperatures for a long enough period of time. These same materials will fail even faster if struck by a hose stream after being subjected to the heat of a normal fire.

Curtain walls of brick and windows often complete the building facade. This type of construction has permitted building heights to rise higher and higher. Before his death in 1959, the noted architect Frank Lloyd Wright spoke of building the mile-high structure around a central supporting core of reinforced concrete.

A current trend is to the all-glass facade or a solid curtain walls unbroken by any opening. This new construction, although the most fire resistant to date, raises problems for the fire service problems that have yet to be completely resolved. There is the difficulty of getting to the fire floor-elevators are frequently tied upon other floors and emergency elevators are a rarity. Ventilation of the fire floor is a tricky and difficult task. Water supply must depend upon standpipes and adequate pressure to deliver

the water to the fire floor. Evacuation of the building's occupants is a slow and difficult task. Fire protection engineering recommendations are often by passed. There is a time lapse between the introduction of new building features and new building code ordinances.

The fire-resistive building need not be a sky scraper or a high-rise, however, there are many fire-resistive buildings that are only one or a few stories high, and many have low cubic-foot con tent. In these structures, it is the fire loading and occupancy that determine the possible fire severity.

B. **Non-combustible construction**

Non-combustible construction is that construction in which structure elements are of non-combustible materials, but which are not generally fire-resistive. This means that although the structural members will not burn, there may be a structural failure due to heat. This type of construction is identified by the exposed steel of the framing members. Structural columns and beams normally will be of structural steel. Enclosing exterior walls may be of curtain-wall construction. If columns and beams are covered for fire protection, they will be only those of the exterior walls. Ceiling and roof construction may be of steel open-web truss construction with roof covering of poured gypsum.

The inherent danger in the exposed steel non-combustible structure is the danger of structural collapse. When subjected to heat. steel beams can expand sufficiently to push out exterior wall. The steel beam or column that is under extreme heat of a fire has been known to buckle and collapse when struck with a hose stream or when the period of fire exposure is long enough.

While the building structure itself may be non-combustible, some components, such as doors, trim, or a grid type of ceiling with acoustical panels, may be combustible. Again, the fire-loading factor of the building contents may offer a high hazard potential. This type of construction may be employed in the shopping centre with high fire-load contents. An example at the other extreme is the metal-fabricating or metal-storage warehouse with only a small Occupancy fire potential.

III. **Heavy timber construction**

The bearing walls of heavy timber construction must be of non-combustible material with a minimum fire resistance of two hours and must remain stable under fire conditions. Non-bearing exterior walls must be non-combustible materials. Occupancy, fire exposure or other factors that can affect fire conditions can cause an increase in the two-hour fire-resistance rating of exterior bearing and non-bearing walls.

Columns, beams, and girders may be of wood. If they are, the columns must be of at least 8-inches timbers, and the beams and girders must be of at least 6 by 8 inches timbers. If not of wood, these members must be of a fire-resistant material carrying a one-hour fire resistant rating.

Subflooring normally is of tongue-and grove wood planking with a minimum 3-inches thickness. The finish floor is of 1-inch flooring laid at right angles or diagonal to the subfloor.

Beams and girders of roof-framing members supporting roof loads must be at least 6-inches in their smallest dimensions. Timber truss or arches may be used for roof-framing. Trusses or arches can be built up of smaller members not less than 3-inches of wood blocked solidly. but the overall dimensions of trusses must be a minimum of 4-

inches by 6-inches. Roof decking must be not less than a minimum of 2 inches in thickness.

Interior partitions around openings and stair ways must have at least a one-hour fire resistance rating.

Heavy timber or "mill", construction results in a "slow-burning" building. It is believed superior to unprotected non-combustible steel. The wood timbers can burn, but because of the heavy dimension, they must be exposed to fire for a long period before structural collapse takes place. The experienced firefighter can gauge the amount of char and burn and predict collapse before it occurs. Neither he nor anyone else can forecast whether structural collapse is imminent by an observation of the steel beam. Collapse can be instantaneous. The heavy timber mill-constructed building is exemplified by them loft type of building or the factory building of the early twentieth century. An inherent hazard is the open wooden stairway from floor to floor.

After World War II, a renaissance in building construction took place. Heavy wooden timbers of the size and length needed for heavy timber construction were difficult to obtain. Fire-resistant construction of reinforced concrete became prevalent for many types of structures and occupancies other than the high-rise. The era of the mill-constructed building, as known, was over. There was, however, a revival of heavy timber construction in the exposed glue laminated wooden-beam structure. Roof decking is of 2-inches planking and is left exposed. This "new look" is found in the typical A-Frame structure. in churches. and auditoriums, and in many other occupancies.

Building Framing or Western (Platform)

Building framing is no longer so prevalent as in once was but it still exists in the split-level type of house. In balloon framing, the 2 by 4 inches studding runs continuously from foundation plate line to the floor ceiling. Where the various levels occur a ledger board of 1-inch by 4 to 6-inches is notched into the studding to carry the floor joists. If the studding is not properly fire-stopped at the floor levels, this type of construction offers continuous path for fire travel to progress up partition walls or to cross over into ceiling joists and spread horizontally across the fire building. It is frequently this type of construction in the older, uninsulated home that evokes the firefighter's remark. "No matter where was opened up, there was fire".

In the western type of framing, the studding runs only from grade line, or floor line, to the ceiling line. The wall studding has a single bot tom plate and a double too plate that serves as a fire stop-unless it has been cut for the pipe or duct runs that service the building.

All standard and acceptable present-day methods of building construction fall into one of the five mentioned building construction types. There may be an interchange or a variation in form, but the finished structure can be classified into one of the five basic types. In essence, minimum standards quoted are performance-based criteria. Any material that can. meet the required fire resistance rating, that can perform the job required of it, may be used in the construction.

It then becomes a matter of aesthetics or material cost that determines the choice of material used. Thus, the use of new materials, developed within the private sector, is not dis criminated against once they are in compliance with the accepted standard fire tests.

Only the final test of time remains to be passed before the material takes its place in building construction history.

Temporary enclosures such as tents or air supported structures are not classified as buildings under the guidelines of NFPA No, 220. However, they do create fire protection problems involving both life and property. There is the ever-present hazard of collapse and entrapment of victims. This danger is compounded if fire is present. Many of these enclosures are used for public assembly, and their contents may be highly combustible. One example is the circus fire in Hartford, Commercium, in 1944 that took 168 lives.

The spread of fire

The normal path of fire communication is in an upward vertical direction. Heat and smoke have a tendency to rise as temperatures build up. Fire can burn its way upward much faster than it will burn through a floor and drop downward to a room below.

At the same time that it is travelling upward, especially if upward travel is blocked, it will travel in any direction horizontally. Wind velocity and direction, along with the construction and occupancy of the fire building, will determine the fire direction,

iv. **Ordinary construction**

Ordinary construction requires the same type of exterior wall construction, both for bearing and-non-bearing walls, as heavy timber construction, Roofs, floors, and interior partition framing is of wood, but of smaller dimension than the interior beams and timbers of the timber construction. Interior structural members may be exposed, but more typically, the construction of wood stud and joist is covered with lath and plaster, or dry-walls construction of panel board or sheetrock.

The heavy timber construction has no hidden stud or joist space. Beams are quite widely spaced and the bottom of the flooring serves as the ceiling of the floor below. The ordinary con structed building normally has well-stud spacing of 16-inches cantering and ceiling joist spacing of 16-inches cantering. When closed in. these spaces offer a flue way for fire travel through openings that have been cut for electrical conduits, plumbing stacks or pipes, or heating ducts. It is this type of construction that must be "opened up" to detect hidden fire.

Some commercial one-storey buildings of ordinary construction may have a truss roof. This roof is particularly vulnerable to fire and structural collapse. Roof boards are nominally 1-inch sheathing or ¾ inch plywood. Trusses are built up of small framing members; structural strength depends on the truss action. The smaller component parts of the truss are quickly consumed when exposed to fire and the entire truss then collapses, bringing portions of the roof down with it.

v. **Wood-frame construction**

When exterior walls, bearing walls, partitions, and floor and roof construction are of wood or other combustible material, the type of construction is known as wood-frame construction. This typical construction has exterior studding walls of 2 by 4-inches, or 2 by 6-inches, wood. The exterior normally is covered by ¾ inch sheathing boards. Modern construction uses ½ inch gypsum or ½ inch plywood for the sheathing coat. A finish of wood siding, plywood. aluminium, or plastic siding is the finish coat. Stucco, plaster, or a 4-inches brick veneer may also be used as the exterior coating.

Many older frame homes in the urban have been covered by a simulated brick or stone finish. This material is made of a wood fibreboard with a stone finish, simulating brick or stone, cemented on with asphalt binder. The radiant heat of an exposure fire causes the asphalt to liquify and drip.

Insulation that is in itself fire-resistant, such as the spun-rock or glass type of insulation, and that has been placed between studding or ceiling joists of the wood-frame or ordinarily con structed building, tends to retard the passage of fire. Some of the element contributed to the vertical spread of fire are :-

- Stairwells and escalators
- Elevator shafts Pipe shafts
- Conveyor openings
- Partitions

The goal of the fire protection engineer is to seal off each floor of a building making it a separated unit so that the passage of heat and smoke to upper and lower floors is stopped.

For this to be done effectively, all the vertical openings to the other floors may be enclosed with a fire-resistant material commonly used with the fire-resistant rating of the interior construction. Openings in partitions enclosing stairwells and elevator shafts must be provided with fire doors. A fire door is a door designed and tested to withstand a required fire-hour resistance rating, Pipe shafts and direct openings must be sealed off at floor and ceiling. Conveyor openings can be protected by a water-spray curtain or sprinkler head that is activated under fire conditions when protection in another structure is not feasible. Escalator openings should be enclosed as a stairwell. If an escalator exists in addition to enclosed stair well, it may be protected by a water-spray curtain.

Fire must be prevented from travelling horizontally over an uncontrollably large space by sub-dividing the large horizontal area with fire walls or partitions. A fire partition is a wall subdividing only one or several floors, it does not extend from basement through roof. A fire wall sub-divides areas enclosed by the exterior walls, but, in addition, it extends from basement-floor level through the roof and cover. Thus, flames breaking through the roof in one area cannot communicate to another portion of the roof without Jumping' the fire wall parapet. Exterior walls also extend above the roof line as a barrier to communication of fire by exposure.

Openings in these fire walls, or partitions to provide access to other areas within the exterior enclosing walls must be protected by fire doors. Large areas must be sub-divided into smaller areas so that they can become more readily controllable in the event of fire. Sub-divisions will depend somewhat on construction and occupancy. There are many case histories of fires that owe their large loss to the undivided large area. The General Motors fire in Livonia, Mishigan, encompassed a building spreading over three acres, all under one roof with no fire walls or partitions.

Although properly sub-divided with fire walls and partitions, unsuspected openings may present a hazard. Openings may have been made for the passage of pipes or ducts remodelling may have necessitated the breaching of a wall. In many instances, a common wall between two mercantile or industrial occupancies may be breached to provide a doorway.

So that the two occupancies can operate as one. If this opening is left unprotected, a natural path of fire communication in either direction is provided. An electrician or a plumber may have knocked an 8-inch or larger hole in a wall for a 1-inch pipe. The hole permits fire to communicate through the wall also. In setting joists on the wall, the carpenter may have permitted the joists of one section to butt up against the joists of the next. With no fire break between joists. fire can travel across when the joist burns.

In other cases, partitions on the floor may provide horizontal protection to fire spread, but the concealed space between ceiling and roof may have no sub-divisions. In the ordinary or frame type of construction, this area will contain much wood framing, particularly in the truss roof type of construction. Fire can spread quite rapidly in this space before it is even detected. and when detected, it is difficult to head-off and control. Many times, the building is "Lost" before fire in the space is detected. The NFPA Life Safety Code recommends a maximum of 3,000 square feet without a life-stop partition in attic areas.

It must be realized that the occupancy of the building will play a decisive factor in the spread of fire within that given structure. A good building code is cognizant of this and will not permit more hazardous occupancies in a structure of low-hour fire resistance rating. Neither will it allow life to be endangered by permitting large groups of people to be housed nor gathered in the low-hour-fire-resistance-rated structure.

Occupancies have been classified and a correlation between construction and occupancy needs can be established.

4. **Classification by occupancy**

NFPA standard No. 101. Life Safety Code. 1967 edition, also classifies occupancies and hazards of contents. The following guidelines are in the main from this code:

(i) **Assembly**: Crowd attendance by persons voluntarily and not usually of a fixed attendance. Usually able-bodies persons not subject to discipline and control, with inherent panic hazard in an emergency. Fifty or more persons gathered for worship, entertainment, amusement, or awaiting transportation, for example, in churches, theatres, bowling alleys, passenger stations.

(ii) **Educational**: Group attendance of a fixed and regulated nature subject to discipline and control, as in schools, colleges, kin derogate, vocational and commercial institutes and tutorials etc.

(iii) **Institutional**: Eating and sleeping facilities; care of the sick, young, aged, and physically or mentally handicapped penal and corrective incarceration. Specifically, Health care facilities, including hospitals and nursing homes; Residential facilities including custodial care, nurseries, and homes for aged or mentally handicapped. Residential institutions, providing res trained care in jails, reformatories.

(iv) **Residential**: All normal residential purposes with sleeping accommodations other than institutional. Sub-groups include:

- Apartments
- Dormitories (orphanages)
- Lodging or rooming houses
- One-and-two-family dwellings

(v) **Mercantile**: Stores, markets, and other locations for the display and sale of merchandise, including supermarkets. shopping centres, departmental stores, neighbourhood grocers.

(vi) **Business**: Buildings used for the transaction of business (other than mercantile) accounts or record keeping, and so on, included are doctors, dentists, libraries, banks, laboratories, archives, record room, research establishments. test houses and computer installations etc.

(vii) **Industrial**: Manufacturing, processing assembling. packaging, repairing of various processes and products and other activities performed in factories. laboratories, refineries, and similar locations.

(viii) **Storage**: Storage of goods, merchandise, vehicles, housing of animals, ware houses, garages, freight terminals, grain elevators, and similar structures.

(ix) **Hazardous**: Buildings used for storage. handling, manufacture and processing of highly combustible explosive materials.

5. **Content-hazard classification**

The process or material of any given business may offer a hazard peculiar to that particular manufacturing process or material substance. This hazard can be given a broad classification index as a guide to the inherent fire potential:

(i) **Low-Hazard Contents**: Non-combustion or low combustion, so that self-propagating fire cannot occur. Evacuation might be necessary because of smoke, fumes, or an outside source of fire.

(ii) **Ordinary-Hazard Content**: Combustion of moderate rapidity with considerable smoke, but no poisonous fumes or explosion.

(iii) **High-Hazard Content:** Combustion of extreme rapidity or poisonous fumes or explosion hazard in attendance with the fire.

6. **Surface-burning tests of building materials**

The spread of fire across the exposed surface of a combustible material has a direct bearing on the extent and severity of the fire and plays an important role in life safety. Many cases can be cited where loss of life was attributable to the rapid spread of flame and heat over the finished walls and ceilings of the fire building.

Various factors contribute to the flame spread. The thickness and texture of a material. Its composition, base materials, and the combustible vapours generated all are instrumental. These characteristics can be tested and classified. Again, standards derived by the NBFU, the NFPA and the ADTM are the criteria for classification of surface burning materials.

The medium is the tunnel test. The tunnel is a test chamber 17½ inches wide, 12 inches deep. and 25 feet long. The material to be tasted is fastened to the top surface of the tunnel. A gas flame is initiated 8 ½ feet from one end. The gas flame is so adjusted that a test sample of red oak flooring has a flame spread of 19 ½ feet in five and one half minutes. This sample is given a classification of 100. ¼ inch asbestos cement board is similarly tested and given the classification of 0.

The test specimen is then tested to see whether flame propagates along its entire length, and if so, to determine the time necessary to do so. If the flame goes not spread the 19 ½ feet in ten minutes, the test is stopped and the distance of flame spread is measured. From these measurements a flame-spread classification in relation to the standard of red oak can be determined.

In brief a flame-spread rating of less than 100 means that flame spread is slower in test specimen than in red oak that is, the flame spread is less than 19 ½ feet in ten minutes.

Other characteristics, such as the amount of smoke generated, and the toxicity, also are measured. The valuation report will include observations on delamination, shrinking, sagging, and so on.

Under the specifications of this testing method, five classifications for interior-finish materials have been established.

Class A. Flame Spread	0	-	25
Class B. Flame Spread	25	-	75
Class C. Flame Spread	75	-	200
Class D. Flame Spread	200	-	500
Class E. Flame Spread	over	-	500

Various codes change the class flame-spread rating slightly. However, life safety considerations make it mandatory that all exits and exit ways have interior finish of low flame spread Class A. In other occupancies where people live or gather in large numbers, Class A should also be required. In occupancies that are only partially occupied with smaller grouping of people. Class B or Class C may suffice.

7. Summary

Broadly speaking, buildings may be grouped in five classifications relating to their fire potential:

(i) Fire-resistive
(ii) Non-combustible
(ii) Heavy timber
(iv) Ordinary
(v) Wood-frame

Occupancies of buildings and the hazard of their contents can be classified. A correlation can then be made in the building code between the hazard of occupancy and contents and the fire-resistance rating of the structure housing the occupancy.

Occupancy classifications are:

Assembly	Office
Educational	Industrial
Institutional	Storage
Residential	Miscellaneous
Mercantile	

Fire will always tend to travel upward primarily and also to adjacent rooms or combustibles on a horizontal path, particularly where upward travel is impeded.

Fire prevention measures must consider means of blocking off the spread of fire vertically and horizontally. The spread of fire can be slowed primarily by:

(a) Limitation of fire areas
(b) Fire doors and fire walls
(c) Closing of vertical and horizontal means of communication.

The standard time-temperature curve is the guideline used in fire testing of building construction and materials.

Materials or components of construction that are tested, are subjected to controlled temperatures that follow the rate-of-temperature rise curve to the specific hour for which the materials are being tested. The materials being tested must be under working loads and stresses to be borne in actual field use. Other specialized criteria may be added for certain materials.

The surface burning characteristics of building materials are determined in the tunnel test, a test that gives an indication of the spread of flame propagation over the surface of the material being tested.

A comparison is made with the flame-spread characteristics of red oak and a rating given. A rating less than 100 means that the flame spread of the rated material is slower than that of red oak. A rating over 100 means that the flame propagates faster than it does with red oak.

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CHAPTER 19

FIXED FIRE FIGHTING INSTALLATION

1. **Introduction**

The importance of an early warning of an outbreak of fire cannot be exaggerated. Most fires could be extinguished without difficulties if they are attacked by suitable personnel and appliances in their early stages. Every minute of delay increases the likelihood of the fire grown into one which cause extensive loss or even of it getting out of hand. First aid appliance are intended to be used in the very early stage of fire and are invaluable as their timely use has prevented the development of countless fires. Because of the need for them to be portable and readily handled, their capacities is limited and they are ineffective once a fire has grown. To ensure fire extinction even beyond the scope of First aid appliances, Fixed installation like hose reels, hydrants, wet risers, sprinkler installation, foam installation CO_2 installation, steam installation etc. are provided.

All occupants of premises should be instructed in the use of First aid appliances as are installed there. It is too much to expect that, in the excitement of an outbreak of fire, people who are not familiar with an extinguisher will read the instructions and apply them intelligently and confidently. An annual inspection time provides an excellent opportunity to demonstrate how the appliances should be used. Installed equipment's are divided under two main heads:

(a) Hand appliances, such as buckets, hand pumps, extinguishers etc. not connected to a piped water supply and

(b) Fixed installation, such as hydrants, hose reels, wet and dry risers, Foam installations, CO_2 Methyl-bromide or steam, which may either be available at any time or available only on outbreak of fire.

2. **Installation of Hand Appliances**

(i) One unit of extinguishing media is to be provided for every 600 m² of floor area or part thereof.

(ii) There should be minimum of two units for each floor.

(iii) Depending upon the Risk, suitable type of equipment and extinguishing agent, shall be provided.

(iv) The person who supposed to use it should not normally be required to travel a distance of more than 15 meters from the site of fire to reach the extinguishers.

(v) Extinguisher should be sited in conspicuous position readily accessible for immediate use, preferably near to room exits or on staircase landings.

(vi) It is unadvisable to position them at the and of the room, remote from exits unless to protect a particular hazard located there.

(vii) One or more extinguisher should be within easy reach to deal with any special risk but should not be placed so close to such risk that they may be inaccessible in the event of fire.

(vii) In buildings of uniform design, extinguisher would be sited in similar position on each floor.

(ix) Extinguishers should be fitted on wall brackets or shelves in such a way that the base of each appliance is 1000 mm above ground level. Best is to cut wall portion and insert the same so that it will not cause any obstruction in the normal passage.

(x) Extinguishers liable to freeze when exposed to temperature below 40°C should be given adequate protection against post. The enclosures should be painted red, permit easy access to the appliances and be conspicuously marked in white letter "**FIRE EXTINGUISHER**".

3**. Fire Bucket**

The most ordinary equipment is the fire bucket which can be used by any person. One 5 litre fire bucket shall be provided for every 100 m² or part thereof with a minimum of four buckets on each floor of the building. Fire buckets are painted red and sometimes provided with lids. Some have round bottoms with the object of preventing its ready use for purposes other than firefighting. Sometimes the most of buckets are stored in a tank of water. the buckets being so arranged that each is withdrawn, it is automatically filled with water. Where use of water is not recommended, the buckets are filled in sand or foam producing liquids, stored in two compartments.

4. **External Hydrants**

Private hydrants generally installed in large premises with extensive yards, sides etc, where the nearest street hydrants is at a considerable distance, from the building to be protected. They are connected with the piping, supplying water etc. to the buildings to a separate branch from the town's main, or to a ring main usually connected to the town's main at two points.

5. **Internal Hydrants**

Hydrants inside the building are often situated on the valves, or they may be placed around the walls of a building, then they are called wall valves. They consist of an outlet from the water main to which hose can be coupled and controlled by a wheel operated valve which should be indicated the direction to twist the wheel in order to open the hydrant. The construction of the valve is similar to that of external hydrants but, of course, no stand pipe is required, a branch pipe and a length of hose are usually placed near the hydrant. Sometimes the hose is permanently connected to avoid delay in operation but, as it is difficult to prevent seepage of water which would be liable to cause the canvas hose to rot and so it is better to keep it unconnected. A convenient and satisfactory method of storing hose is to flake it in a cradle which can swing from side to side to enable the hose to be twist out easily in any direction. The branch pipe is ready to couple to the hose.

6**. Hose Reels**

Mounted on a hallow rotating shaft, to the centre of which water is fed through on stuffing box gland, the tubing being connected to an outlet on this rotating shaft. Rubber tubing of ¾ or 1" diameter is employed, length usually 60.75.100 or 120 feet and a light branch with a shut-off nozzle is invariably fitted to operate, all that is necessary is to turn on the valve, grasp the branch and pull the necessary quantities of tubing from the reel, opening the shut-off nozzle, when the fire is reached. The height of the bracket shall be 135 cm or 4.5 feet from the floor level.

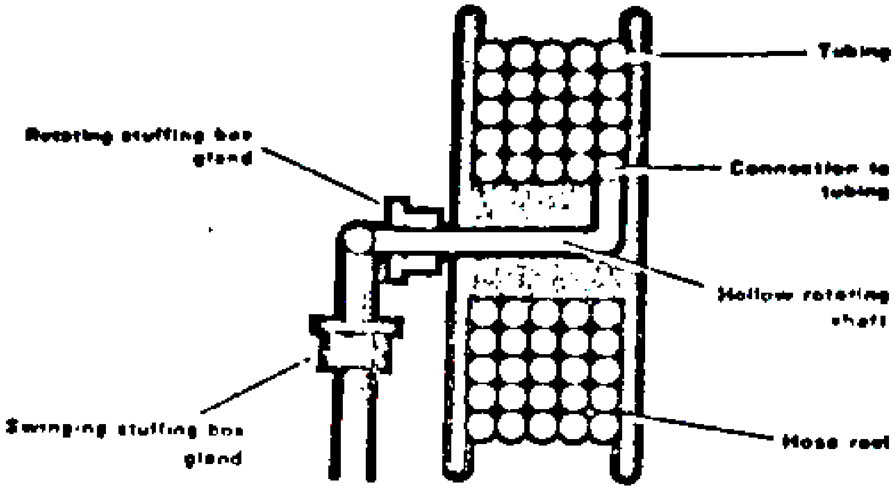


Fig : Diagram showing the construction of a typical hydraulic hose reel

A metal plate showing in clear legible letters. the instructions for operating the first-aid hose reel shall be fixed preferably near the bracket. The hydraulic hose reel, installed in modern buildings. have a advantage that valve is automatically opened out and be brought into action after the required amount of tubing pulled off. Hose reels are sometime provided with fixed metal cover to prevent them collecting dust and to protect the rubber tubing from deterioration.

7. **Rising Mains**

A rising main consists essentially of vertical piping usually of 4" diameter and most commonly installed on the staircase of a building and has outlet at each floor. Rising Mains are of two principal types.

(a) wet risers;
(b) dry risers.

(a). **Wet Risers**

A pipe, generally of 4" diameter, rising vertically through a building and kept permanently charged so that water is immediately available for use on any floor, at which a hydrant is provided. This is connected to a town's main of suitable capacity. A central valve being provided at the junction to enable water to be shut off, if required. A fire service inlet may some times be found fitted at the foot of the main, to pump additional water if required.

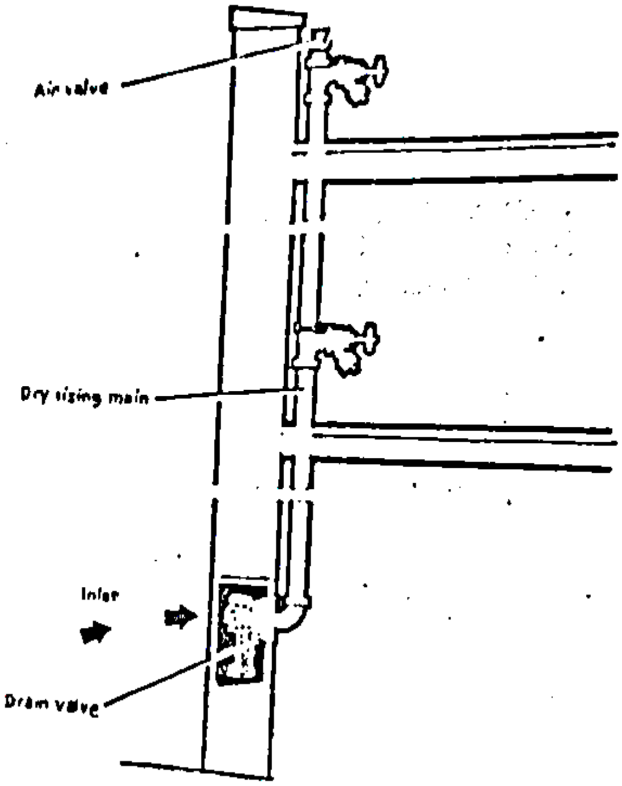
The size of the main and the pressure should be regulated in such a way, as to have required pressure at the highest outlet to produce four 13 mm jets at a nozzle pressure of about 2.5 bars.

Down Comer

Similar to wet riser but supplied with water from a tank in the roof or at intermediate levels.

(b). **Dry Risers**

A vertical pipe, normally kept empty, not connected to a town's main, but is charged with water when required, by means of Fire Service Pumps. It possesses several advantages over an ordinary line of hose. A fire on the top floor may be attacked without any loss of time and it has a considerable greater water capacities than 2 ½” or 2 $^{3}/_{4}$” hose and obviates the risk of water damage. It can also be used to feed branches at or near the roof level covering a fire. in an adjacent building.



An Air Valve

It is generally fitted at the highest point in the pipe to allow the contained air to discharge to atmosphere, when the riser is charged with water, as otherwise, air in the riser might be compressed in the upper part of the pipe and prevent it being fully charged. It can also admit air to the pipe, when it is drained after use and prevent the formation of pockets of water trapped inside.

8**. Sprinklers**

A sprinkler installation comprises a system of inter-connected pipes into which sprinkler heads are fitted on a definite basis of distribution viz. 8 to 10 feet apart according to the nature of risk. The pipes are supplied with water under pressure. The heads are so constructed that the heat arising from fire will cause them to rupture, thus permitting the water to discharge in the form of spray at the seat of outbreak.

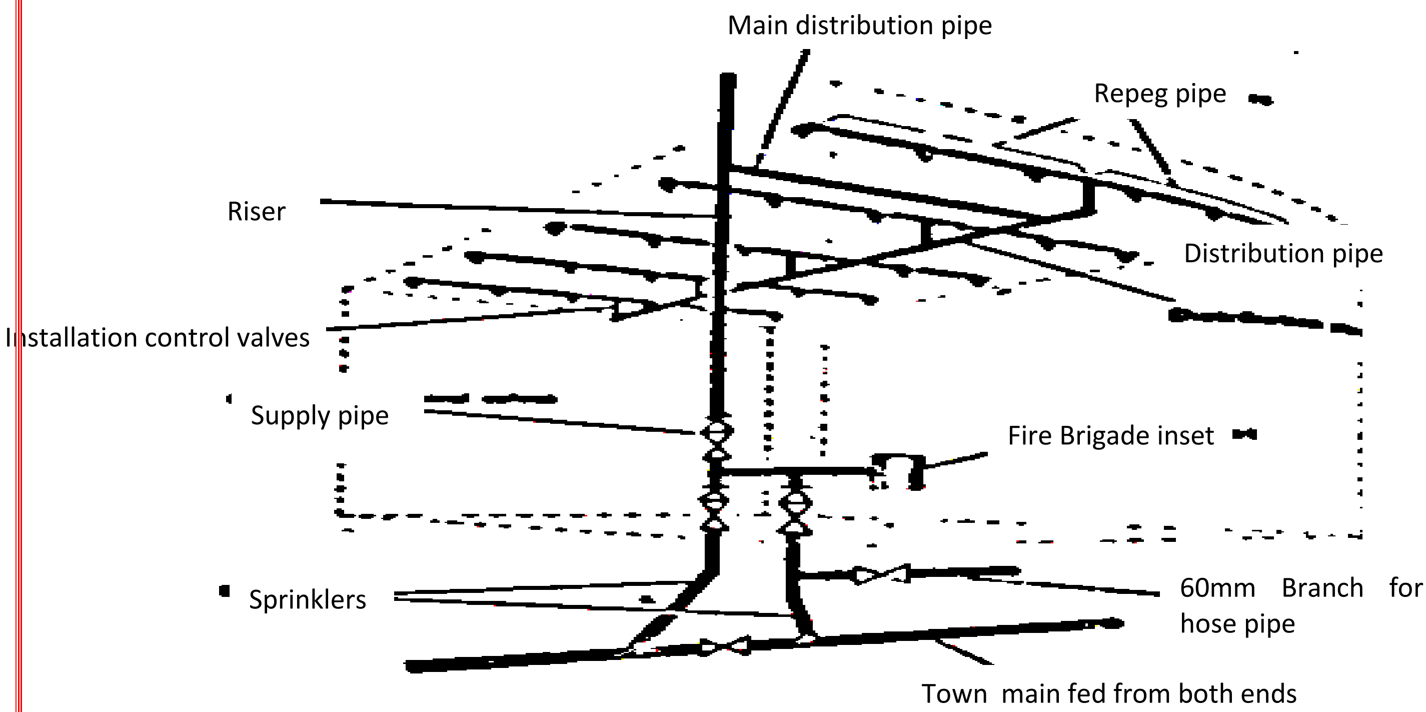


Fig : Diagrammatic layout of the pipework of a sprinkler installation

1. **Functions**

Sprinklers are installed inside a building and operate automatically when a fire occurs. Their main functions are:

(a) to detect a fire
(b) to sound an alarm
(c) to attack the fire
(d) to restrict the spread of fire.

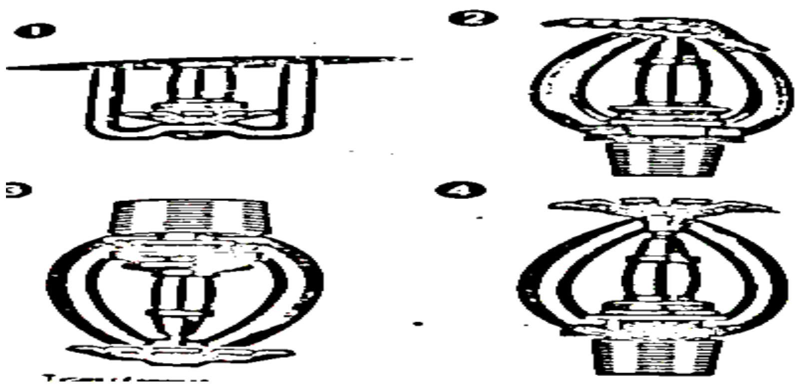


Fig: Types of sprinkler (1) Celli g flush pattern (2) Sidewall pattern (3) Pendent type(4) Dry upright line

(9) **Types of Sprinkler Systems** :

There are six types of standard sprinkler system they are:

(a) Wet Pipe
(b) Dry Pipe
(c) Alternate wet and dry pipe

(d) Tail-end dry pipe (used in conjunction with a or b)
(e) Tail-end alternate (used in conjunction with al
(f) Pre-action In addition to these, there is also what is known as the deluge system.

(a) **Wet Pipe System**

In this system, the commonest and simplest In general use, all the pipes that lead from the water supplies through the various controlling valves to the sprinkler heads throughout the building are kept permanently filled with water. Wet pipe systems are installed in premises where there is no danger at any time of the water is the pipes freezing.

(b) **Dry Pipe System**

This type of system is only allowed in buildings where the temperature conditions are artificially maintained close to or below freezing point, such as in cold or cool stores and fur vaults or where the temperature is maintained above 70 °C, as in drying ovens. The pipes are at all times kept charged with air under sufficient pressure to hold back the water. The con trolling valves of a dry pipe installation comprises a main stop valve, as in wet pipe system, and a differential air valve, which is a substitute for the alarm valve in a wet system.

Maximum Number of Sprinklers

Dry pipe systems are so designed that the number of sprinkler controlled by one set of valves does not exceed the limits laid down for this type of system. The sprinkler must be installed in the up right position above the range pipe, although an exception to this may be allowed if approved dry pendent pattern sprinklers are installed.

Numbers of sprinkler permitted on alternate wet and dry pipe system controlled by one set of valves.

	Extra light hazard system	Ordinary/ or extra high hazard system.
With accelerator or exhauster	250	500
Without accelerator or exhauster	125	250

(c) **Alternate Wet and Dry System**

This system usually installed in premises without adequate artificial heating where the water in the pipes of wet system would be liable to freeze during cold weather. It usually operates on the wet principle in the summer and the dry principle in the winter. When functioning on the wet system the valve is either changed over or placed out of commission and the system functions as a wet system changing the system from one method of operation to the other can be affected quickly.

(d) **Tall-end Systems (Dry Pipe or Alternate)**

These systems are essentially similar to those previously described, except that they are of comparatively small extent and form extension to standard sprinkler installation. They are permitted.

(i) As extensions to a wet pipe system in comparatively small area (a) where there. is possible frost danger in an adequately heated building, and (b) in high temperature areas on stoves. The tail-end would be on the alternate wet and dry pipe principle in the case of (a) and on the dry pipe principle for (b).

(ii) As extensions to an alternate wet and dry pipe system in high temperature areas or stoves, when the tail end system would be on the dry pipe principle.

Sprinklers in tail end systems must be installed in the upright position above the lines of pipes, an exception being if approved dry pendent pattern sprinklers are installed. The number of sprinklers in a group of tail end systems controlled by one set of wet pipe system or alternate wet and dry pipe system valves, must not exceed 250 in the aggregate. with not more than 100 sprinklers on any one tail end system.

(e) **Pre-action system**

A pre-action system is a combination of standard sprinkler system and an independent approved system of heat or smoke detectors installed in the same areas as the sprinklers. In general, heat or smoke detectors operate prior to the sprinklers and so a pre-action valve will open to allow water to flow into the sprinkler pipe work before the first sprinkler operates. The sprinkler system pipe work is normally charged with air under pressure and is monitored so that an alarm is given on reduction of air pressure.

(f) **Deluge system**

The deluge system has been designed primarily for special hazards, such as polyester and polyurethane foam-making machines, drying section of a hard-board plant, fire work factories, aircraft hangers, etc. where intensive fires with a very fast rate of fire propagation are expected, and it is desirable to apply water simultaneously over a complete zone in which a fire may originate. This is a system of open sprinklers controlled by a quick-opening valve. operated by approved heat detectors or sprinklers, installed in the same area as the open sprinklers.

Quartzoid bulb detectors are mounted in an independent pipe work system contains com pressed air, so positioned that wherever a fire may originate, one at least will operate and allow the compressed air in the pipe work to escape. This causes a rapid fall in pressure on the diaphragm in the automatic deluge valve, to which both systems of pipe work are connected. The movement of the diaphragm causes the deluge valve to open and water to discharge through the projectors.

9. **Drenchers**

While a sprinkler system protects a building from internal fire, drenchers are placed on roofs and over windows and external opening to protect the building from damage by exposure to fire in adjacent premises.

A drencher system is comprised of water heads somewhat similar to those of sprinklers: these may be sealed or unsealed (open drenchers), but in the latter case the water is turned on manually. In a few instances drenchers may be controlled by quick-opening valves one rated by loss of air pressure in a detector line system in a similar manner to high velocity water spray systems.

Drenchers are of three main types.

(1) Roof drencher
(2) Wall or curtain drench
(3) Window drencher.

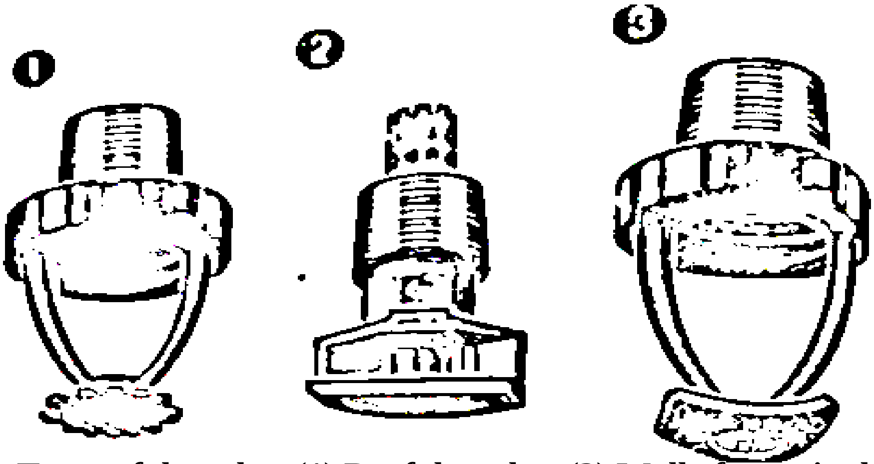


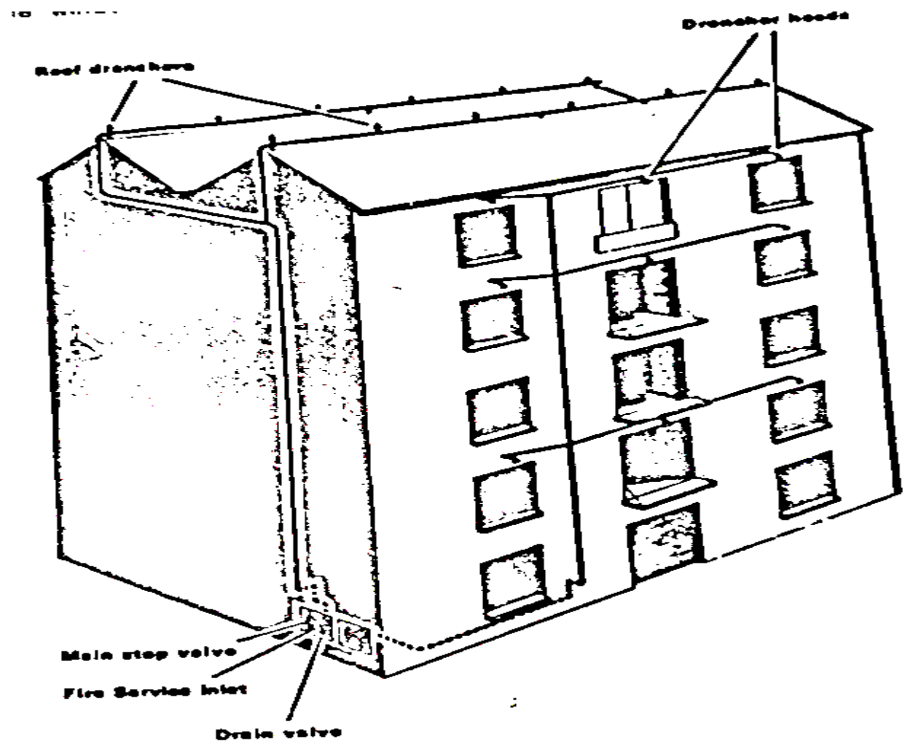
Fig: Types of drencher (1) Roof drencher (2) Wall of curtain drench

(a) **Roof Drenchers**: Roof drenchers have a deflector rather similar to that of a sprinkler head. From the roof ridge they throw a curtain of water upwards which then runs down the roof. All parts of the roof and any skylights, windows or other openings must be protected.

(b) **Wall or curtain Drencher**: Wall or curtain drenchers throw water to one side only of the outlet in the form of a flat curtain over these openings or portions of a building most likely to admit fire. The drenchers must be fitted so that the streams form a water curtain which must come in contact with the window 600 mm from the top.

(c) **Window Drenchers:** As their name implies, window drenchers are used to protect window openings. They are placed horizontally level with the top of the window, with the deflector 100 mm from the surface of the wall providing a curtain of water to protect the glass. From the tail of the deflector, a jet is thrown inwards on to the glass near the top of the window, while two streams are directed at an angle of 45 degrees to the lower corners.

Spacing of drenchers heads: Drenchers fitted on the top row below the eaves and those on the apex of the roof, must have maximum horizontal spacing of 2.5 metres. Windows or other openings, or combustible materials in walls exceeding 2.5 m in width must be protected by two or more drenchers not more than 2.5 m apart, and not more than 1,25 m from the window jambs. Windows separated by not more than 600 mm of incombustible material may be treated as one window. Not more than 12 drenches may be fixed on any horizontal line of pipe and not more than six on one side of the vertical feed pipe.



Roof drenchers
Drencher heads
Main stop valve
Fire Service inlet
Drain valve

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CHAPTER 20

HOSE FITTINGS

1. **Object**

Medium of extinguishment in majority of the fires is water. The mode of application may vary depending upon the types or kind of fire viz: jets, spray, fog or foam.

As water is the most clean and easily available matter, fire services all over the world use it extensively. Water for fighting fires has to be taken from the source, conveyed on the scene of the fire and delivered in the desired mode or shape.

Rarely do we get water right where it is required. It is drawn from the source, pressure imparted if necessary, and delivery hose helps to carry it to the scène of fire. To join such hose lengths, to help us adapt ourselves to situations present at fires, to select the most suited method of applying water on to the fire are in any way useful for such purposes. A variety of equipment are being used, which will be dealt in this subject under the heading of "Hose Fittings".

2. Fittings: In order to enable the various types of hose fittings to be grouped, they are dealt in the following order:

(i) Couplings
(ii) Branches and nozzles
(iii) Collecting heads and Suction hose fittings
(iv) Breechings
(v) Adaptors
(vi) Miscellaneous hose fittings and
(vii) Hose ramps.

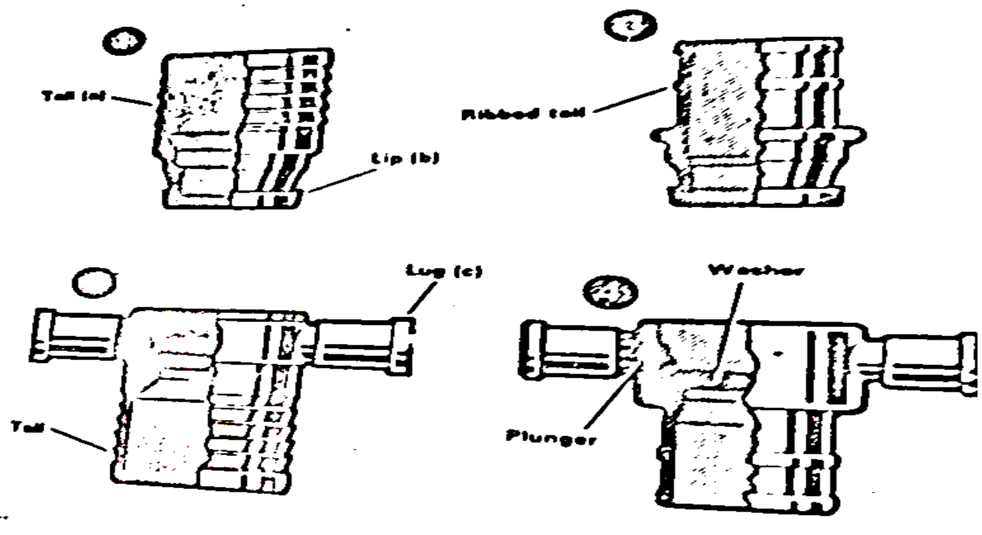


Fig: Standard instantaneous hose couplings (1) Male with multi serrated tail (2) Female with multi serrated tail (3) male with ribbed tail(4) female with ribbed tail.

(i) **Couplings**: Couplings are metal fittings used for joining two lengths of hose together, or a hose to an apparatus or vice versa. They are fitted to either end of hose lengths used for suction or delivery purposes and are grouped as follows:

Couplings

Threaded | Interlocking

"Round" Threaded | "V" Threaded | Instantaneous | Sure lock | Bayonet | Hermaphrodite

All couplings are always a pair i.e. in two places, one of which is termed to "male" and the other "female" and differ in shape and function except in the hermaphrodite, in which, each the pair are similar in shape and function. Instantaneous couplings are now standard fit tings in India for delivery hose and pump outlets, whereas threaded (round) couplings are used for suction hose and pump inlets.

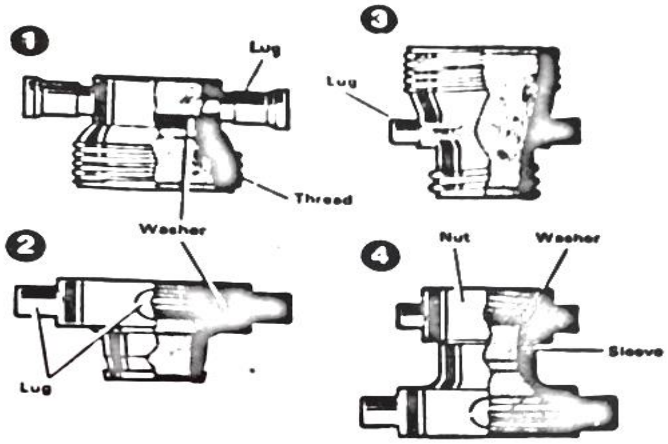


Fig: Screw type couplings (1) round thread male (2) round thread female (3) "V" thread male (4) "V" thread female .

(a) **Interlocking type**:-There are three types of coupling, of which the most extensively used is the instantaneous type. All standard instantaneous female hose couplings are fitted with two pull-release spring-loaded plungers while standard female couplings on pumps and standpipes outlets are fitted with a single twist release spring-loaded plunger.

To enable these couplings to be disconnected under pressure of water, pressure release types of coupling have been developed by which the necessity to pull apart directly the cap is obviated by introducing a pair of rollers which act by partly rotating the cap.

Component parts of Interlocking Couplings

(1) **Instantaneous Type:**

Male: 1. Tall (Serrated). 2. Lip (with a squared-off-tooth edge to grip the plunger in the female coupling. 3. Rounded flange (which assists in making a good joint)

Female: 1. Tail (Serrated) 2. Two hollow lugs (Diametrically opposite) 3. Spring loaded plunger (with cam shaped tooth), 4. Stop nut: 5. Cap (with externally enlarged knurled rim). 6. Metal disc, 7. Spring, 8. Washer.

These may be pull-release as in hose, or twist release as in pump deliveries and hydrant standpipes.

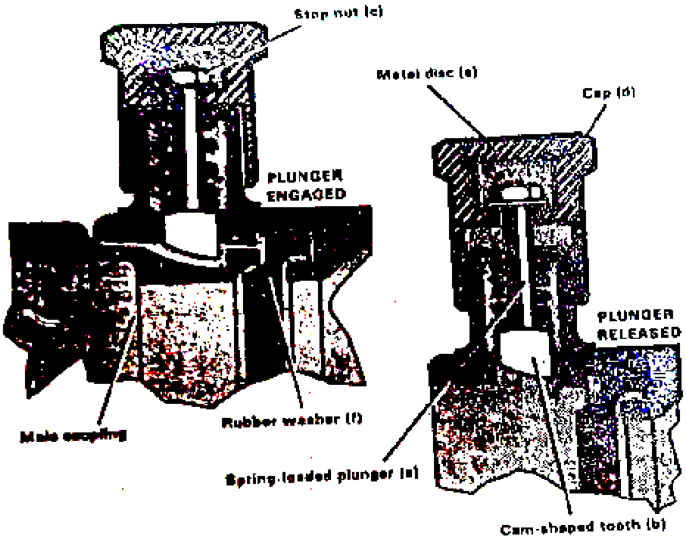


Fig: Sketch showing the principal parts of a female instantaneous coupling

(II) **Sure lock or Bayonet Coupling** :

Male: 1. Tall (Serrated). 2. Wide Flange around which are three regularly spaced semi-circular indentations. 3. Three lugs.

Female: 1. Tall (Serrated) 2. A heavy collar slightly stepped back in two steps towards the tail, 3. Squared boss protruding from the collar, 5. Holding Nut (with its head towards the shank end). 6. Three equidistant lugs inside the orifice of the coupling and 7. Rubber washer.

(III) **Lugged or Hermaphrodite or "Nunan Stove" coupling:**

As its name implies, both parts are identical and is the one case where no reference is made to male or female coupling. Each part consists of (1) Tail (Serrated), (2) Two diametrically. opposite lugs on a collar. (3) Squared indentations. (4) Two tapering flanges, (5) Lugs.

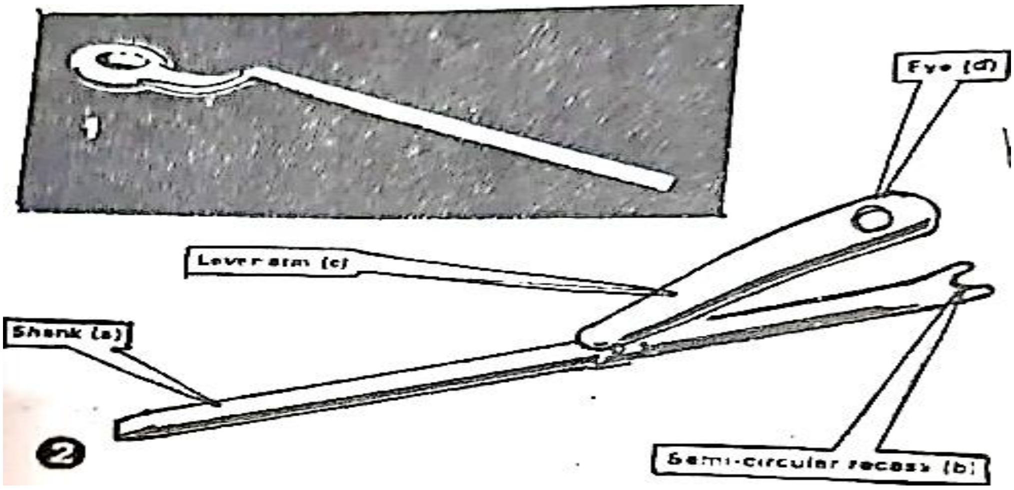
(b) **Suction Hose Couplings (Threaded)**

These couplings are similar in principle to the screw thread delivery hose coupling. The thread normally Round Thread has three turns to the inch (2.54 cm) and the number of turns varying between four and six according to the nominal size of the coupling. This type of thread is used on 3" (76 mm), 4" (102 mm). 5 ½" (140 mm) and 7" (178 mm).

Suction couplings of other sizes, some having 'V' threads, are also to be found on small pumps.

Component parts:

Male: 1. Tail (serrated), 2. Two fixed lugs and 3 Externally threaded end. Female: 1. Tail (serrated). 2. Nut (threaded inside), with four lugs. 3. Sleeve, 4.Washer (leather or composite).



Note: The coupling threads should be kept lightly greased with graphite grease.

(c) **Suction Coupling Wrenches**:

(i) A pair of tools used for the purpose of tightening the suction hose couplings air tight. This is necessary, as a leak, however small would allow air to enter and make it impossible to obtain the necessary pressure drop to lift water. A suction wrench consists of a short length of steel bar, about 9 inches (23 cm) long. one end of which is beaten flat and shaped into a semi-circle to fit the size of the suction on which it is to be used. An eye is provided at the shaped end for engaging the lugs of the couplings and care should be taken to use the wrench in the correct way. so that, its curve follows the coupling. This type of suction wrenches are called as conventional type suction wrenches. There is another type of suction wrench which is known as universal type suction wrenches, which will fit all sizes of suction hose couplings. Its parts are named as (1) Shank, (2) Lever arm with an eye, (3) Semi-circular recess at the lever end.

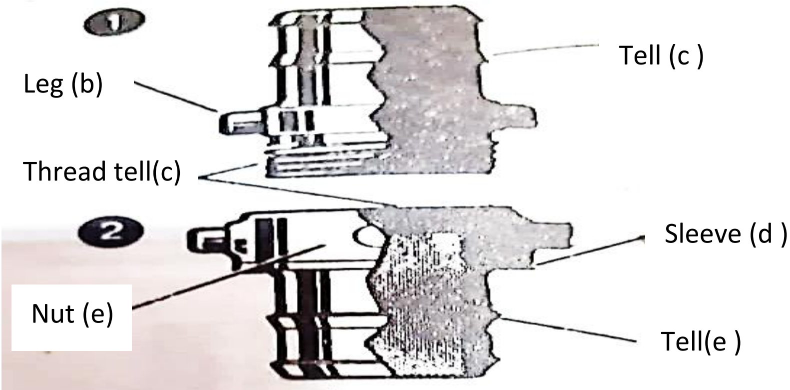


Fig : Suction coupling (1) male coupling (2) female coupling

(ii) **Branches, Nozzles and Branch Holders**: Branch pipe or branch as it is now generally called is tapering metal fitting, used at the delivery end of a line of hose for slowly narrow Ing down the area of the water-way, thus causing the water on the outside to move more quickly, and attain the same speed as the inner core. It consists of a brass pipe or copper pipe. the length of which varies according to its type of manufacture. It has male instantaneous coupling at the base to receive the hose and a male threaded end of smaller diameter (since the shape is tapering) at the top for the nozzle to be screwed in. There is also, a washer to make the connection water-tight. So, the general idea of the branch is to increase the velocity of water and may be defined as a metal fitting between hose and the nozzle, that converts pressure energy in to velocity energy, to provide the nozzle a solid jet for fire-fighting. The diameter measurement of the orifice or the nozzle is that by which the size of nozzle and jet are known.

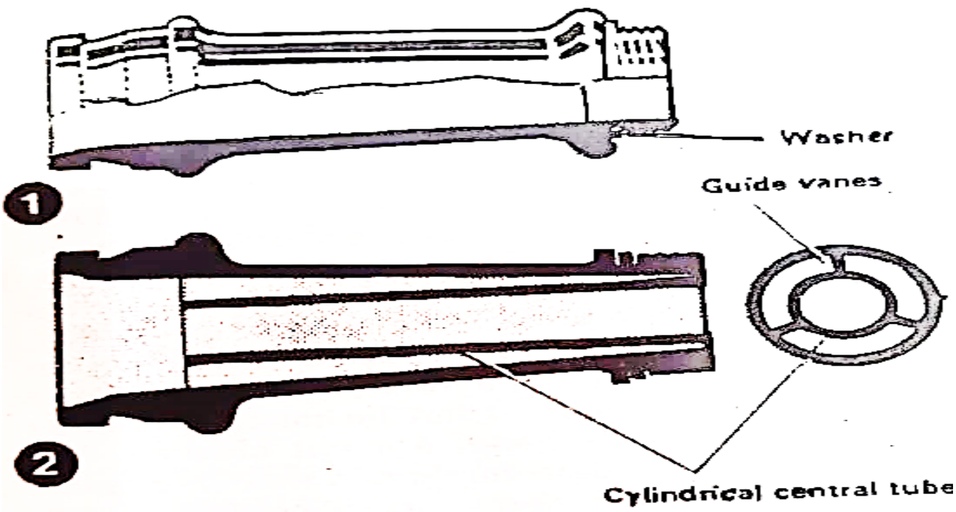
Classification of Branches: Branches may be divided into two principal classes:

(a) Those that yield a fire stream in the form of a jet which cannot be controlled by the branch operator.

(b) Those that provide some form of control for shutting off the jet, altering its shape or size, or changing its character, g converting into a spray.

(a) **Branches and Nozzles giving a jet not controlled by Operator**:

(i) **Emergency Branches or short Branch or Standard Branch**: It is sometimes known as short branch and is only 8” (20 cm) in overall length for the round or "V thread type or 8.25" (21 cm) for the instantaneous type. It consists of a solid brass casting the approximate weight is 4½ lbs. (2 kg) for threaded type and 3 lbs. 10 oz. (1.54 kg) for the instantaneous type is robust in construction and it can withstand rough treatment.



(ii) **Stream-form Branch:** It is similar to the short branch in outward appearance, but internally, is fitted throughout its whole length with a cylindrical centre tube, open at both ends and of 1" (25 mm) diameter held in position by three longitudinal guide vanes. The advantage is that it gives a more solid jet. Theory is that speed of flow of water in hose is greater in the centre than at the boundary where there is friction with the wall. As the cross-section area of the central tube does not diminish, the velocity of the tapering of the water which travels through the centre tube must be the same at the end as in the beginning. The velocity of the slower moving water in contact with the walls of the hose is greatly increased in the branch owing to its tapering shape, and on reaching the nozzle actually travels faster than the central core held together by a faster moving other sheath of water which tends to come along with it, the friction of the particles holding the whole together and giving a solid jet. This branch is usually of much the same length as short branch.

(iii) **Twin or Siamese Branch**: This type of branch consists of a relatively long branch bifurcated at the lower end, each leg terminating in a coupling for attachment to a line of delivery hose. Then it is fed by twin line of hose. With this branch, it is possible to deal with greater quantities of water than is possible with a twin branch fed by single line hose. Jet from it can reach greater heights than a single branch can reach. Its high-pressure jet can be used for collapsing building walls etc. in dangerous condition.

(iv) **Extended Branch**: It is sometimes used for fires involving grain, coal hay stack etc. They are made of varying lengths and sizes from copper, brass or other metal to suit particular requirements.

A typical branch for dealing with coal stacks and bunkers consists of steel piping usually 10 ft. (3 m) in length and 2 ½ ins. (63 mm) in diameter, having at one end a pointed head with a number of $^{1}/_{8}$ inch (3 mm) holes on it, and at the other end, a thread on which may be screwed either collar containing a standard hose coupling, or another 10 ft (3 m) section of piping to extend the branches still further. A driving head may also be screwed on to this head to enable the branch to be driven into the stack or bunker after which the head is withdrawn and the coupling is screwed on so that hose can be connected.

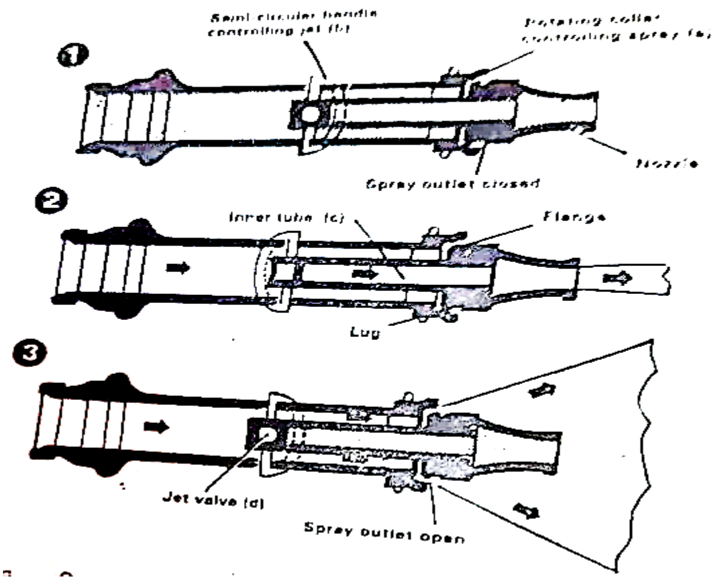
In some localities, smaller branches often from 2½ inch to 3 inch in length and less than 2½" (63 mm) diameter are used, particularly for dealing with fires in haystacks. A sliding adjust able collar is sometimes provided on such branches by means of which the angle at which the water is emitted into the stack can be varied.

(b) **Branch which can be controlled by the operator**:

(i) **Hand-controlled branch**: This branch. also known as 'London' branch, has devices. either to shut off/alter to spray, or to get jet alone or deliver jet and spray simultaneously. each being capable of independent control. The branch has 11 main parts viz.

1. Main body
2. Hexagonal base
3. Nozzle
4. Flange
5. 2 Screws
6. 2 Stop nuts
7. 2 Nuts
8. Semi Circular handle
9. Jet valves

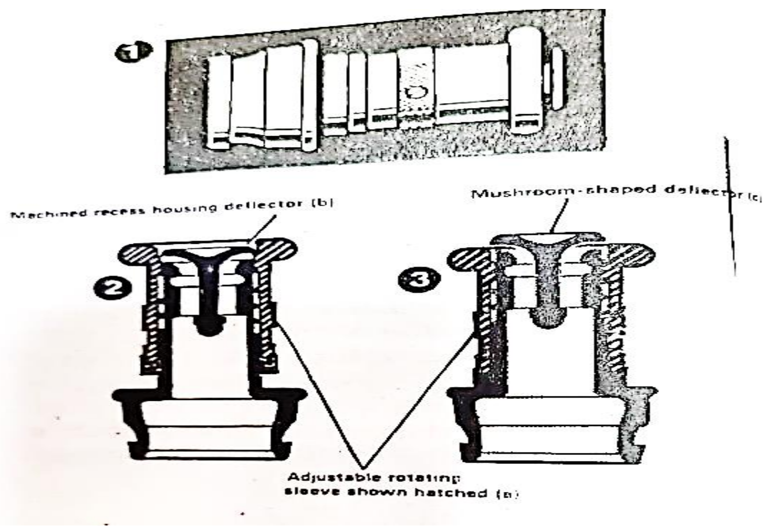
10. Inner cylindrical tube
11. Rotating collar with 4 solid lugs.



Fig; One type of hand-controlled branch (1) both jet and spray shut let open spray shut (3) let shut open.

Besides these there are washers and packing for turning the rotating collar in antidetection. The spray can be varied from a cone of 30 to 40 deg. to a flat sheet of 180 degrees. But the size of the jet is unalterable and depends on size of the nozzle, which is usually recommended to be from $^5/_8$″ (16 mm)," ¾ ″ (19 mm) and should not be more than $^7/_8$″ (22 mm) as the internal dimension of the branch, would not permit.

(ii) **Diffuser Branch**: This branch can give spray or a jet of variable size which can be shut off at will whilst the water is running, if necessary. The spray should be varied from an intense mist over an angle of 180 degrees to a complete shut off. However, this branch should not be confused with a hand-controlled branch which can give a jet and spray simultaneously or each independently. Its parts are (a) Main Body. (b) Adjustable rotating sleeve, (c) Mu shroom shaped defector. Machined recess housing deflector (b) Mushroom-shaped deflector.



(iii) **Fog Nozzle**: It is also a hand-controlled type of branch though it is commonly known as Fog Nozzle. It can be adjusted to give a water stream or straight jet, a fine or coarse spray and complete shut off. The fine spray is in the form of mist or fog and so this type of branch is called as "Fog Nozzle". A floating rotary valve connected with the handle facilitates the control operations. To prevent the entry of any foreign material, wire mesh is provided in a cylindrical tube in between the rotary valve and male instantaneous inlet so that the holes of the spray nozzle or spray head, are not blocked. The spray head is detachable and held in position by the spring-loaded interlocking device. With this type of hand-controlled branch, the spray head or spray nozzle can be connected with extension piece or low-pressure applicator can be connected to extinguish small oil fires or dis charge the fog directly to the burning surface. The size of the orifice of the jet is normally 5/6" (16 mm). The Fog Nozzle is made of light alloy specifically useful for indoor fires including small oil fires.

NOTE: When hand-controlled type of branches are shut off suddenly, the velocity of water is reduced and converted into pressure energy depending upon the rate of closing. This sudden increase of pressure is called "Water Hammer" which has many times resulted in bursting of delivery hose. To prevent such a situation. the shut off device should always be operated gradually. In case of hand-controlled branch, when changing over from Jet to spray-the spray should always be turned on before the jet is shut off in order to avoid sudden build-up of pressure along the hose line.

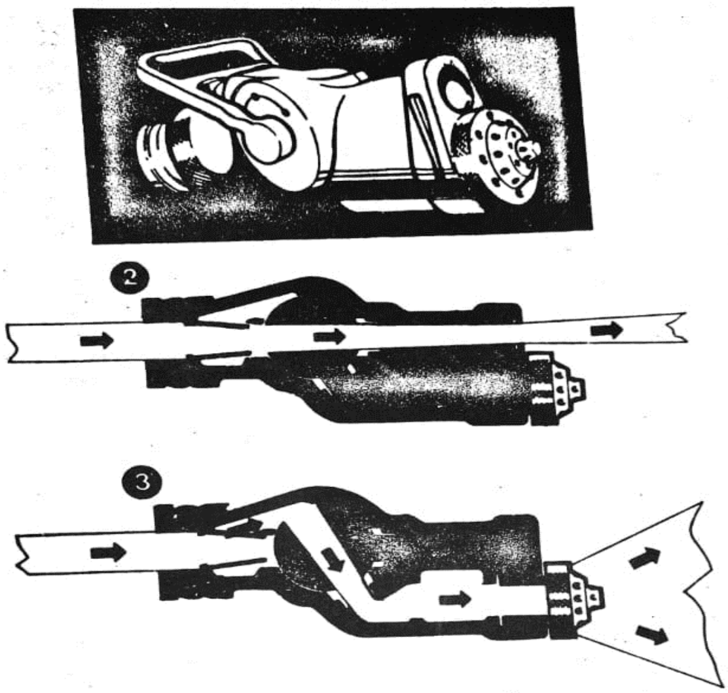


Fig: 53 Another type of hand controlled branch (1) general view (2) operation of the jet (3) operation of the spray.

(c) **Special types of Branches**

(i) **Branch with Revolving head**: This is a gun metal fitting having 2½" (63 mm) male instantaneous or female screwed coupling at the lower end and revolving round head supported on ball bearings on both sides with cylindrical cap and nut on top. The revolving round head having the appearance of a dome, is pierced with nine (9) holes of $^{1}/_{4}$" (6.35 mm) diameter.

(ii) **Foam-Making Branch**: This name is applicable to any branch used for generating mechanical foam. irrespective of whether a knapsack tank or an inductor is being used.

(iii) **Low Pressure Applicator**: Made of brass (Nickel plated) 6 ft (1.8 m) long 1" (25) mm) diameter with an instantaneous coupling at one end for connecting hose, the other end fitted with Fog head to produce. fog. Useful for small oil fires.

(d) **Nozzles**

The nozzle is a small metal fitting made of gun metal or bronze, having a tapering shape, or the shape of a round disc. etc.. depending on the nature or purpose it is manufactured for. It is provided with a threaded female connection at the base for attachment to the branch and is meant to control the stream or jet directed to the fire as the circumstances require. As a precaution against damage, the delivery orifice is countersunk in the nozzle, to a depth of 1/8 inch (3 mm). The nozzle has a large rim as a further protection. The base of the nozzle is hexagonally shaped to permit the use of spanner when necessary, although, the hand tight joint is usually sufficient, pro vided the washer is in good condition.

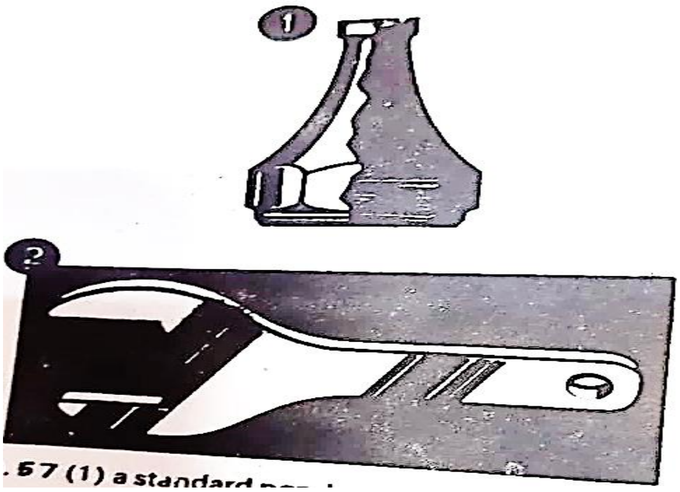


Fig : 57 (1) a standard nozzle (2) nozzle spanner .

Standard nozzle to fit any of the branches used with 3 ½ ″ (63 mm) and 2 ¾ " (70 mm) hose are made of machined gun metal or brass and vary in average length from 4" (102 mm) to $4^{1}/_{2}$ ″ (115 mm). Standard nozzles are fitted with a female connection for attachment to the branch and may be of 'V' thread or round thread of five threads to an inch (2.5 cm). Standard nozzles are made with the following delivery bores by which they are known. 3/16" (4.6 mm). ¼ " (6 mm). 5/16" (8 mm), $^{3}/_{8}$ ″ (10 mm). ½" (13 mm). $^{5}/_{8}$″ (16 mm). ¾ ″ (19 mm). $^{7}/_{8}$″ (22 mm), 1" (25 mm), 1 -$^{1}/_{8}$ ″(29 mm). 1-$^{1}/_{4}$″ (32 mm). 1-$^{3}/_{8}$" (35 mm). 1½″ (38 mm). 1-$^{5}/_{8}$ " (41 mm). 1-$^{3}/_{4}$″ (44 mm), 2" (50 mm) and occasionally larger size. The 3/16" nozzle is generally used with 14 hose.

The term 'working nozzle' is used for a nozzle normally attached to the branch which is first used when getting to work at a fire. The size adopted is usually ¾ inch (19mm) or less.

(iii) (a) **Collecting Head and Suction Hose Fittings**: Consists of a metal casting usually aluminium or gun-metal fitting with two, three. four, five or six inlets for Delivery Hose and a Single Female Suction Coupling for attaching to the Suction inlet of a pump. Each inlet is provided with a non-return valve which consists of a metal casting and screwed into the body of the collecting head and fashioned to a male instantaneous coupling. The valve is mushroom shaped with either a synthetic rubber or a metal ground face and is held against seating by means of a spiral spring. The water pressure forces the valve off its seating and passes in and when the pressure is reduced, the valve comes back to its seating preventing the escape of water, getting fast stuck to its seating. The valve lift must not be less than 5/8" (16 mm). These fittings are primarily used in closed relay, when they are fitted to the inter mediate and delivery pumps. It is used in case of collector pumping to augment the water supply to a pump from weak pressure fed sources. It may help in priming a pump with a defective primer. It may serve the purpose of blank cap while a pump works from it mounted on a tank. It may also be used at the end of suction hose to avoid repeated priming if the pump is to be stopped from time to time.

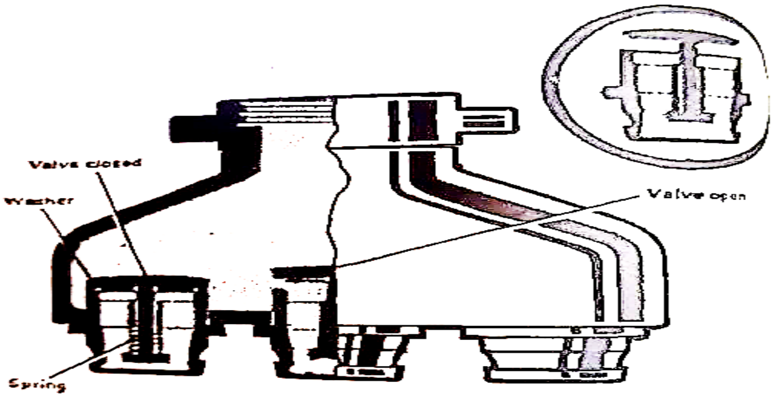


Fig: Collecting head (three way) inset alternative type of valve seat.

(b) **Foot Valve**

It consists of a metal suction strainer fitted with an extension tube in the casting between the strainer stopper and the coupling. In this extension, a flap-type reflex valve is fitted in such a manner that, water rising up into the suction forces it open. If the pump is shut down for any reason, the flow ceases immediately in the suction, the flap valve falls back on to its seating, thus preventing the water from escaping and keeping the suction fully charged. This avoids re-priming of the pump, when it is to be started up again. A device is provided to trip the valve to empty the suction hose, when withdrawing. It may also help in priming a pump with defective primer.

(c) **Deep Lift Suction Fitting**

It is the most efficient device for pumping out water from depths greater than maximum suction lift. It is also extremely effective for working on normal lifts where it is not convenient to lay salvage hose from the pump and also where the pump is not of self-priming type.

It consists of a light alloy body incorporating an inlet strainer plate and housing a two stage ejector unit. The inlet connection is 2 ½ ″ (63 mm) instantaneous male and outlet depends on the application. When used for Fire Service work, it usually has 4" (102 mm) dia. outlet and for Marine Work: 6" (127 mm) dia. outlet. Two eyes are provided for attaching the lowering ropes.

Operation

It takes delivery of high pressure water from the normal fire pump and transfers the energy to a larger volume of water at lower head. Lifts up to 80 ft. are possible with this fitting.

(iv) **Breechings**: Breechings are generally used for the purpose of uniting two lines of hose into one, or for dividing one line into two. The one which use for former purpose is known as Collecting Breeching, while the other is called Dividing Breeching. Apart from these, there are special breechings such as suction breechings which brings two or more suction to a common inlet.

(a) **Collecting Breeching**

Collecting breechings may be of two principal types (i) where the two inlets and one outlet are all designed to connect to hose of the same diameter, and (ii) the one in which two inlets are designed to take hose of same diameter and the outlet that of another diameter.

The simple form of collecting breeching is shaped like 'Y'. Each of the two legs is fitted with a male coupling if the device is instantaneous and female coupling if the breeching is for screwed couplings. The coupling, on the stem of reversed 'Y' is male if screw threaded type and female if instantaneous type. In the case of instantaneous, at the female coupling a single lug pressure released device is common. A control type, fitted with control valve to shut off either one or both of the inlets, turning the control valve by hand or key as and when necessary may also be encountered. Breechings are normally made of gun-metal, brass or bronze.

In the case of "Relaying" the absence of non-return valve in breeching (collecting) may result in reserve flow when twin lines of hose connected to it work at unequal pressure.

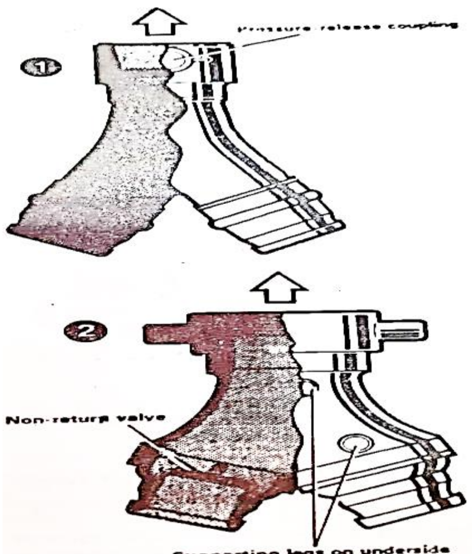


Fig: 8.1 Collecting breeching (1) with standard instantaneous coupling (2) breeching for use with a monitor

(b) **Dividing Breeching**

It is a fitting made of gun-metal, brass or bronze etc. like that of collecting breeching. In appearance it is also shaped like 'Y'. But it has unlike collecting breeching two female outlets and one male inlet in the case of instantaneous hose couplings and two male outlets and one female inlet in the case of screwed hose couplings. A specialised form is the "Control Dividing Breeching". Its chief function is also to divide a line into two, in this case, the two outlets and the inlet are controlled by a valve which can be rotated to shut off either of the lines. The advantage of this breeching is that either hose line can be shut off without closing down the other and length can be added or removed as desired. The exact position of the valve varies with different models.

There are also designs, where separate valves on each outlet are visible.

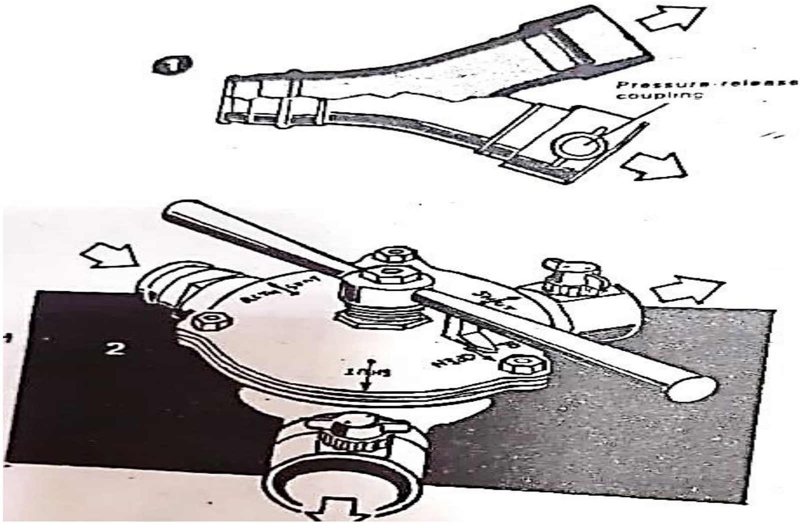


Fig: Dividing breeching (1) with instantaneous couplings (2) a control breeching

(v) **Adaptors**:-These are fittings made of metal used for the purpose of connecting hose of suction couplings of different types or sizes or for connecting the male to male or female to female parts of the same type of coupling. Adaptors are usually cast as one fitting, except in the case of screwed female ends, where the nut and sleeve are separate, the average bet ween 4 inch (102 mm) and 6 inch (152 mm) in length, and terminate at each end into a coupling.

(a) **Delivery Hose Adaptors**: The following types are in general use:

(i) Adaptors for connecting male or female parts of the same type of coupling: male to male and round thread, 'V' thread or female to female, instantaneous.

(ii) Adaptors for connecting two different types of couplings:

male to male &	round thread to instantaneous round thread to sure lock.
female to female	'V' thread to Instantaneous.
male to female	round thread to 'V' thread.

NOTE:-

1. In an emergency, adaptors for connecting screw thread to instantaneous may be made by tying the two respective couplings, one into either end of a small piece of hose.

2 Special adaptors for connecting the delivery into the hard suction hose of pump are also used with multiple jet inductor for large size foam making branches.

(b) **Hydrant Adaptors**: These adaptors are used between the base of the stand pipe and the hydrant outlet, and may be of the same pattern as delivery hose adaptors, though other combination of thread or connection, such as female bayonet to female instantaneous, female round thread to lugged or lugged to male 'V thread will also be found.

(c) **Suction Adaptors**: These are used for connecting delivery hose to hard suction or to the pump inlet or to join length of suction of different diameters.

Suction Adaptors normally consist of a metal casting with either a male suction coupling and a female instantaneous or male screw coupling to take the hose or a standard female suction coupling with a male instantaneous, or female round thread coupling at the other end. Adaptors for connecting suction of differing diameters usually have a female connection at one end and a male at the other.

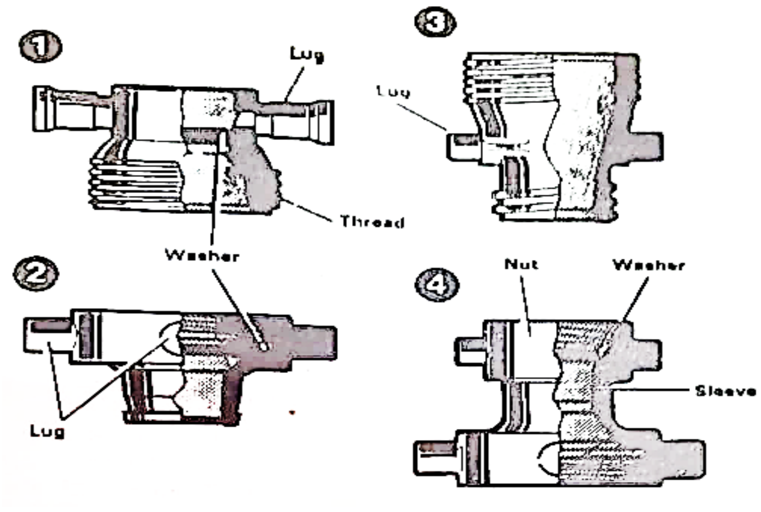


Fig: Suction adaptors (1) male suction to female instantaneous delivery (2) female suction to male (3) male suction to male round thread delivery (4) female suction to female round thread delivery

(d) **Suction Reducing Piece**: This consists of a short length of suction hose from 3' (0.9 m) to 6 ft. (1.8 m) in length, smaller in diameter than the main suction, with an attachment to a stand pipe head, and a female suction coupling at the other for union with the main suction hose or pump coupling at the other for union with the main suction hose or pump inlet.

(vi) **Miscellaneous Hose Fittings**:

(a) **Elbow for Nozzle:** A metal attachment for fixing in between the branch and the nozzle to enable a jet to be delivered at right angle to the branch. Used mainly for attacking fires in basements or ship holds when it is impossible to get down to the fire due to density of smoke or for any other reason.

(b) **Blank Cap**: Metal cover which is attached to the delivery outlet or suction inlet when not in use.

(c) **Gooseneck:** It consists of a short length of pipe of uniform fore throughout, curved in a semi-circle and fitted with a coupling at one end for attachment to a line of hose in place of branch. It used for filling emergency water supply tanks.

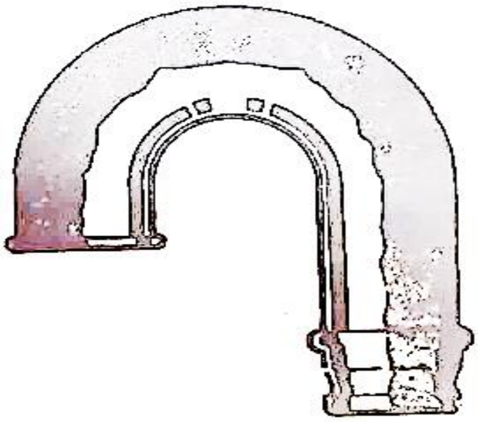


Fig: Gooseneck

(vii) **Hose Ramp**: To enable vehicles to cross charged lines of hose during firefighting operations, special fittings known as hose ramps are employed. The ramps are so con structed as to have angles of inclination on both sides along which vehicles might pass. A well-designed ramp will prevent contact of tyres or wheels of a passing vehicle with hose.

Ramps are almost invariably designed to accommodate 3½" (90 mm) dia hose and therefore, can be used with all types of delivery hose.

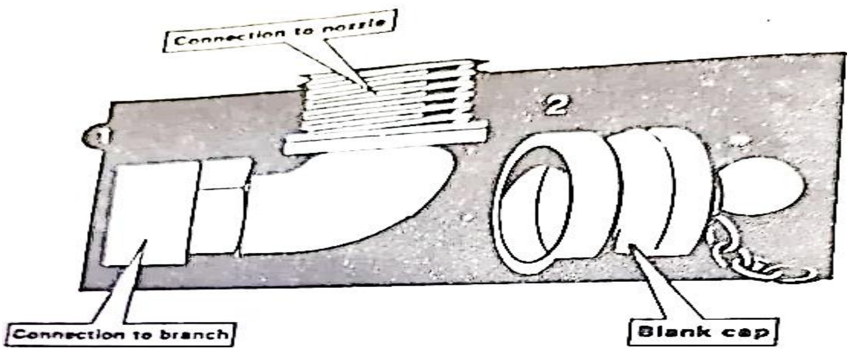
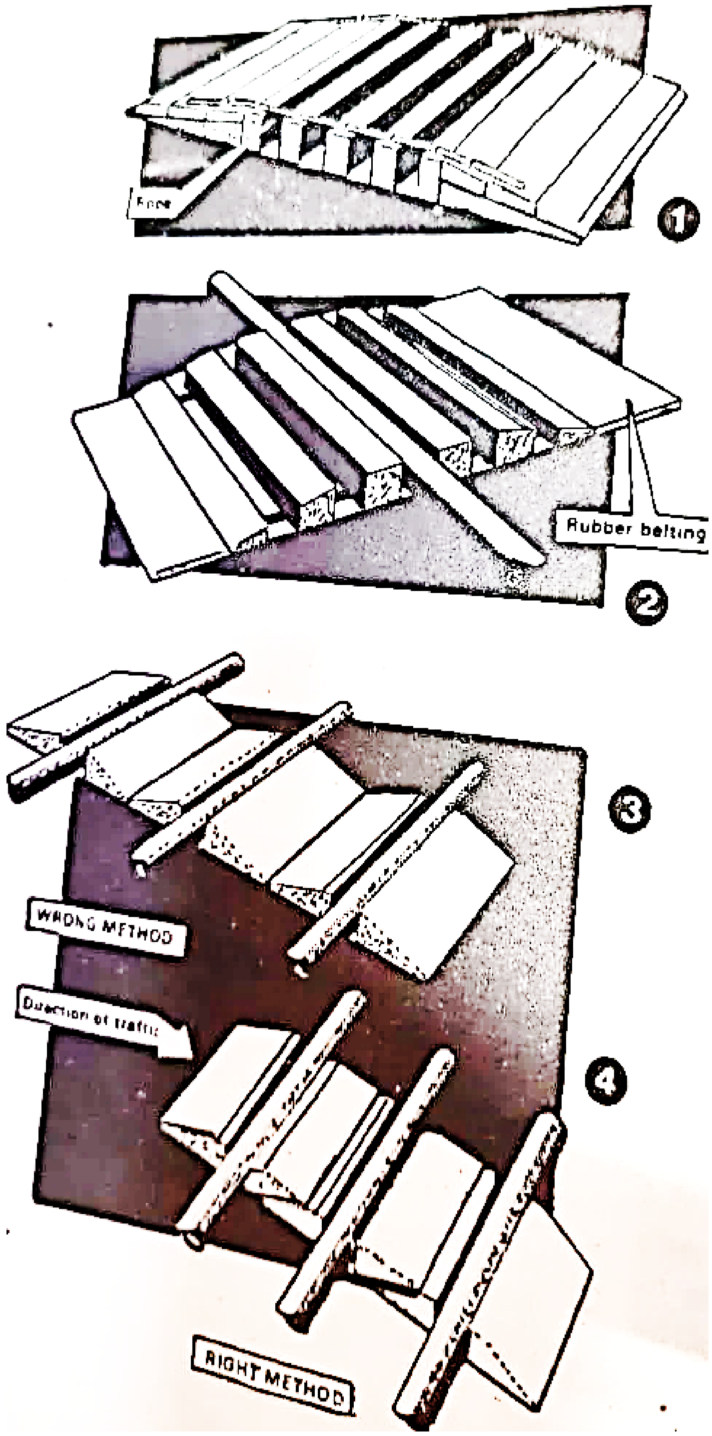


Fig: (1) Elbow for nozzle.
(2) Blank cap.

(a) **Wooden Ramps** : Consists of wedge-shaped pieces of wood joined together by either leather or canvas straps or ropes, so as to provide a channel bet ween them of about 3½" (90 mm) in which a length of hose can be laid. The ramp makes as incline on each side to carry the wheels of the passing vehicles over the hose. The performance of these ramps can be greatly improvised by attaching an apron of old hose or belting.



Ramps are made in rectangular sections connected between the two wedges. to provide two or more channels to accommodate two or more lines of hose.

The rectangular section of an emergency type of ramp consists of 3½" (90 mm) square and 3 ft. (900 mm) in length, placed 4" (102 mm) apart between the slipping wedges joined together by can vas straps.

(b) **Metal Ramps**: Where heavy and continuous traffic is involved steel ramps are employed. These consist of rigid metal section built up from rolled steel. The angle of slope varies between 8° to 12°. This can accommodate any number of lines of hose by the addition of extra channel.

(c) **Rubber Ramps**: Ramps are made of reinforced rubber are now in widespread use in fire services.

(d) **Improvised Ramps**: This can be made from old lengths of discarded hose. Some 3' (0.9 m) to 4' (1.2 m) is cut off 3' (0.9 m) to 4' (1.2 m) and one and turned over and rivetted. The end is then tightly packed with a pad of waste cotton etc. The other end is similarly turned over and rivetted to the discarded hose. The charged hose can be accommodated between them. For the sake of convenience, usually discarded hoses of 32" (90 mm) dia. are used for these ramps.

3. **Cleaning and Maintenance of Hose Fittings** :-Hose fittings are to be maintained well, for ready and immediate use at fire ground. They shall be periodically inspected, cleaned and kept fit.

Ail moving parts shall be lightly oiled to ensure free operation. Wherever washers are fitted, they shall be checked for wear and tear and proper fittings. Rough edges on fittings like couplings etc. shall be removed or smoothed off. Paint oil or grease shall be removed to keep threads, passages or holes free from obstruction and to obtain maximum efficiency.

Couplings which have lost shape and do not marry properly shall be reshaped or taken off from hose. While cleaning nozzles, particular care shall be taken.

Special care should be taken not to damage or distort threads of couplings or branch connection. Light alloy fittings shall be treated with special grease or oil to prevent corrosion.

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CHPATER - 21

HYDRAULICS

1. **Object**

Water is the most extensively and commonly used extinguishing agent by the fire services, because of its free supply and availability. Water, however, has certain characteristics when it flows through the pump, hoses and nozzle which are important from the fire fighting point of view and that a fireman must know.

2. **Pressure and Head**

The pressure may be defined as "Force acting on a unit area". If 'F' is the total force acting on an area of 'A' then the pressure 'P' can be written as:

$P = F/A$

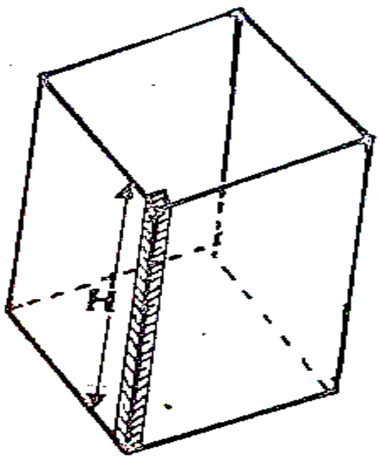
The most commonly used units for the pressure include Bar, Kgf/Cm^2, Pounds/square inch.

a. **Head**

It is customary to denote the pressure at any point in terms of water column. The Head at any point in a liquid column may be defined as:

"The vertical height of the free liquid surface from the point at which pressure in terms of water column is denoted".

The head is denoted by the capital letter 'H' and has the unity length i. e. inches, feet, meter.



b. **Relation Between Pressure and Head**

The pressure at any point in a system can be converted into head or vice-versa with the help of the following relation:

$H = 10.19 P$

Where 'H' is the head in meter and P is the pressure in bar. However, for quick conversion of pressure into head or head into pressure at the fire ground, following approximate formula can be used:

$H = 10 P$

3. **Characteristics of Pressure**

There are six basic rules governing the principle of pressure in liquids. These are:

(i) Pressure is always perpendicular to the surface on which it acts.
(ii) Pressure at any point in a liquid at rest is of same intensity in all directions.
(ii) Downward pressure of a liquid at an open vessel is proportional to its depth.
(iv) Pressure applied from outside to a liquid contained in a vessel is transmitted in all directions.

(v) The downward pressure of a liquid in an open vessel is proportional to the density of liquid, and
(vi) The downward pressure of a liquid on the bottom of a vessel is independent of the shape of that vessel.

Pressure and Flow

Pressure is the driving energy for the flow of water through fire-fighting hoses, pipes and nozzles. It should be noted that there is always a loss of pressure when the water flows through a pipe or hose e. g. if we connect a delivery hose to a trailer pump and connect the hand controlled branch at the free end of hose and run the pump at 5 bar-pressure then keeping the branch closed, the pump will give 5 bar pressure at all points in the hose, whereas, if we allow the water to flow through the nozzle then at pump the pressure will be slightly less than 5 bar and as we move away from the pump this pressure will go on reducing and the minimum pressure shall be available at the base of branch. This reduction in pressure from the pump to the branch is attributed to loss of pressure due to friction in hose. This loss of pressure is dependent on the size and type of the pipe. The pressure in the hose when there is no flow is known as static pressure. This is particularly important for calculating the maximum flow through a hydrant or pump and the formula. is:

$$\text{Max. Flow} = \text{Actual flow} \times \sqrt{\frac{\text{Static Pressure}}{\text{Loss of Pressure}}}$$

5. **Mensuration**

It is the branch of mathematics (geometry) dealing with the measurement of length, area and volumes of different shaped containers. This basic knowledge is necessary for the fire fighters to enable them to assess the amount of water a particular shaped tank contains which in turn is useful in the planning of water supply arrangements for combating the fires. Following are few shapes which a fireman come across:

(i) Rectangular shaped tanks;
(ii) Square shaped tanks:
(iii) Sloping tanks (swimming pool):
(iv) Circular or cylindrical tanks.

(i) The Capacity of a Rectangular Tank The volume of a rectangular tank is calculated by multiplying the length, breadth and the depth. Remember all dimensions (units) should be the same.

Thus, if I is the length of tank in meter, breadth in meter and h-the depth of tank in meter, then, the volume of the tank:

$y = 1 \times b \times h\ m^3$

(ii) **Capacity of Square Shaped Tank**

A square shaped tank is one in which length and breadth is equal, thus the capacity of the square shaped tank :

= length x length x depth
$= l \times l \times h$
$= l^2\ h\ m^3$

Where I is the length of one side and his the depth of tank.

(i**) Capacity of Sloping Tank**

The capacity of rectangular tank with uniformly sloping bases, such as, swimming pools can be obtained by multiplying the length, breadth and average depth of the tank.

$$\text{Capacity} = 1 \times b \times \frac{(h_1+h_2)}{2}\ m^3$$

$$\text{or} = 1 \times b \times \frac{(h_1 + h_2)}{2} \times 1000 \text{ litres}$$

where
l-length of tank in meter.
h_l-depth at shallow end in meter
b-breadth of tank in meter
h_2-depth at deep end in meter.

(iv) **Capacity of Circular (Cylindrical) Tank**

The capacity of a circular tank can be obtained by using the formula:

$$\text{Capacity} = \frac{\pi}{4} D^2 h \quad m^3$$

Where D is the diameter of tank in meter h is depth of tank in meter and π (Pi) is the universal (value is equal to 3.14).

6. **Nozzle Discharge**

Nozzle is a short converging pipe fitted at the end of delivery hose with a fundamental purpose of converting the pressure energy into velocity energy so that water leaving the nozzle travels longer distance (Jet length) in the atmosphere. Such a flow through the nozzle is applied on the fire for its control and extinguishment. In fire services various sizes of nozzles are used ranging from 6 mm to 63 mm diameter. The smaller size nozzles are used on fires where less amount of water is required whereas large size of nozzles are fitted at the end of water monitor which are used to meet the higher amount requirements for fire-fighting purpose.

The amount of water flowing out of a nozzle is known as nozzle discharge. This is denoted by the capital letter 'L' and is expressed in the units of litre per minute.

If, P-is pressure in bars at the nozzle, d-is the diameter of nozzle in millimetre, then, the dis charge through the nozzle L is given by the formula:

$L = \frac{2}{3} d^2 \sqrt{P}$ Litres/min

Moreover, sometimes instead of giving pressure at the nozzle, velocity of flow is given, in such cases the discharge through the nozzle can be calculated by using the following formula:

$$L = \frac{Vd^2}{21.2}$$

Where Lis the discharge through nozzle in litre per minute. V is the velocity of flow in. metre per second and d is the diameter of nozzle in millimetres. However, for quick estimation at the fire ground the above formula is approximated as:

$$L = \frac{Vd^2}{20}$$

Large Monitors

For large monitors requiring several lines of hose to supply each monitor, it is not possible to calculate flow rates with any accuracy by this method. However, the discharge of monitors is usually known, and furthermore, each monitor is generally supplied by its own individual pump, so there should be no difficulty in establishing the quantity of water being delivered.

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CHAPTER 22

WATER RELAY

1. **Introduction**

A situation may arise, in which, a fire may be very far from the supply of the water, so that, it may not be possible to get the required pressure from a single pump for carrying the water to the fire. Intermediate pumps are, therefore, placed to get the required pressure for carrying the water to the fire.

It is not always the case that water would be available readily from any available source near the fire ground. Water has sometimes to be relayed over a long distance from the available source by means of pumps and delivery hose to the fire ground by what is known as Relay Techniques. Every Fireman should be familiar with certain basic principles of water relay.

2. **Types of Relay**

(a) Open Relay (Relay Pumping): In this case, from the supply pump (also called the lifting pump) the water is discharged into a port able water tank through open deliveries and a second pump is set in this tank to relay the water to another tank to be lifted by a third pump and so on.

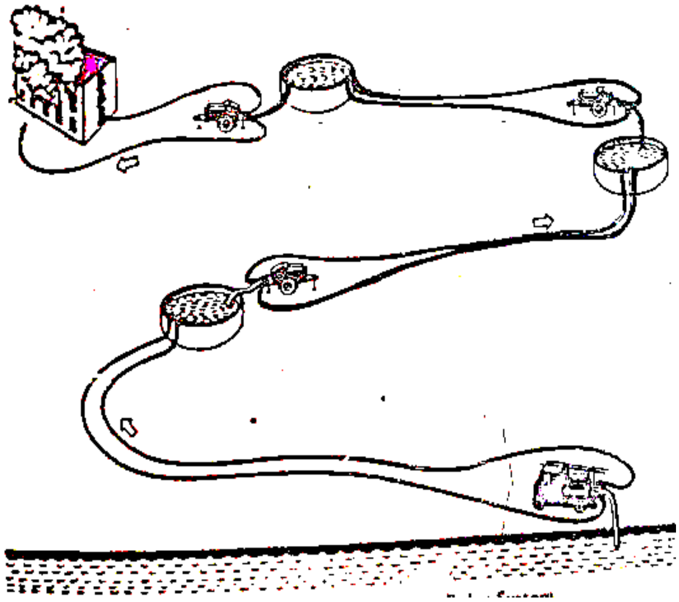

Fig: Diagram illustrate the open Relay System

(b) **Closed Relay (Series Pumping):** In this case, the water is pumped direct from the source to the fire ground by booster pumps interposed at intervals in the hose line. The first, or base, pump takes its water from the source and pumps through hose line into the inlet of the first booster pump, the first booster pump delivers through lines into the inlet of the second booster pump, and so on until the fire ground pump is reached.

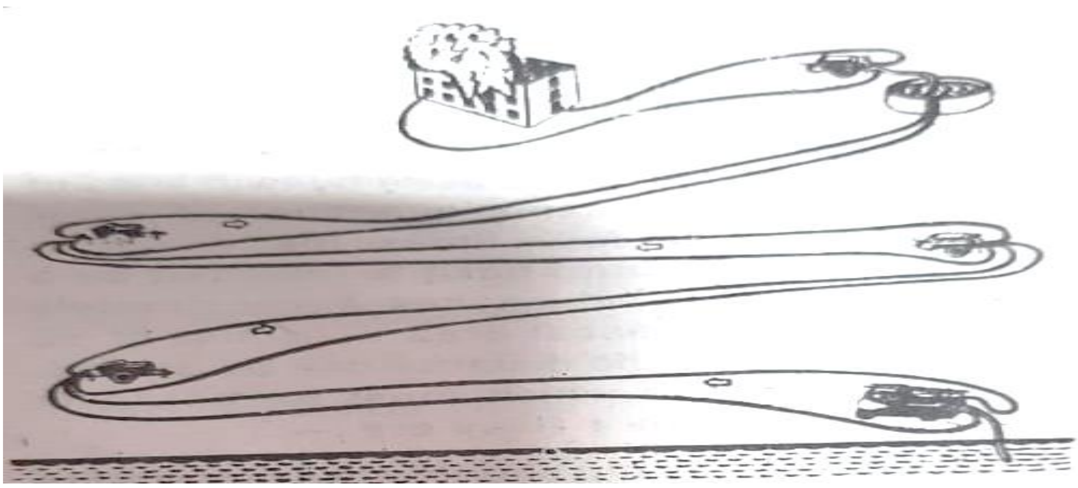

Fig: Diagram allocating the closed Relay System.

(c) There is also a third type of relay known as "COLLECTOR PUMPING" which means collecting water from several different weak sources of water supply to one pump and carry the relay thereafter in the usual way.

Open Relay has certain disadvantages:

(i) Loss of time as each pump has to prime water necessary, waste of time for suction hose connection etc.

(ii) Loss of Manpower: Additional men required for every tank.

(iii) As otherwise good pump but having defective priming system cannot be used in the open relay system.

Its main advantage is that the pump operator of the intermediate pumps can see the water supply position and adjust its throttle so as to build up a little reserve stock.

Advantages of Closed Water Relay System:

(i) **Economy in Equipment**: It does not require portable tank, only collecting head is to be fitted to the pump inlet.

(ii) **Speed in getting to work**: Time is not lost either for adding suction hoses to each pump or for priming the pumps (except the base pump).

(iii) The pumps, except the base pump, having defective priming system can be used in this relay system.

3**. Standard table for a relay having all 350-500 G. P. M. Pumps at a pump pressure of 75 LBS.**

Types of Hose	Distance between Pumps
Single 63/70 mm non-percolating	350 Ft.
Twin 63/70 mm non-percolating	1400 Ft.
Single 90 mm non-percolating	1150 FL
Twin 90 mm non-percolating	4600 Ft.

When a single line is replaced by twin lines of same size hose, the same quantities of water can be carried to four times the distance, similarly a 2½" (63 mm) hose is replaced by a 3% (90 mm) hose which has approximately twice the cross-sectional area than that of 63 mm size, four times the distance can be gained. A number of points which must be borne in mind in carrying out a relay are:

(a) The largest pump should always form the lifting or base Pump.

(b) Instead of trying to lay all the lines simultaneously, one line must be completed first so that at least some water is carried to the fire scene.

(c) Operators of intermediate pumps would have to control the relay by studying their gauges. Since only the base pump is lifting water, its compound gauge would give a reading on the vacuum side proportionate to the lift. All the intermediate pumps must deliver the exact quantity of water they are receiving and such their compound gauge should register a reading of zero.

(i) If compound gauge of any intermediate pump shown reading on vacuum side, it would mean that the pump is trying to deliver more water than receiving. The throttle in such case should be eased until the reading zero is obtained.

(ii) If the pump shows a reading on the pressure side of the compound gage, it means that the pump is delivering less water than received. The throttle has to be adjusted in such case to obtain the zero reading.

(iii) If the pressure gauge registers a sudden increase, it means that the line between this pump and the one ahead is obstructed by fallen debris, vehicle standing on it etc.

(iv) If, on the other hand, there is a sudden fall in the pressure gauge, this would mean sudden release of the water e. g., bursting of hose. disconnection of coupling etc. In such a case, the affected line should be found out and the delivery closed so that water is not wasted.

(d) Proper ramping at road junction must be made so that vehicles may not pass over hose directly and damage them.

(e) Friction loss between pumps to be reduced to a minimum.

(f) Use of non-percolating hose to be preferred to percolating hose.

(g) Largest diameter to be used.

(h) Two or more lines to be used in between pumps.

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CHAPTER 23

PRACTICAL FIREMANSHIP

1. **Introduction**:

In the fire service, a fireman is required to be conversant with so many different things in addition to the technical knowledge which he must possess. Of these amongst other things comes his daily routine work care and maintenance of appliances and equipment's, maintaining of different records etc. It is therefore, necessary that a fire officer must have some basic idea about his different functions:

- At station ground.
- On way to fire.
- At fire ground.
- On return to station from fire.

2. **Qualifications for a Good Fireman**: To be a good fireman, one must be:

(a) Physically fit: So that he is able to undergo the strenuous duty of a fireman, e.g., working at fire ground for hours and effecting a rescue from high buildings etc.

(b) Mentally alert: He must be quick thinking and capable of foreseeing the danger at a fire ground and act accordingly.

(c) Thoroughly disciplined: As otherwise he cannot expect his subordinates to carry out his orders.

(d) In addition, he must be always eager to learn.

(e) Lastly, he must have a good idea about the topography of his station area.

3. **Duty at Station Level:**

(a) Report for duty correctly.

(b) Checking up appliances, gears, etc. and reporting any shortage etc. and arranging for replacement of same. More deli cate or intricate equipment's, like B. A. set etc. should be checked up by him personally.

(c) Sickness or absence to be reported immediately.

(d) See that each member of crew performs his duty properly.

(e) Conducting drills and parades as per routine.

(f) Different records and registers are also to be maintained and that should be done by him correctly.

The different records and registers will include the following:

(i) Occurrence Book
(ii) Hose Card
(iii) Petrol Register
(iv) Log Books of Vehicles and Pumps
(v) Workshop Order Book
(vi) Fire Report Forms-This is usually done by Station Officers
(vii) Stock Register

4. **On Way to Fire**: On receipt of fire call, he has to turn out with his appliance in quickest possible time, but, while proceeding to a fire. there is a possibility that the vehicle meets with an accident such as knocking down a man, in which case

(a) if the vehicle is alright-proceeded to fire after dropping your leading fireman or a senior fireman with the First Aid Box, with instructions to:

(i) Render First Aid to the injured person.

(ii) Report to a policeman, if possible to assist him.

(iii) Arrange for sending him to Hospital. If the accident happens in a rural area, so that, no ambulance is available for removing the injured person to hospital. then the second fire engine may be used for removing the casualty to hospital.

(b) If the vehicle is damaged and cannot go to fire, then:

(i) Ride the second vehicle and proceed to fire with one vehicle only.

(ii) Take the crew of the damaged vehicle also along with you, excepting the driver and a leading fireman. The leading fireman should render first aid to the injured person, should arrange to send him to hospital and should also inform H. Q. about the accident so that another vehicle could be sent straight to the fire.

In case, he finds a road blockage or is held up at a railway level crossing and it is not possible to turn back the 'vehicle', he should inform the H. Q. to send additional vehicles to the fire by another route.

5. **On Reaching Fire Ground:**

(a) Carry out rescue work first. Place ladder at appropriate place for this purpose.

(b) At the same time-send message to H.Q. giving all details of fire e. g. size of building, size of fire, water supply etc. and whether any additional help is necessary. Messages to be sent at regular intervals. giving all particulars about progress of operations.

(c) Place pumps in suitable position.

(d) Arrange for supply of Petrol, Oil, Lights, Extra Hose, if firefighting is likely to continue for some time.

(e) Keep a vigilant eye to see that everyone is doing his job properly and is in safe position.

(f) Sending 'Fire Out' message and then order for 'making up'.

6. **Bringing the Fire Under Control**: From the start of the operations, arrangement should be made for the branches to work in. Branches should be moved once at a time, and as each. one is temporarily shut down to add length of hose, so it could be moved further forward, the area covered by it should be covered by other branches in the same group lines, should be moved forward according to the specific requirement and all concerned with operation of fighting the fire, must be able to realise immediately that the fire is coming under control. Apart from the reduction in heat and flame, the principal signs are a lightening in the colour of the smoke and the formation of visible steam.

An experienced fireman, on realising that the fire is coming under control should immediately substitute a shut off type of branch or changing to a smaller nozzle or knocking off entirely, according to the station

7 **Ventilation**: At any building fire of even moderate intensity most serious obstacle the rapid and successful attack on the fire has been the presence of impenetrable smoke and gases. This is more so the case of fires occurring in the night. The volume of smoke prevents the firemen from rapid attack on fire or for effecting rescues. It also does not give a true indication of the extent and severity of the firs Therefore, ventilating a fire se releasing the pent-up smoke and hot gases into the outside atmosphere is very important

Improper ventilation, however, is very dangerous. The following points are worth remembering for obtaining good results.

(a) Must ensure that all occupants have been led or rescued to safety.

(b) Must surround the fire with charged branches so that immediately on ventilation, the fire may not spread due to the sudden supply of oxygen.

Ventilation may be accompanied by:

(a) opening of ceiling ventilation
(b) opening of glazing's above lift shafts or stairwell.

When making the opening in the roof for ventilation always work from the windward side. It should be remembered that ventilation, should be accomplished above the fire. After an opening has been made for ventilation never drive any branch inside it.

8**. On Return to Station from a Fire:**

(a) Report to Control Room correctly.

(b) Check-up the message sent from fire and make necessary corrections of modifications.

(c) Check all fire appliances and equipment's check patrol, oil etc: of all vehicles and pumps attending fire. Replace dry hoses, charged oxygen cylinder of B. A. Sets, etc. and any other gear damaged or missing at the fire. Then report ready for duty again.

9. **At Fire Ground Practical Fire-Fighting Finding the Fire:**

External indications like smoke, crackling sound, discolouring of window glass, blistering of door paints, and gradual increase in temperature will indicate the fire.

a. **Method of Entry**: It is often necessary to enter Inside the building for rescue or firefighting purposes. For entering a building normal means of entry should be tried first.

(i) Try to enter from the main entrance, as access to all other parts of the building usually leads from this point.

(ii) If main entrance is not available, then try other doors at ground level.

(iii) Next try windows at ground floor.

If doors or windows are found closed, do not hesitate to break them open when necessary, but this is to be tried only as a last resort or where immediate entry is necessary for rescue purposes. When breaking a door or window remember:

(i) Break only that portion which is required for unlocking the latch.

(ii) In case of sash window-break the glazing nearest to the latch.

b. **Working in Darkness**: If the ladder is in darkness-first see whether the electric circuit is in order. If so, switch on the lights. High voltage circuits should be left in 'off' position.

c. **Working in Smoke**: When working in a building full of smoke, the following points be remembered:

(i) Put on B. A. set, if available, as unnecessary smoke punishment may be avoided.

(ii) Always move in pairs. This gives confidence.

(iii) Test each step before actually putting your weight on it. Therefore, do not walk but shuffle i. e. slide forward.

(iv) If not provided with B. A. then go by crawling as it is coolest near the floor.

(v) While crawling. occasionally the right hand with fist clenched should be raised with the back of first uppermost, to feel if any live electrical wire is hanging near the floor.

(vi) Make a mental note of any special feature enroute so that you can retrace back to safety.

10. **Rescuing a man caught in electric wires**: Fireman may often come across per sons caught in hanging electrical wiring. The current is usually of high voltage, and if the victim is found affected when standing on wet ground, it creates a problem. A few simple hints may be borne in mind.

(i) Send a man immediately to put off the main switch. This will cut out the supply of current.

(ii) In the meantime, proceed in the following manner.

(a) put on rubber boots.

(b) put on rubber gauntlets.

(The gloves must be absolutely leak proof, as even a small hole in it may prove dangerous. Make sure by blowing the gloves.)

(iii) If the victim is lying on wet ground get hold of a wooden platform (improvised by using wooden scaling ladder or door plank). Place the same on wet ground and then treat on it.

(iv) Try to earth the electric supply by dropping a long metal object across the wire, between the victim and the source of supply, (Do not let your body touch the wire or the water or the metal object) when it comes in contact with the wire, but simply drop it loosely.

(v) Get the ceiling hook to and pull the wire off the victim (The wooden handle of the ceiling hook will provide necessary protection).

(vi) Even after this, don't touch victims' body with bare hands (as there may still be an accumulation of or static charge in his body). Use rubber gauntlets.

11. **Hints on firefighting**: -When fighting any fire of intensity, every fireman must take care to see that nothing is done which will worsen the fire situation. Therefore, the following should be taken as guidelines.

(i) Arrange for water to be drained out from upper floor.

(ii) Do not remove heavy machineries during firefighting.

(iii) Do not play water jets unnecessarily on substances liable to expansion e.g. jute. cotton, tea, tobacco etc.

(Iv) Do not suddenly play water jets on heated metal members e.g. steel joists, C.I. columns etc. This is dangerous.

(v) Do not throw jets of water haphazardly, try to keep the water damage to a minimum.

(vi) When opening the door of a room in which fire may be burning, take all precaution not to open it all of a sudden. Open it slowly all the time pressing your legs against the door and yourself stooping down (an inrush of air might aggravate the situation with possible dangers of a dust explosion, gas explosion or back draught).

(vii) Whenever possible. a diffuser type branch or better a fog nozzle to be preferred to ordinary branches.

(viii) When fighting a fire, always keep an eye on any indication of collapse in, which case, withdraw your men and appliances to a safe distance.

Depending on the nature of the fire or of the contents of the building, and the type and condition of structures, it may be necessary to post one or more competent officers or men to watch for signs of collapse of the structure.

12**. Process of elimination applied in locating the seat of fire:**

Firstly, look for the smoke,
Secondly, see if any window glasses are discoloured:
Thirdly, find out where there is a gradual rise in temperature.
Fourthly, ensure if any paint on doors has a blistering effect on it.
Fifthly, find out if any crackling sound of burning material could be heard.
Sixthly find out if any flame could be seen.

Each of the above indication guides the fireman/Officer-in-charge towards the seat of fire, though the place where each indication is located is not the seat of fire, except the sixth.

Thus, a fireman or the Officer-in-charge of the crew, has to eliminate the less likely indications for the more certain indication where he could locate the fire with certainty. The process of elimination applies equally good in carrying out the reconnaissance of other. things on fire ground.

13. Rescue after carrying out the preliminary reconnaissance: The first and the foremost duty of the firefighting personnel is to save the lives, trapped in burning building, res cue work, therefore, achieves a greater importance along with fire fighting. A fireman may have to carry out two types of rescue. (i) Ordinary and (ii) General,

(i) **Ordinary Rescue**

A situation may arise in which persons I may become panicky and try to jump from the windows from upper floors of a building which is on fire, but the fire is not of a very serious nature. In such cases the fireman will have to go to these per sons and encourage and lead them to come out of the little smoke and heat which is quite bearable. This is known as ordinary rescue.

(ii) **General Rescue**

A situation may arise in which a fireman is required to use his appliances and equipment for rescuing the trapped lives. which is known as a General Rescue. The usual method adopted in case of a general rescue is as under –

Firstly, the escape ladder is to be pitched and extended near the place where per sons have been last seen.

Secondly, a line of hose with a branch that can give spray may be started to cool down the temperature as the fireman enters and proceeds inside the building. (the hose line also enables the fire man to retrace his way while coming out the building). Breathing apparatus, may be used if it is necessary to avoid smoke. Each step should be tested before actually putting weight on it. A fireman, therefore, should not walk, but slide forward. If a room where a person is trapped, is full of smoke, then the fire man should always move in pair. This will give them confidence.

When the trapped persons is found, he may be rescued by a method depending upon the rescue equipment which the fireman has with him & the condition of the casualty.

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CHAPTER -24

RURAL AND FOREST FIRES

1. **Introduction**

Fires in rural area are usually different than those encountered by a fireman in city or town areas, and therefore, this subject needs to be dealt separately. Fire risk in rural areas, as compared to that of an industry or industrial town, is definitely much lower and less concentrated, but this initial advantage is more than off-set by the difficulties that arise in almost all rural fires. They are:-

(i) **Delay in receiving calls**:-Due to absence of telephone system in almost all villages. the alarm call is received after a considerable delay, in many cases after hours, and it is easily imaginable, as to how this initial delay may turn a very small kitchen fire into a major conflagration involving often the entire village. before the arrival of the Fire Brigade.

(ii) Bad road conditions and distance to travel which may often be twenty miles or more and this also adds to the consider able delay, for the Fire Brigade to arrive at the scene of fire.

(iii) Difficulty of communication also prevents the Fire Officer from asking for re enforcement, which is so often badly needed in a village fire, and therefore, the fire officer has to fight the fire with whatever appliances he has under his command, and try to make the best of a bad job.

(iv) Lack of systematic arrangements of water sources. In many towns, there are evenly spaced hydrants services, from which a fire engine can draw its requirement. In a village, however, unless there are good tanks near the scene of fire. which is seldom the case, water has got to be relayed from a distance, which adds to the difficulty.

(v) Combustible nature of dwellings and stocks. The Indian village huts invariably consists of thatch type roofing on a split bamboo frame, supported by wooden rafters. The whole roof construction is therefore like a magazine adding a chance of spark from anywhere. The straw and hay stacks are also often kept within the courtyard of the village houses seriously increasing the hazard.

These apart, one main characteristic of the village fire is that they are seasonal i.e. the risk in village areas is subject to rise and fall with seasonal and climatic conditions, low in rainy season and autumn and high in the late winter and particularly summer when everything is parched and dry. The fall in the volume of water in the tanks, canals and rivers in summer days also adds to the difficulty listed above.

Normally the village fire mainly consist of:

(a) Grass or standing crop fire.
(b) Stacks of hay or straw.
(c) Other combustibles i.e. thatch roof on wooden and split frame work etc.

2. **Causes of village fire**: Various causes may be attributed to a village fire. The more important of them are:

(i) **Lightening:** A large number of village fires every year occur as a result of lightening, which strikes the combustible construction of the stacks.

(ii) Sparks from rail road locomotives where the railway lines pass too near a village.

(iii) Careless throwing of lighted Bidi ends by passing village people or the burning embers from the hookah at village parlays etc.

(iv) Use of fireworks, e.g. rockets, balloons etc. during religious and social festivals.

(v) Fires caused by electricity, the modern trend is to electrify as many villages as possible. The dangers arising of electrical faults are also present in such cases.

(vi) Spontaneous ignition in cases of hay stacks, hay stacks particularly those with certain quantity of moisture are liable to overheat and unless this heat is decapitated, spontaneous ignition may occur i.e. hay stacks may start burning from inside, hence white building up hay stacks, the following points are worth remembering

(a) Moisture from fresh cut hay should be allowed to dry out feat before stacking the same to prevent spontaneous ignition

(b) Build up stacks with a vertical opening in the centre to be filled up with loose straw subsequently) to allow the heat to dissipate into the atmosphere easily

(c) Maximum height of stacks should not exceed 6 meters

(d) Maximum quantity for stack should not exceed 18000 ko

(e) Distance between stacks should not be less than 18 meters.

(f) Distance between stacks and residence also should not be less than 18 meters.

(vi) That incendiarism is a very common cause for rural fires.

(vii) Broken bottle ends, may under suitable conditions assume the role of lens and ignite the nearby straw or hay etc.

(ix) Kitchen in village houses: This is probably a major cause. As already stated. the village kitchen are also constructed of thatch type roofing on wooden framework and very often provided with a split, bamboo ceiling underneath, for storage of fuels on such ceiling in rainy days etc. The cookhouses are almost always provided with open type "choolah" (stove) and firewood, providing the normal cooking fuel. The chance of burning embers from this firewood rising up, particularly when the wind is high and igniting the ceiling is therefore, very great.

(x) Oil lamps (naked or otherwise): The possibility of oil lamps being upset by children or pet animals accidentally, thereby. igniting the entire dwelling place.

The first job of a fire officer on arrival at a village fire is to make a quick survey of the following:

(a) Extent of fire.
(b) Direction of spread i.e. wind direction and velocity.
(c) Possible chance of natural Fire Break i.e. open field, village road etc.
(d) Nearest source of water supply. If it is a pond, calculate approximate supply that can be obtained.

3. **Normal appliances and method of attack for attending a village fire should be:**

(a) A water tender or a small trailer pump, so that it can be detached off its chassis and carried right up to the water, if the water supply is unapproachable for a T.P. or the W.T. and (b) "Hi-lift" or Aquator type or similar other deep lift suction fitting device where water tenders cannot go close to the water supply and the water level is below the pumping range from the ground. The hose lines carried in such appliances should preferably be rubber lined, so that friction loss is lowest and consequently more water can be drawn from a greater distance. One precaution, however, must be taken in all village fires, the hose must not be laid out over grounds which have become hot, neither the appliances i.e. the W.T. or the T.P. should be allowed to go over land which is still hot, as in both cases, the rubber composition of the tyres will get damaged.

Extremely judicious use of water should be made for this purpose. a 5 /16 ″(8mm) jet at 25 P.S.I. pressure is considered ideal. It must be realised that in a village fire, use of water supplemented by various types of beaters along the line of fire break will prove most effective. The crew or the spare village men should be made to stand along the line of attack with beaters, spades, shovels etc. The advancing of fire to be checked by the water jets and beating out the small pockets of fire caused due to play of water jets on the main fire, will prove to be most useful.

The wind velocity is of considerable importance in fighting a village fire. For a low wind velocity, the fire should always be attacked from the lee-ward side. For a moderate wind velocity, a frontal attack may not be possible and in such cases attacking from sides and rear will prove effective. In case of high wind velocity, however, it will neither be possible to attack from the front nor to chase the fire from rear and in such cases, concentration should be made on both flanks. gradually gaining ground on the front side, in a linear fashion.

4. **Forest Fires**

Problems arising out of forest fires are very much akin to village fires, but there are few important differences namely:

(i) Forest fires often are of a vast magnitude, in comparison to village fires. involving many square miles.
(ii) Life risk hazards either of men or cattle is absent in a forest fire.
(iii) Difficulty owing to bad road conditions or water supply is often more acute than in a village fire.

Causes of forest fires are precisely the same as for village fires excepting, causes iv, vii and ix which do not apply in case of forest fires. Method of attack in a forest fire is also same as in a village fire. There is, however, one important point. In case of forest fire, the fire service will always have to work in conjunction with the forest department men, and their advice regarding possible chance of fire spread, wind velocity and direction, natural fire breaks, if any like open field, roads passing through the forest, should always be counted in selecting a line of attack, and placing of men along that line with beaters etc.

In case of forest fires, one method is often resorted, to which is known as "counter-firing". This is nothing but starting another small fire ahead of the main fire. This small fire sheltered by the big advancing fire, burns quickly, and due to convection currents created by the major fire is gradually drawn towards it. As a result, when the live fires meet, because of absence of fuel. (all the combustible material having already been burnt by the small fire) the major fire cannot proceed any further. and is extinguished by "starvation". This procedure, is however, an extremely technical one, and should under no circumstances, be practised by any Fire Officer. The forest department are the only competent authority to do it.

5. **Fire Fighting Implements**

The firefighting implements which are usually useful in fighting fires in rural areas, are as follows:

(a) Fire beaters
(b) Forks
(c) Hay knife
(d) Fireman's axe
(e) Fire hook
(f) Shovels & Spades
(g) Stirrup or hand pumps
(h) Buckets and big sized drums for water.
(i) Manually operated portable pumps etc.

First aid firefighting equipments: These equipments are mostly available with house holders and with wardens, and very handy to fight the fire at the incipient stage. The details of equipments are as follows:

a. **Fire Beater**: This equipment is made of 4' to 6' long bamboo with metal disc of 6"-8" radius attached to one end of it. This is very useful for beating-out fire.

b. **Ceiling Hook**: This equipment is made. of 7' to 8' long bamboo with a metallic hook attached to one end of it. This is used either to pierce a ceiling which is filled with water or to pull down material which are fallen down. This is very useful for fighting Hay Stack Fire.

c. **Blanket**: This is commonly available household item, which is very useful for blanketing when an individual is engulfed in fire. This puts off the Fire by smothering.

d. **Fireman Insulated**: This is a personnel equipment of the Fireman, being an insulated axe, it is very useful for cut tings live electrical wire up to 15 K.V. This is also useful for cutting through obstacles.

e. **Life Line**: This consists of 40' length of 1½" circumference rope, which is very useful for either self-rescue or for rescuing casualties from confined places. This can also be used for signalling while I working in confined places.

f. **Bolt Cutter:** It is a standard equipment available in the market, by which easy entry into the burning spot can be achieved and used for cutting metal bolts and pad-locks.

g. **Door Breaker**: This is also a standard equipment by which the entry can be easily achieved by breaking the closed doors. This equipment is just like hammer, with a blunt head on one side and sharp fulcrum head on the other side.

h. **Debris Basket**: Made out of cane or bamboo which is very useful to throw sand/mud on the burning fire or to clear debris.

i. **Bucket G.I.:** The G.I. buckets which can hold 10 to 15 litters of water is a very useful household equipment for using/ throwing water on the burning fire or as a standard equipment of House Fire Party.

J. **Short Ladder (Bamboo or Wooden):** 10' long short ladder is used for basic rescue to climb first floor, for fighting fire or to bring down a casualty by fireman lift.

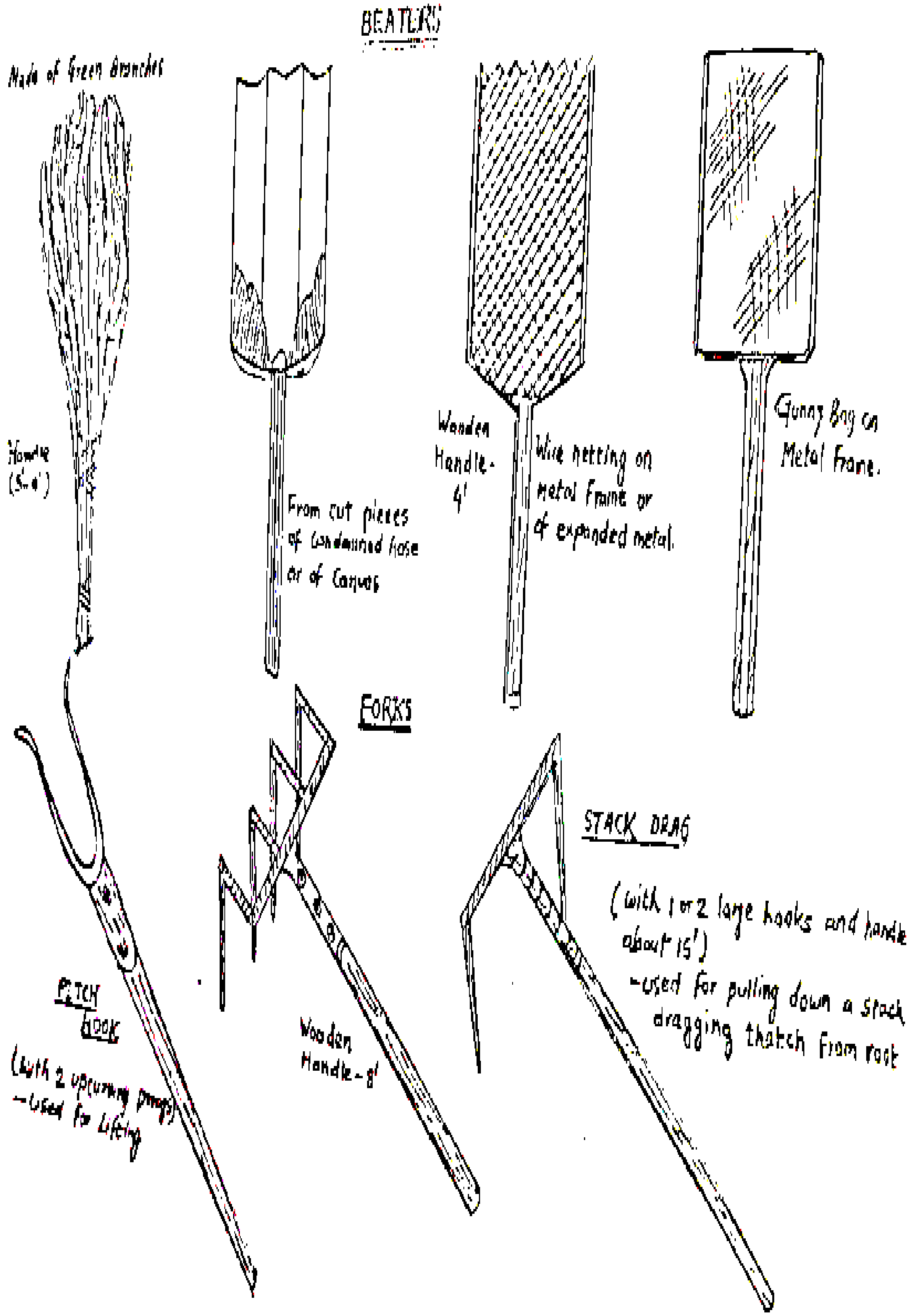
k. **Hand gloves (Rubber, Leather, Asbestos):** This is useful to a fireman for working in areas with live electrical wire. This is tested up to 15 K.V. The leather and asbestos gloves are used to prevent heat or abrasions to hand.

1 **Portable Chemical Fire Extinguishers**: These are very useful extinguishers of various types, which are used on various classes of fire at the Incipient stages They are easy to carry, operate and recharge.

m. **Stirrup Pump:** This is the standard equipment of House Fire Parties. This is called as "Water Economiser and very useful equipment for fighting incendiary bomb fires.

n. **Crowbar**: 4' to 6' long equipment useful for digging and cutting hard surfaces.

o. **Shovel & Phawda**: Very useful equipment for shovelling earth and beating fires.


BEATERS
Made of Green Branches
Handle (5'-6')
From cut pieces of condemned hose or of Canvas
Wooden Handle - 4'
Wire netting on metal Frame or of expanded metal.
Gunny Bag on Metal Frame.
FORKS
PITCH HOOK
(with 2 upcurving prongs) - used for Lifting
Wooden Handle - 8'
STACK DRAG
(with 1 or 2 large hooks and handle about 15')
- used for pulling down a stack dragging thatch from roof

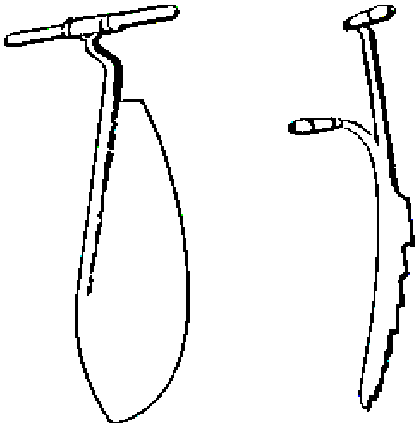
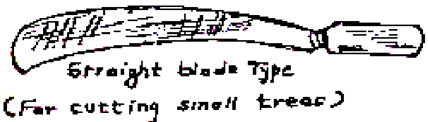


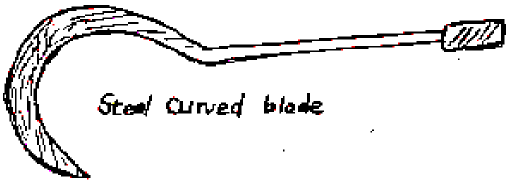
Fig. Typical hayknives used for cutting into hay stacks. Left: straight-blade type. Right: saw-tooth type.

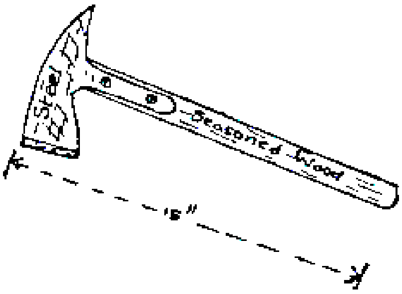
FIREMAN'S AXE

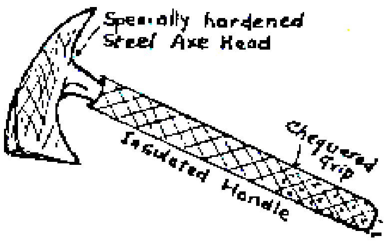
BILL HOOK

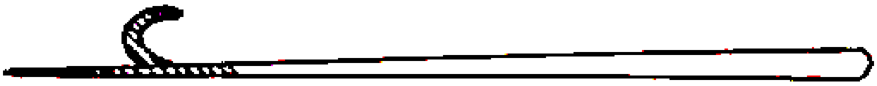


SLASHER









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CHAPTER 25

GAS FIRES

1. **Introduction**

One of the main hazards due to Industrialization is fires involving various types of gases and vapours of inflammable liquids used in different stages of processing in industries. This hazard is all the more a cause for concern, as gases and vapours which are combustible in nature, presents the additional risk of explosion, once ignited. Such explosion often follows the combustion at a rapid pace which makes a gas fire difficult to tackle. Further, number of these combustible gases and vapours are of toxic nature and some of them are highly poisonous.

2. **Importance**

All these facts point to the necessity for an officer dealing with such risks to correctly know the nature and composition of different combustible gases/vapours and their behaviour once ignited, so that he is in a position to handle such fires efficiently and with confidence.

The subject will be discussed under the following headings:

(i) Definition of Gas.
(ii) Types of Gases.
(iii) Flammable limits.
(iv) Vapour Density.
(v) Common characteristics of Gases.
(vi) Flash and ignition temperature of inflammable vapours (Flash Point).
(vii) Dust Explosion.
(viii) Extinguishing a Gas Fire.

(i) **Definition of Gas**: Gas means bodies that exist in the gaseous state at ordinary temperature and pressure conditions in which we live.

(ii) **Types of Gases**: From hazardous point of view gases might be divided as under:

(a) Gases, which are combustible and inflammable i.e. Acetylene, Coal Gas, Hydrogen Sulphide, Methane, Hydrogen, propane etc., plus inflammable and Poisonous gases like Carbon Monoxide.

(b) Few of the gases which support combustion are: Oxygen, Nitrous Oxide etc.

(c) Few of the gases which are 'inert' are Nitrogen. Helium, Carbon-di-oxide etc.

(d) Some of the gases which are toxic, suffocating and very irritating, making firefighting a very difficult operation, for example, Chlorine, Ammonia, Hydro Chloric Acid Gas, Sulphur-Dioxide etc.

(iii) **Flammable Limits**: All combustible gases, as also vapours of inflammable liquid form ignitable mixture; when these are mixed with air at definite minimum and maximum of their volume in air, such as Acetylene Gas forms ignitable mixture between

2.5% to 81% in volume with air. Petrol vapours forms ignitable mixture between approximately 1.3% to 6% in volume with air etc. This is known as the inflammable range of the gas or vapour and the wider this range, the more hazardous is the gas or vapour. Under normal circumstances, however, when in pure state all gases or vapours are non-ignitable and generally non-explosive, as propagation of flame does not take place when the concentration is below the minimum or above the maximum percentage of limits by volume with air.

(iv) **Gas or Vapours Density**: Each gas or vapour possesses a definite weight in relation to air volume. This is termed as the density of the gas or vapour. Some are heavier than air e.g. Sulphuretted Hydrogen, Chlorine, Nitrous Oxide (Nitrous Fumes). Petrol vapours etc. Others are lighter than air e.g. Hydrogen, Coal Gas. Acetylene, Ammonia, Carbon Monoxide etc.

If the gas is heavier than air, it should be ventilated at floor level, while if it is lighter than air, ventilation near about ceiling level is necessary. In both cases, however, openings have to be provided at opposite levels to allow air to enter to enable the gas or vapour to flow out quickly.

Gases or vapours having approximately equal density to that of air, provide some difficulty in removing them by mere ventilation method, as these gases and vapours hang about the place where the leak occurs. In such cases, it is necessary to employ a powerful fan or blower or exhaust to throw them out into the atmosphere through the openings.

(v) **Common Characteristics of Gases**:

(a) All gases are elastic. They have no shape. They occupy the volume of the container.

(b) When gases are heated, they expand in volume much more than liquids or solids. For every rise of 273°C in temperature. the gas doubles its volume.

(c) When gases are compressed, the temperature rises depending on the compression.

(d) When two or more gases are introduced into the same space, they diffuse into each other to form a mixture of uniform vapour density.

(e) In the same space, a gas remains at a uniform pressure.

(vi) **Flash & Ignition Temperatures of Inflammable Vapours**: The flash point is the lowest temperature at which an inflammable sub stance is capable of emitting sufficient quantities of vapour, so as to form an ignitable mixture with air which can flash momentarily on the application of a flame in the prescribed manner; whereas the ignition temperature denotes the temperature at which the sub stance is capable of bursting into flame without the application of a flame. The ignition temperature of an inflammable substance is generally much higher than its flash point. For Petrol, the flash point is -45°F. and ignition temperature is about 49°F. It is the flash point, which is more important from the point of view of fire and explosion.

(vii) **Dust Explosion**: Finely divided dusts of many substances and also of metals, when well dispersed in air, behave just like gas and when in contact with a flame and in suitable proportion in air (viz. 0.02 to 0.04 oz. per cubic foot of air) gets ignited, ultimately leading to explosion. Such explosions are very often violent in nature. This is commonly known as

Dust Explosion, and the common dust which are capable of behaving in this way, are. Aluminium Dusts, Magnesium Dusts, Cork Dusts. Carbon Dusts. Coal Dust. Flour Dust. Textile and Wool Dusts.

(viii) (a) **Extinguishing Gas Fires**: Fires involving flammable gases and vapours can be extinguished by using either CO_2 or Dry Powder Extinguishers, as in both the above cases, decomposition hazard is absent for certain gas fires and particularly flammable vapour fires. water can be used successfully in the form of fine spray. Flammable vapour fires can also be put out by use of foam.

Gas fires, however, differ from other vapour fires in one important respect, i.e. in the case of flammable vapour fires, extinction of the fire is the main concern of the fire fighter but in case of gas fires, stoppage of flow of gas is most important aspect. If the fire involving gas is extinguished, but the flow is not stopped, then the escaping gas will accumulate in a greater volume and will result in a more serious fire and explosion.

Therefore, in case of fire, the procedure should be as follows:

(i) Stop the flow of gas at the earliest and cool the gas holder by water spray. This is most important.

(ii) CO_2 or Dry Powder Extinguisher may be used to put out the fire so as to gain access to the valves for closing the same. After the fire is put out, the valve must not be left open even for a short time.

(iii) In case of cylinder fires, water spray must be used to cool down the cylinders, so as to obviate the danger of cylinder explosion.

(iv) If the leak in cylinder or gas vessel cannot be remedied or its flow cannot be stopped, the vessel should be taken out in open space and the gas allowed to burn in a controlled state, water being all the time sprayed to cool down the cylinder. Alternatively, if there is adequate opening on all sides, so that there is no risk of gas migrating to nearby buildings; then the gas may be allowed to escape into the atmosphere. by completely opening the valve.

During either of these operations. i.e. allowing gas to burn or to escape. standby of a crew with hose lines laid out ready, with hand-controlled branch is a must.

(v) Where gases are supplied through piped installations i.e. coal gas, or producer gas, these pipes sometimes develop leakage or even burst. Under such circumstances, the leaking or the burst gas main must be plugged off, with mud or similar substance so as to stop the gas escaping. Intimation should then be sent to the supply company so that appropriate main valves may be turned off from junction boxes.

(vi) Where it is suspected that gas has been leaking for some time, it must be ensured that all the neighbouring buildings are completely evacuated, until the defects have been remedied and, the condition is safe enough.

(vii) Under no circumstances, a fire hose branch should be introduced into a Gas Main, as this may set up dangerous conditions.

(b) **Preventive Measures:**

(i) Ample and suit able ventilation should be provided to remove the gases, and prevent them from forming a flammable or explosive mixture with air. Many gases and vapours used in industry are heavier than air and ventilation should, therefore, in these cases be provided at floor level. For example, vapours of Acetone, Ether, Benzol, Petrol, Carbon disulphide are heavier than air. Where the gas is lighter than air, the ventilation should be at ceiling or roof level. For example. Hydrogen. Coal gas, Acetylene Ethylene and Carbon Monoxide are light gases.

(ii) Possible source of ignition should be kept away from the gas chambers and cylinder which may be leaking.

(iii) Relief Panels should be provided in walls and roofs to limit damage due to explosion. they may be so constructed as to be easily broken by an explosion and thus relieve the pressure on the structure or building itself.

(iv) Gas containers should be stored in an unheated, well ventilated place, well away from the main building. They should not be stored below ground level or where gas which is heavier than air, could drift through drains etc, it might accumulate and present a serious hazard.

(c) **Control Measures**:

Following control measures may be taken in case the gas mains and gas cylinders are on fire:

(i) **Gas Main Fires: -**When a gas main is on fire, there are two alternatives open to us allowing the fire to burn or extinguishing the fire.

Allowing the fire to burn: A burning gas main should not be extinguished by the fire service except on the definite instructions of responsible officer of the gas undertaking. Message should, therefore, be despatched immediately to the gas undertaking notifying the occurrence.

Extinguishing the fire: The gas main fire may be extinguished very exceptionally by us. The following method should be adopted in tackling the fire. The leaking or burst main should be plugged off with. mud to prevent the gas escaping from the main.

The officials of the undertaking should be asked to shut off the gas pressure in the main.

If the gas from the burst main has escaped into adjacent buildings, the people living in the building must be asked to throw open the openings in buildings for ventilation and leave the building until all traces of gas have escaped. Any source of ignition present in the vicinity should be removed.

Never use the fire service branches to project water into the gas mains as it might set up dangerous conditions in the main,

(ii) **Cylinder Fires**: There can be two situations, i.e. firstly when the cylinder is involved in a fire, and secondly when the cylinder is not involved in a fire.

When the cylinder is not involved in a fire. the main valve should be shut off, dis connected and removed to the place of safety.

When the cylinder is involved and heated by the fire, there is a danger of the cylinder exploding. In this case, the cylinder may be cooled by a spray of water from far and behind a cover.

If, however, a small fire exists at a leak. it may be extinguished efficiently and quickly by covering it with a damp cloth.

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CHAPTER 26

FLAMMABLE LIQUID FIRES

1. **Classification of flammable Liquids**: Flammable liquid fires are very common now-a days. To prevent and control the flammable liquid fires effectively, we should know the miscibility of flammable liquids with water and their specific gravity. The specific gravity of liquid is lighter or heavier than water.

CLASSIFICATION OF FLAMMABLE LIQUIDS

Miscible	Non-Miscible & Lighter	Non-Miscible and Heavier
Acetone	Petrol	Carbon-di-sulphide
Alcohol	Fuel Oil	Tetra-Ethyl Lead
Glycerine	Lubricating Oil	Tetra-Methyl Lead
Methylated spirit	Paraffin Oil	
Rectified spirit		

2. **Causes of Flammable Liquid Fires**: They are as under:

(a) Unsuitable storage conditions: Flamm able liquid may be stored in a building which has a temperature higher than the Flash point of the liquid to set off flammable vapour.

(b) Improper handling: Improper handling may cause a leakage in the containers of a flammable liquid, and the liquid may collect in a place where it might catch a fire.

(c) Inspection with naked lights: Inspection of empty petrol tanks with naked lights. may cause fire because even as little as 1/5th of a cubic inch of petrol in the form of a film on the inside of a petrol tank of 1 cubic foot capacity is sufficient to produce with air, a mixture which only requires a spark or other form of ignition to explode. Fire which takes place while soldering or welding the joints of empty flammable liquid tanks is some times. because of aforesaid reasons.

3. **Preventive Measures:** Some of the important preventive measures are as under:

(a) No flammable liquid should be stored in building unless in sealed cans, kept in special fire resisting compartments, ventilated to the open air and having well fit ted doors.

(b) Petrol should preferably stored in the underground tanks, sunk into the earth, two or three feet below ground level and concreted over.

(c) Where small quantities of oil are kept in a building, arrangements should be made to avoid floors being soaked with drips, by providing at the filling place a metal tray containing sand.

4. **Control Measures**: Depending upon the situation, any of the following methods may be adopted for extinguishing fires involving flammable liquids classified in the following:

Methods of Extinguishing flammable liquid fires

Miscible liquids	**Non-miscible & Lighter liquids**	**Non-miscible & Heavier liquids.**
a) Dilution with water (depending on qty.)	a) Application of water in the form of spray or fog.	a) Covering with water and
b) Covering the container (depending on qyt.)	b) Covering the container (depending on qyt.)	b) Application of foam (where sealing effect cannot be contained by water)
c) Application of or ordinary foam (at the rate of 5 gallons per minute per sq. foot of area i.e.. 5 times more than the normal rate) or Application of alcohol resisting foam compound (at the prescribed rate) and	c) Application of foam (at the rate of 1 gallon per minute per sq.ft) and	
d) Employment of Dry chemical extinguishers or CO_2 – Extinguishers.	d) Employment of CO_2 extinguishers.	

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CHAPTER 27

FOAM AND FOAM MAKING EQUIPMNT

1. **Introduction**

Most commonly and generally fires are extinguished by cooling the burning material to below its ignition temperature using water in the form of a jet or spray, depending upon the type of fire, however, water cannot be used to extinguish fires in liquids which are lighter than water i.e. if water is applied they float on the water. In such cases, fires are extinguished by forming a blanket of froth (Gas filled bubbles) on the burning liquid surface. This froth is lightest amongst all liquids and is termed as firefighting foam. In this subject. types of foam. their generation etc. is discussed.

2. **Area of Application**

Foam can be used primarily for liquid fires. However, it can also be used for:

(i) Extinguishing fires in enclosed spaces where access is difficult, such as ship hold, basements, sewers and ducts.

(ii) Extinguishing fires in the places of high fire risk, such as, tyre stores, spills.

(iii) Inserting storage tanks during repair or demolition.

(a) **Chemical Foam**

It is normally used in old type portable extinguishers and produced by mixing the aqueous solution of sodium bicarbonate and the solution of Aluminium Sulphate. In the pro cess of mixing, chemical reaction take place producing Carbon dioxide which agitates the solution to produce froth (foam). Thus, in chemical foam, bubbles contain carbon dioxide whereas in mechanical foam, bubbles are filled with air.

(b) **Mechanical Foam**

Mechanical foam may be defined as expanded water or air-filled bubbles. This is produced by aerating (mixing air) the foam solution (water+ foam concentrate).

Water+ Foam Concentrate → Foam Solution → Mechanical Foam

↑↑↑ Air

3**. Foam Concentrates**

It is a concentrated aqueous solution of foaming agents and surfactants, such as hydrolysed protein or fluoro-chemicals. Also, it contains:

(i) **Preservatives**: To prevent formation of bacteria.

(ii) **Iron Salts:** These are added to protein foam concentrates to make the foam more fire resistant.

(iii) **Anti-freeze agents**: For preventing freezing of foam concentrate liquids.

(iv) **Solvents**: To reduce viscosity.

(v) Stabilizer: To stabilize the foam bubbles 1.e, preventing breaking of bubbles quickly.

(vi) Corrosion inhibitor.

4. **Types of Foam Concentrates**

The most commonly used foam concentrate includes.

(a) **Protein Foam Concentrate**: -This is a solution of hydrolysed proteins and generally contains 5 to 10 per cent of Sodium Chloride. It is usually the cheapest foam concentrate. Protein foam can be used on most hydrocarbons but not on water miscible liquids or deep pools of low flash point oils. It is mixed at the rate of 4% to the water for making foam solution.

(b) **Fluor protein foam concentrate**: -This is a protein foam concentrate to which fluorochemical additives are added. This is also mixed at the rate of 4% for making foam solution.

(c) **Fluorochemical foam concentrate**: This is a solution of synthetic fluoro chemical surfactants generally used at 3% to 6% concentration for making foam solution.

(d) **Synthetic foam concentrate**: -This is a solution of synthetic detergents used for producing low, medium and high expansion foam. It is generally used at 1.5% to 3% concentration.

(e) **Alcohol-resistant foam concentrate**: This is usually protein foam concentrate with additives to stabilise the bubbles in the presence of water miscible solvents. Generally used at 4-6% concentration for low expansion foam.

(f) **Aqueous film forming foam (AFFE) concentrates: -**It contains fluorinated synthetic hydrocarbons with additional capacity over other foam concentrates, of forming water solution films on the surface of flammable liquids. These are used in concentration of 1% to 3% in water to make foam solution. This type. of foam can be used on deep seated fires Involving class 'A' & class 'B' materials.

5. **Storage of Foam Concentrates**

Foam concentrate is generally supplied in 2 gallons tins, 5-, 20- & 40-gallons drums and kept in stores for long time. To maintain their proper ties during the storage, following precautions are to be taken:

(i) Foam compound should always be kept in sealed (air tight) containers.

(ii) Decanting and re-canning should never be done unless absolutely necessary to prevent sludge formation.

(ii) Foam concentrate drums should be kept in a dry and cool place.
(iv) If a container of foam concentrate has been opened, it should not be kept for use on fire at later date.

(v) No two types of foam concentrate be ever mixed.

(vi) Periodic inspection should be done to ensure that foam concentrate containers are intact.

6. **Action of Foam**

Foam produced by aerating the aqueous solution of foam concentrate when applied on a burning liquid surface has the following main effects:

(i) It cools the burning liquids with water that it carries in suspension.

(ii) Limits the supply of oxygen, it forms a blanket of foam on the burning liquid and prevents the supply of heat from the flame to the burning liquid, thus tends to prevents the formation of vapours.

7. **Properties of Foam**

The properties of foam that influence its firefighting characteristics mainly depend on the following:

(i) Expansion ratio.
(ii) Concentration to be mixed with water.
(iii)Size of bubbles.

The term expansion ratio is used to indicate the increase in volume of water when converted into foam i.e.

$$\text{Expansion} = \frac{\text{Wt. of volume of water}}{\text{Wt of same volume of foam}}$$

Depending upon the expansion ratio, foam is classified into three groups viz

(a) Low expansion foam for expansion ratio up to 50: 1.

(b) Medium expansion foam for expansion ratio from 50: 1 to 500: 1.

(c) High expansion foam for expansion ratio from 500:1 to 1500: 1.

Remember, higher the expansion ratio, larger will be the size of bubbles or vice versa.

The concentration of the foam concentrates to be mixed with water for producing good quality loam depends upon the type of foam concentrate. Normally, it is never more than 6% by volume.

Size of bubbles is an important factor that determines the firefighting characteristics of foam. If the size of bubbles is large, they will break quickly or vice-versa. For good foam, the bubble should neither be too large that will break quickly nor too small that will affect the fluidity of foam when applied on burning Equid surface.

Stability of bubbles is related to the size of bubbles. Smaller bubbles are stiff and will not break quickly thus have high shear stress whereas large bubble will have less shear stress and when applied on fire will quickly break.

Therefore, for a good firefighting foam the expansion ratio, concentration, shear stress criteria should be a compromising value to meet the firefighting requirements.

8. **Foam Making Equipment**

The production and discharge of foam in sufficient quantity on a fire involves three basic functions. These are:

(i) Mixing of correct amount of foam concentrate into the water to make foam solution.
(ii) Mixing of air to the foam solution to produce foam, and
(iii) Discharging the foam so produced on the fire.

The mixing of foam concentrate into water stream is done with the help of inductors, aeration is done by aspirators to produce foam whereas the produced foam is discharged on to the fire with the help of foam branch pipes.

Depending upon the jobs performed by an individual equipment, they are classified into following three groups:

(i) Foam making equipment which performs all the three functions at the discharge point viz. foam branches i.e., FB2, FB5X and FB10, etc. High expansion foam generator and foam monitors.

(ii) Foam making equipment which mixes a correct proportion of foam compound to water stream viz., inline inductor, knap. sack tank.

(iii) Foam making equipment which are designed to mix the foam concentrate and aerate the foam solution to produce foam away from the branch viz., Mechanical foam generators and require a plain branch pipe to discharge foam on to the fire.

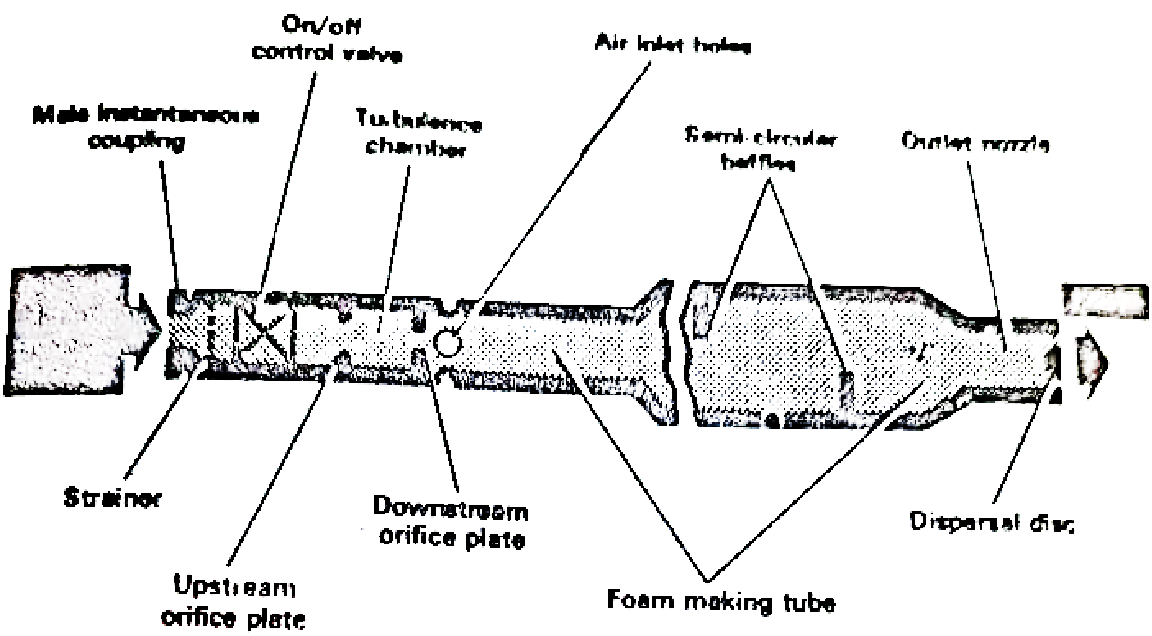
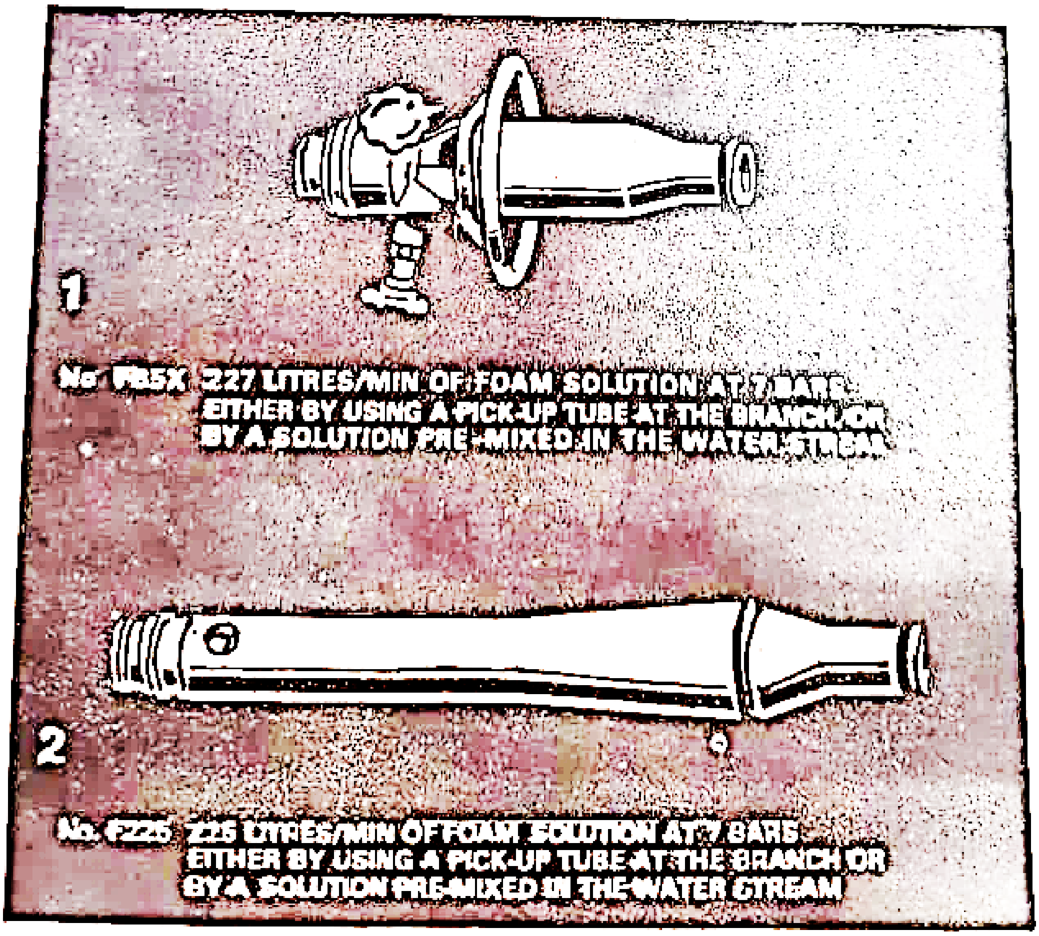


Fig. Diagram showing the mixing of foam inside a foam branchpipe.



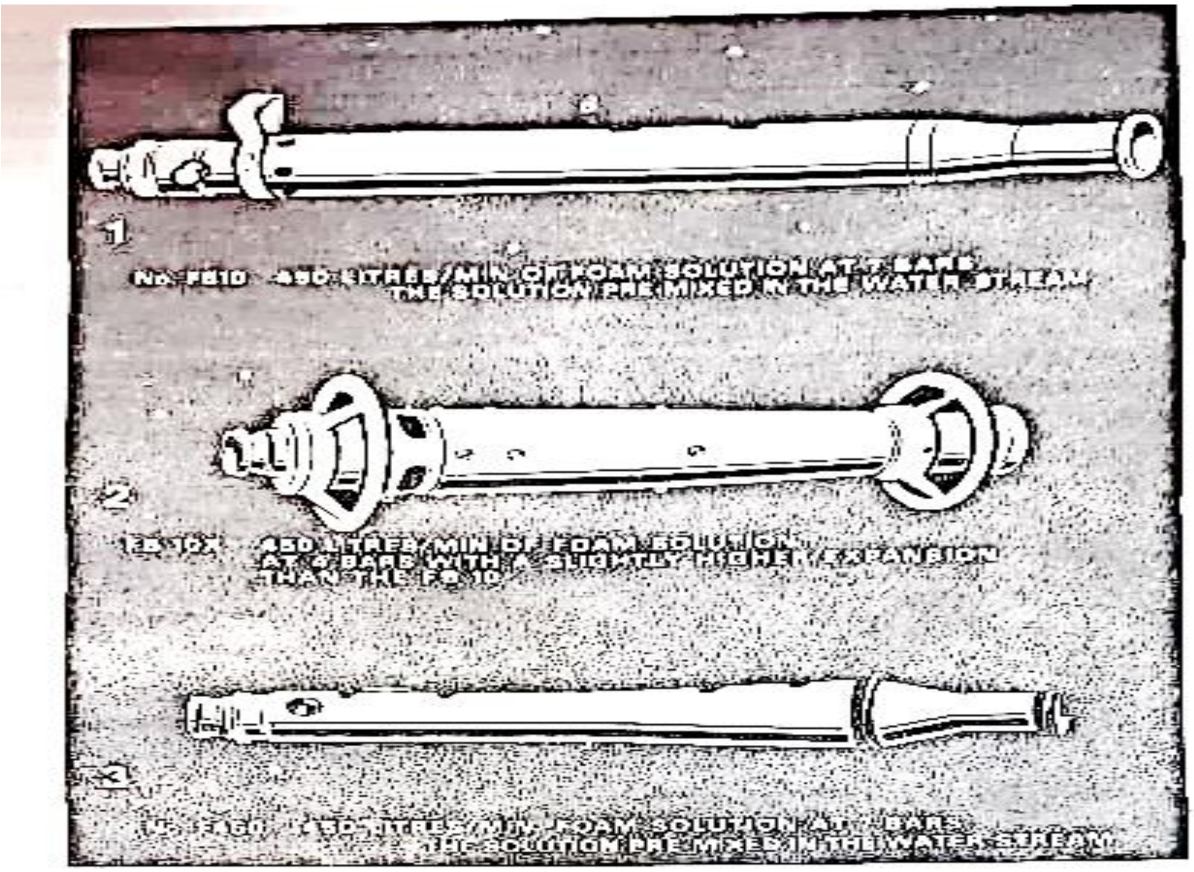


Fig. Foam branchpipes (current types) requiring 450 litres/min

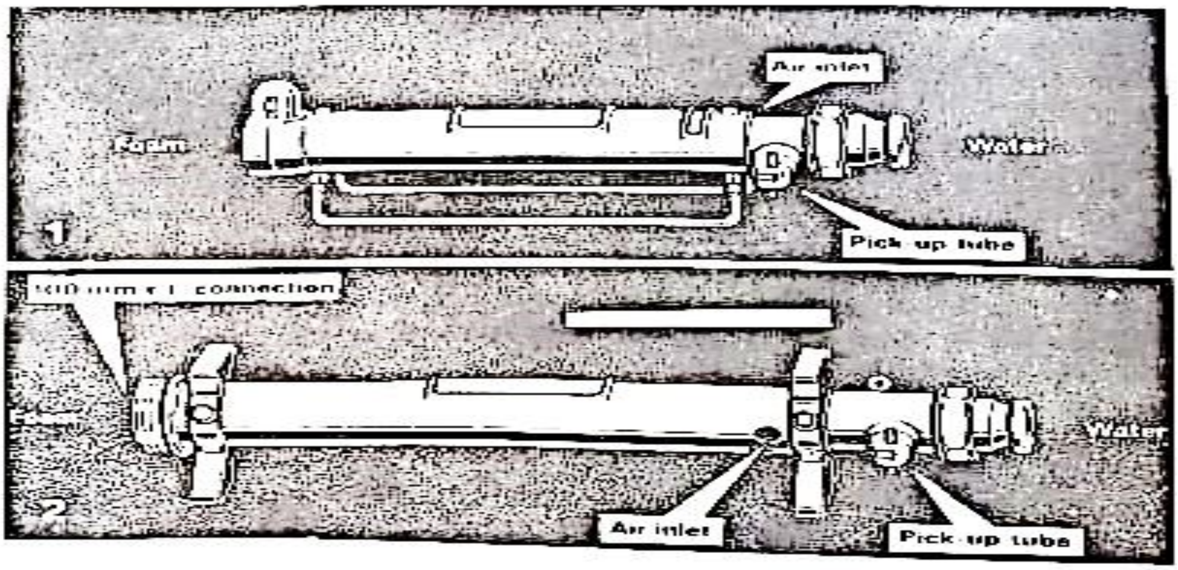


Fig Foam generators (1) Model 5A, (2) Model 10.

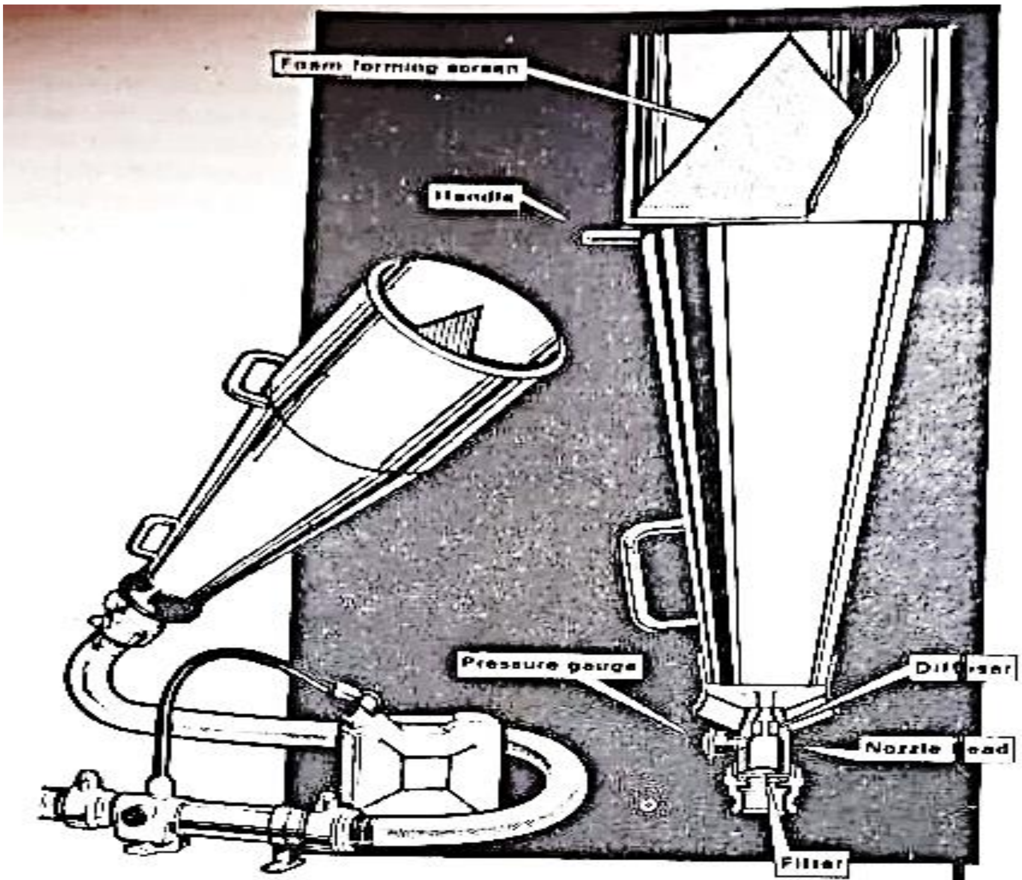
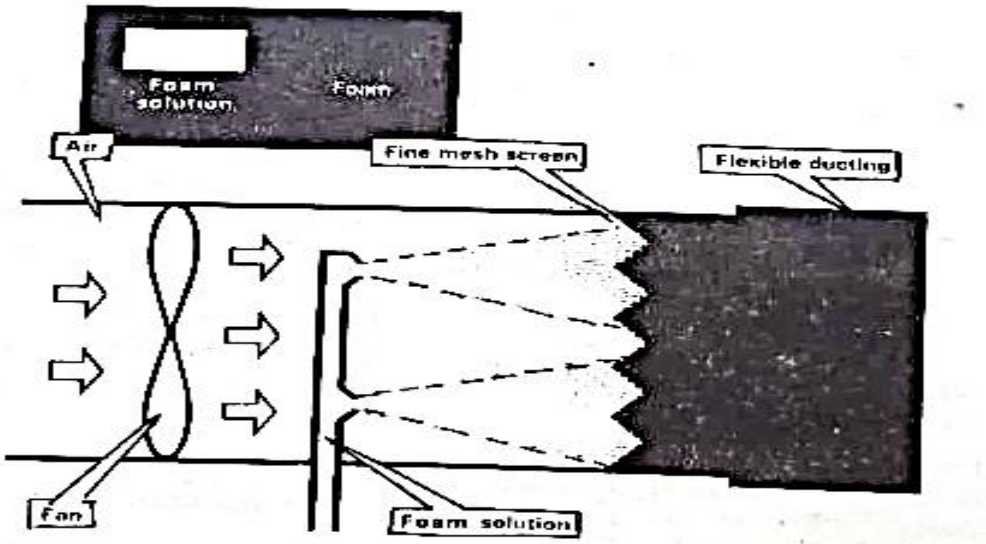


Fig. Diagram showing the principles of operation of a medium expansion foam branchpipe.



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CHAPTER 28

SPECIAL SERVICE

1. **Object**

Rescue of life and property from fire is the primary duty of the fire services. However, the fire services are also called upon to rescue persons from lifts, accidents on highways and railways, aircrafts explosions and petrol tankers catching fire, cliffs, wells, drowning in rivers. building collapses and sometimes to rescue animals as well.

2. **Introduction**

Knowledge of various conditions available at the scene of accident, machinery involved or causing the accident and a thorough grasp of the utility of all types of equipment stowed in: Fire or Emergency Tenders for such purposes is essential.

Special Service calls shall be attended in the same way as a fire call when life is involved. otherwise permission from competent authorities must be obtained for turning out the appliances.

A rescue work may either be.

(a) Rescue by ordinary means,
(b) Rescue using fire brigade equipment.

A fireman shall remain with those who are to be rescued, to infuse confidence. A fireman to carry out efficient rescue work shall develop the qualities of:

(i) Ability.
(ii) Balance.
(iii) Common sense.
(iv) Directional sense inside smoke filled buildings.
(v) Effective improvisation.
(vi) Fine judgement based on experience and
(vii) General capacity to withstand heat and smoke punishment.

Educating the public regarding the "DOS" and DON'Ts will by very useful.

Methodical and systematic search should be carried out at the earliest possible moment. Search should always start at the point of greatest danger, and in the case of multi-storey buildings, the search shall be started at the top of the building and work down. Men shall work in pair. Emergency escapes may be used very effectively. A fireman must be conversant with all the methods of removing a trapped injured or unconscious person to safety. He must also be thorough with first-aid and resuscitation, in using ladders of various types, every fire. man must learn the maximum utility of the lad der, within minimum time. Proper and correct techniques of siting and bridging must be observed while using the Turn Table Ladder or Hydraulic Platform.

Sometimes the stairs or ladders should not be used and lines may be cumbersome and slow. However, whenever they are used they must be to the best use. Occasionally, it may be necessary to lower persons, who are severely injured by lashing them to stretchers. Where a person has to be lowered or hauled vertically. the 'Neil Robertson' stretcher will be very useful. Apart from all this, different self-rescue methods must also be mastered to enable trapped persons or the fireman himself to reach safety in a hurry. To achieve this consistent training is essential.

3. **Rescue from Sewers**

Sewer rescue must be handled with considerable speed. Persons who are trapped are likely to be overcome by "Sewer Gas" i.e. a mixture of methane and sulphuretted hydrogen. Sulphuretted Hydrogen is highly toxic. Every effort should be made to bring the casualty to the surface as quickly as possible to preserve life.

Wearing Breathing Apparatus (preferably enroute to incident) is highly essential. Every sewer "Rescue Party" will have two men. A third man will also go and station himself at the foot of the manhole shaft. All three will be wearing Breathing Apparatus.

Remove manhole covers on other side of the point of entry to enable more daylight to enter. as well as for ventilation.

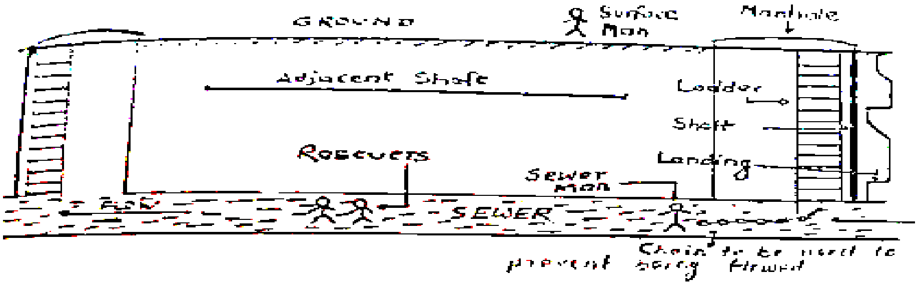
"Surface Man" of the sewer man at work will be able to give the correct location of the trapped persons.

A trapped person might have been carried down stream in the sewer, a considerable distance, In such cases, he must be brought to the surface from the nearest manhole, instead of being brought all the way back to the entry shaft.

For bringing the casualty up, a sling or hoisting harness or Neil Robertson stretcher must be used so that he can be hauled up vertically.

The victim must be given artificial respiration, as soon as he reaches street level, if the ambulance has not arrived by the time.

Illumination must be adequate, since the sewer gas is inflammable, spark proof safety lamps must be used.



4**. Road & Highway accidents**

Highway accidents will vary and the Fire Officer must be able to adapt himself to situations and conditions available in the scene of accident.

In such accidents, the following special types of tools will be highly useful:

(i) Hydraulic lifting and spreading gear.

(ii) Metal cutting tools, preferably power operated.

(iii) Heavy duty gloves to prevent injury to hands.
(iv) Lighting sets.

(v) Pneumatic power saw or songar saw.

(vi) Pneumatic lift sets.

(vii) Electric power saw.

(viii) Tir-for hauling and lifting equipment.

Operational Procedure

The first officer to arrive at a rescue incident may well find a number of willing helpers endeavouring to assist the trapped persons, each one of the opinions that his method is best. Unless, they are achieving satisfactory results. helpers should be requested to stand clear while a calm but careful inspection of the situation is made. Taking into account the rescue, equipment should be made as soon as possible. Where appropriate, alternative methods should be considered and, where practicable. incorporated into the main plan. It is important. however, not to constantly chop and change and the plan the action.

In his assessment of the situation, the officer in-charge should be concerned with the following tasks:

(i) Ensuring the continued safety of his personnel and equipment.

(ii) Dealing with any fires in vehicles where persons are trapped.

(iii) Dealing with any other fires.

(iv) Taking note of special risks, such as vehicles carrying dangerous substances.

(v) Making an inspection of the incident to ascertain the number and location or persons who are actually trapped in vehicles and the number of persons who are not trapped but who will require medical aid.

(vi) Considering the order or precedence in dealing with casualties.

(vii) Organising and directing personnel and equipment to vehicles where persons are trapped.

(viii) Considering whether further special equipment will be required for the extrication of casualties.

(ix) Deciding whether to move casualties to a place of safety whilst awaiting the arrival of ambulances.

(x) Co-operating with other emergency ser vices in the removal of casualties from the scene.

As soon as possible a thorough search must be made to locate casualties and to assess the extent of injuries. It should be remembered that casualties are not always confined to crashed vehicles; valuable information can often be obtained from witnesses of the accident as to the where about of injured persons, some of whom may have been taken into nearby property.

5. **Rescue from Collapsed Building**

Collapse of buildings though rare, always pose problems for the Fire Officer. To extricate persons trapped under the debris, demands a lot of manual work.

Officer-in-Charge of such an occurrence should get the utility services like electricity. water and gas, disconnected to enable safe and easy operation.

Locate the casualties by a quick survey and enquiry, take into consideration the type of pre mises, and business carried on in the building for this purpose.

Large number of persons may be necessary to cope up with the extra manual labour. Hence, it will be very useful to send back an assistance message as early as possible.

Any violent and uncalculated disturbance of debris may affect the trapped victims and shall be avoided.

Precautions shall always be taken to protect the personnel from the dangers of further collapse.

Suitable lighting arrangements must be provided for operations in night.

Each person rescued must be rendered pro per first-aid and sent to hospital for further medical care.

6. **Survey-The Basis of Planning**

If the survey is not done systematically, thoroughly and rapidly, it will not be an easy job to assess the following:

(i) Manpower.
(ii) Equipment.
(iii) Methods employed.

Rescue "Do's"

(a) Do keep yourself calm and cool.

(b) Do carry survey before starting rescue work.

(c) Do examine casualty before removal and see that you give it the proper first aid.

(d) Do free nose and mouth of the casualty from dust and grit to facilitate breathing.

(e) Do protect a casualty from falling debris and dust by using blankets, tarpaulins, corrugated, iron sheets, etc., if the casualty cannot be immediately removed from the site.

(f) Do be careful how you remove debris from the vicinity of a casualty.

(g) Do keep a casualty warm and so reduce shock and have undisturbed.

(h) Do exercise great care while using sharp tool for removal of debris.

(i) Do give plenty of water to a pinned down casually before releasing him

(j) Do keep as close as possible to the wall when on damaged stairs and upper floors.

(k) De arrange for proper medical attendance of the casualty as early as possible.

Rescue "DON'T

(a) Don't move an injured person without rendering first-aid unless he is immediate danger.

(b) Don't crawl over the debris or disturb part of the damaged structures unless you are compelled to do so, by circumstances.

(c) Don't touch live electric wiring.

(d) Don't pull timber out of the wreckage Indiscriminately or you may cause further collapse.

GENERAL DEBRIS CLEARANCE
SELECTED DEBRIS CLEARANCE
SEARCHING LIKELY SURVIVAL POINTS
SEARCHING SLIGHTLY DAMAGED BUILDING
SEARCHING FOR SURFACE CASUALTIES

7. **Rescue from Wells**

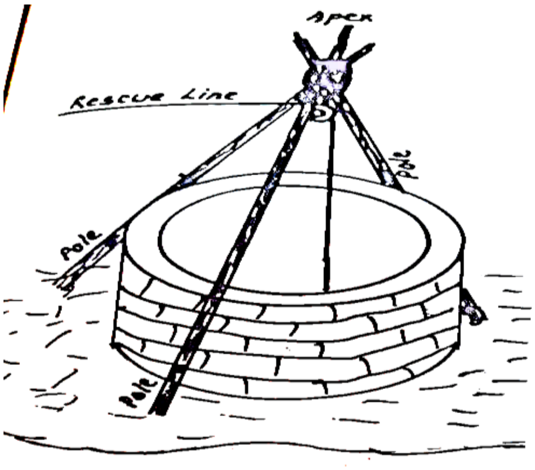
When persons go down a well for desilting. repairing, deepening, they are likely to be trapped, overcome by noxious fumes.

Every precaution must be taken by the rescuer (fireman) by wearing Breathing Apparatus and helmets before going down into a well.

Line used to lower the fireman may possibly cause delay in hauling up the trapped person. hence a second line must be paid out so that the casualty can be hauled in the shortest possible time.

Light, which is quite powerful, must also be taken by the rescuer as the bottom of the well may be dark.

Sheer legs or "Gyn Lashing" for tripods may be used effectively. Lines must never be paid over the parapet wall of the well.



8**. Rescue of Animals**

Animals in danger or pain is sad and distressing to the public. Rescue of such animals shall always be tackled, as long as the lives of fire man are not at risk.

Never approach a trapped animal from the front, but only from the nearside or rear. It will be highly useful to have the owner of the animal along to pacify it.

Many S.P.C.A. (Society for Prevention of Cruelty against Animals) establishments are provided with special gear for such purpose and their services must always be utilised by co-ordination.

A net, called "Pig Net" is useful for small animals like cats, pups and are normally available with the S.P.C.A. establishments.

Lead the animals rescued away from the scene of accident, as they tend to return to the place and get trapped again. It will be preferable to have a Veterinary Surgeon to treat the animals for injuries, etc. after being rescued.

Regular and proper upkeep of all gear used for special services stowed on Emergency or Fire tenders is highly important.

Keeping up the personnel in touch with the techniques with constant training will be highly useful.

Saving human as well as animal lives and property is a primary responsibility of the Fire Services and should never be forgotten.

9. **Persons Rescued from Rivers Etc.**

Fire service is, from time to time, called on to rescue persons in danger of drowning, and is sometimes summoned to assist in reviving the apparently drowned with the aid of artificial respiration and resuscitation apparatus-since the fire service personnel are trained in first-aid and handling of resuscitation apparatus. While dealing with a drowning case, the resuscitation should be started immediately, even when the rescuer is still in the water. In this case, the lungs should be ventilated as soon as the rescuer can get his feet on the ground and should be continued while wading ashore with the casualty.

Persons rescued from water will be suffering from shock and exposure and should be kept warm while awaiting an ambulance.

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CHAPTER 29

ELECTRICITY

1. **Introduction**

The presence of an electrical installation at or close to the scene of fire is an added risk to the firemen, although, if the electricity can be isolated, the extra hazard is completely removed and the extinguishment of the fire can proceed, the extinguishing media to be used depends on the material that is burning. It is no longer considered that electrical fire constitutes a 'fire class in themselves. Since any fire involved or started by electrical equipment must in fact be a fire of class 'A', 'B' or 'D'. It is only when the current cannot be cut off then special extinguishing agents which are non-conductor of electricity with some other specific properties will be required.

2. **Current, Circuit, D/C & A/C**

Electricity when flowing through any conductor is called electric current and the path provided for it is known as electric circuit.

Electricity is generated and distributed either as a direct current or as a alternating current. Direct current always flows from positive to negative terminals. But in alternating current there is a rapid change in direction of flow called a cycle, which occur many times per second and is known as frequency.

3. **Generation of Electricity**

Electricity may be produced by mechanically or electrically:

(i) **Mechanically:** When it is produced by rotating a coil wound on a soft iron piece. called armature wire, in a magnetic field.

(ii) **Chemically**: When it is produced as a result of chemical reaction (in different types of batteries).

4. **Insulator, Conductor and Resistance**

The material which offers resistance to the flow of electricity is called as insulator and that which provides the little or no resistance is a conductor.

The resistance of a conductor is that property by virtue of which it opposes the flow of electricity through it.

The resistance of a conductor depends on the following:

(i) Length of conductor
(ii) Cross-sectional area.
(iii) Temperature
(iv) Material

The unit of resistance is ohm.

5. **Volts, Ampere and Watt**

The flow of current is measured in the unit ampere, power (potential difference) of electricity is measured in the unit volt. The power of electricity is measured in the unit watt.

Current X Potential Difference = Power
Ampere X Volt = Watt

6. **Heating Effect of Current**

When electric current passes through a conductor, a part of electrical energy is converted into heat energy.

If, heat 'H' is developed in a conductor of resistance 'R' in 't' seconds when a current 'C' is flowing through it. Joule's law states that:

H C^2 when R & t are constant

8

H … R when C & t are constant

H t when C & R are constant

i.e. H C^2Rt H=K C^2 Rt

when H is in calories. 'C' in amp & R in ohm

K=0.24

H-0.24 C^2 Rt calories.

7. **Fuse**

Fuse is incorporated in an electrical installation as a protective device to combat against the hazard of burning the insulation and thereby cause damage due to very high current flow.

When an electric current passes through a wire, it generates heat. When wiring of the cables are installed the size of the fuse is calculated on probable maximum current it will be expected to carry. Due to excessive load or accidental contact between the positive and negative, a very high current will flow through the conductors which will become hot and can burn the insulations. In order to avoid that, a metal alloy of low melting point (called fuse wire) is inserted at a suitable point in the distribution system. This short wire of special alloy will melt at a predetermined temperature with the increase of current before reaching any dangerous stage and thereby disconnected the supply.

8. **Short Circuit**

When entire quantity of current rushes through a much shorter path than that it is designed for a circuit due to accidental connection between the positive and the negative wire. it is generally called short circuit and there might be a fire or explosion due to that.

9. **Generator**

A 'Generator' is a machine, which generates electricity and produces a difference of voltage between its terminals. It may be termed as "Dynamo", it produces direct current, or "Alternator", if it produces alternating current. When the terminals are connected with metallic object, the power pressure or voltage sends an electric current through the metallic object, in its attempt to equalise the pressure or voltage between the terminals.

10. **Electric Motor**

If a current carrying coil is allowed to turn freely in a magnetic field, it will acquire Kinetic energy. If this turning could be made to continue we would have a steady conversion of electrical energy to mechanical energy. Any device for doing this is called an electric motor. The action of motor is opposite to a dynamo.

One D. C. motor mainly possess a field magnet, a commutator and an armature.

The armature coil rotates continuously due to transformation of electrical energy into mechanical energy.

11. **Transformer**

Transformer is an electrical device to increase or to decrease the voltage:

Types:

(i) Step up-To increase the voltage.
(ii) Step down-To decrease the voltage.

The big transformers are normally found in:

(i) Electric Generating Station.
(ii) Electrical Sub-Station
(iii) Factories (Heavy)/Industrial Under taking.
(iv) Roadside Electrical Junction.

12. **Use of Electricity**

Electricity is utilised mainly for lighting, heating and obtaining power for different purposes either in domestic occupancies or in industrial undertakings.

13**. Static Electricity**

When two non-conducting substances are rubbed against each other, a static electricity is produced which as its name signifies remains static within the body of the substance involved.

The quantity of charge may be very small but the voltage may be very high and as a result there may be sparks when this voltage is dissipated to the earth by accidental touch of a man standing on earth barefooted or any other conductor coming in contact with it. In industrial undertakings, the generation of static electricity is quite common.

The voltage may be quite sufficiently high to cause a powerful spark. Care should, therefore, be taken to ensure that the machineries etc are properly earthed to dissipate static electricity.

Dissipation of Static Electricity:

(i) By proper earthing.
(ii) By conductive rubber.
(iii) By Humidifier.
(iv) By Static Eliminator.

14. **Danger on Improper Use and Bad Maintenance:**

Fire hazards of electricity originate due to:

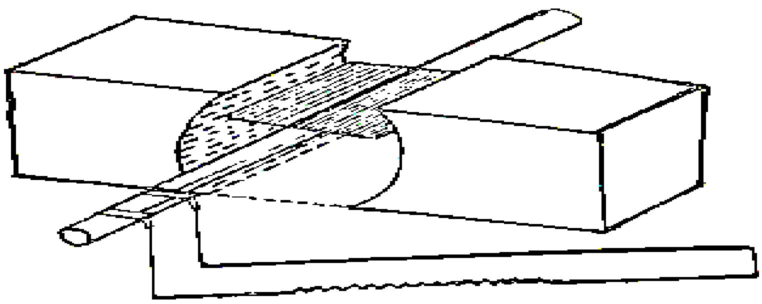
(i) Improper fuse
(ii) Bad workmanship
(iii) Bad maintenance of the installation.

For minimisation of hazard, the following safety precautions may be adopted:

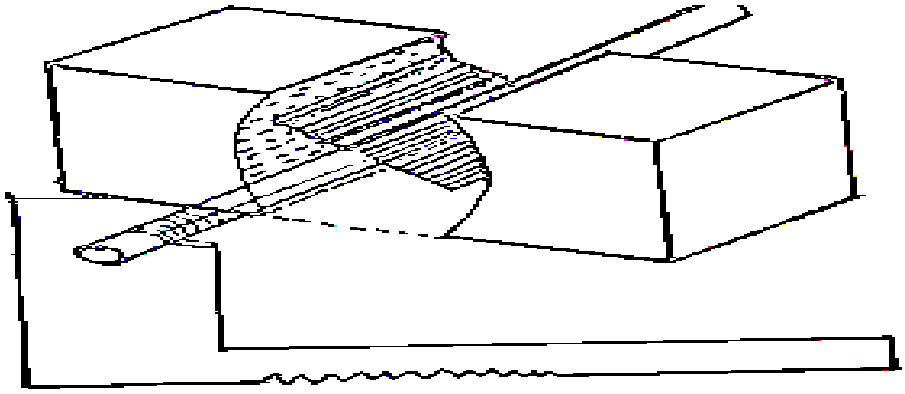
(i) Proper insulation.
(ii) Use of correct size of specified fuse wire.
(iii) Provision for good earthing.
(iv) To avoid excessive load.
(v) Provision of proper circuit and fuse for excess current.
(vi) Proper checking of circuit, fuses, earthing points and of all electrical machineries by competent electrician at regular intervals.

15. **Extinguishers for Electrical Fires**

(i) Co^2 Type
(ii) D. P. Type
(iii) Halon Type



If flow of electricity can be stopped by making switch 'Off' or cutting the circuit, water type extinguisher can be used on fires in ordinary carbonaceous materials close to an electric circuit.



Simple generators: If ends of moving coil are joined to split ring (above). current flows only in one direction. If ends are joined to two brass rings (right). current flow alternates.

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CHAPTER 30

SMALL GEAR

Introduction

It is important that the Fire Officer should have requisite knowledge of the application and utility of various Fire Service equipment such as Hose, Hose fittings, Ladders, B. A. Sets and a miscellaneous tool carried on the appliances. The miscellany of tools and equipments which cannot be grouped under any other heading. are referred to by the term "Small Gear".

(i) Items under "Small Gear" appear to be heterogeneous, but have been carefully selected after years of practical experience. These tools are not similar in size or shape or material or function, but they are of great utility in practical firefighting and rescue.

(ii) All small gears shall be stowed properly to enable the crew members to get at it even in the dark. Hooks, slots, brackets and straps are used to keep the small gears in appliances.

(iii) Most of the small Gears require little maintenance.

(iv) It is highly important, in the interest of the safety of the personnel to remember that the equipments having insulated handles like the Fireman's Axe, pliers, etc. shall be used only after observing necessary precautions on live electrical installations.

(v) Grouping: Small Gear is grouped thus:

(1) General purpose Tools and Equipments.
(2) Miscellaneous special tools and equipment.
(3) Lamps and lighting sets.

1. **General Purpose Tools and Equipment**

A. Conventional Tools:

(i) **Spades or shovels:** They have steel blade and a wooden handle. A Shovel has square sides and a spade has rounded sides. Some may have longer handles.

Uses: To remove mud, scrape, scoop up a dam across small shallow stream. cut shrubs and brush.

(ii) **Pickaxes**: A crescent shaped steel head having two sharp ends, with a wooden handle.

Uses: To dig or turn over.

(iii) Mattock: A steel head with a point on end and a shoe on the other, with a wooden handle.

Uses: To dig, turn over, scrapping.

(iv) Large Axe: A forged steel head having a fine cutting edge, with a well-balanced wooden handle.

Uses: To cut through wooden partitions like doors, screens and chop-up.

(v) Sledge Hammers: A Steel head which may weigh 3 or 14 pounds with a wooden handle.

Uses: To break through, and in conjunction with cold chisels and wedges.

(vi) Steel Crow Bars: A steel bar of about 3 feet length. with one or both ends shaped at an angle, may be claw shaped at one side.

Uses: To lift of sliding doors, or doors. off hinges, knock down unsafe walls. structures, break open locks in con junction with sledge hammers, pull off nails from floor boards with claw shaped end.

(vii) Steel Wedges: Steel pieces of varying lengths tapering in shape, operated by percussion. in conjunction with hammers,

Uses: To drive in the wedge to keep a cleft open, dilute fissure, tighten or secure some part of a structure.

(viii) Carpenter's Hammer: A steel head flat at one end and clawed at the other may have ball point to get better hammering effect with a wooden handle.

Uses: To hammer break, pull of nails. flatten shape edges.

(ix) Saws: A steel blade with teeth, cut on one or both sides with a wooden handle. Uses vary with types of teeth.

Different Types and Uses:

(a) Cross cut saw	-To saw heavy timber.
(b) Ripe saw	-To saw heavy and wet timber.
(c) Hand saw	-To door/ window frames and small timber.
(d) Floor saw (cockerel saw)	-To saw off floor boards.
(e) Key hole saw	-To saw through a key hole to open the door.
(f) Tenon saw	-To saw precisely.
(g) Circular saw (Power operated)	-To saw through floors, wooden partitions.
(h) Chain saw (Power operated)	-To saw heavy timber, cutting a fire break in forest fires.
(i) Hack Saw (Detachable blades)	-Only saw used for cutting metal.

(x) Wood chisels: A forged steel blade of varying width, with a wooden handle. used in conjunction with a mallet.

Uses. To cut wooden boards, partitions, timber.

(xi) Ratchet-Braces and Bit: Drilling machine, utilising the ratchet and bend for fast drilling. The bits are detachable.

Uses: To drill holes through wood or metal, using suitable bits.

(xii) Screw Drivers: Long steel rod of varying lengths, with a wooden handle. The working edge is flat or cross pointed.

Uses: To unscrew screw, threaded screws, bolts, repair vehicles engines.

(xiii) Spanners: Forged steel of cast iron pieces with recess or ring or sockets at one or both ends. The spanners, which are socket shaped are pieces used in conjunction with tommy bars.

Types: (a) Single Ended (b) Double Ended (c) Ring (d) Box (with Tommy Bar) (e) Ring (with Tommy Bar) (f) Adjustable.

Uses: To tighten or loosen bolts or nuts, repair vehicles engine.

(xiv) **Wrenches:** Forged steel pieces similar to spanners, but bigger in size. Types: Pipe wrench, stilton wrench. Uses: To tighten or loosen bolts and nuts, and pipes.

(xv) **Hack Saws**: A steel frame, which can be adjusted to take efficient length blades with teeth. Blades are made of glued steel and have very fine teeth cut on one side.

Uses: To cut metal padlocks, window or door bars, railings.

(xvi) **Breast Drilling**: Drilling machine utilising the ratchet and bevel drive mechanism. The name is because of the fact that the operator can bring his weight to bear for quicker drilling applying his breast on the crescent shaped pieces at the head.

(xvii) **Pllers and Wire Cutters**: Forged steel cutting bits operated by long handles for better leverage. The handles may or may not be insulated.

Uses: To cut wires, bend metal bars. Insulated handle pliers can be used for cutting live electrical wires, only after taking the recommended precautions.

B. **Specialised Equipment**:

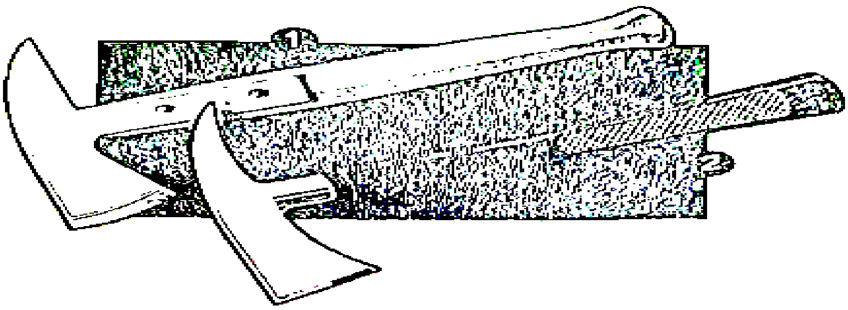
(i) Fireman's Axe: A personal gear carried by every fireman on his belt with the pouch. It is also carried with the hook belts.

A steel head with an axe head on one end and a point or spike on the other with a wooden or rubber insulated handle.

(a) **Fireman's Axe with wooden handle**: A head with specially hardened steel, polished and treated with clear lacquer with seasoned wood handle. The head is secured with counter sunk rivets.

The overall length of the axe is 15 inches (37.5 cm) and weight between 2 to 2½ pounds (1.5 kg).

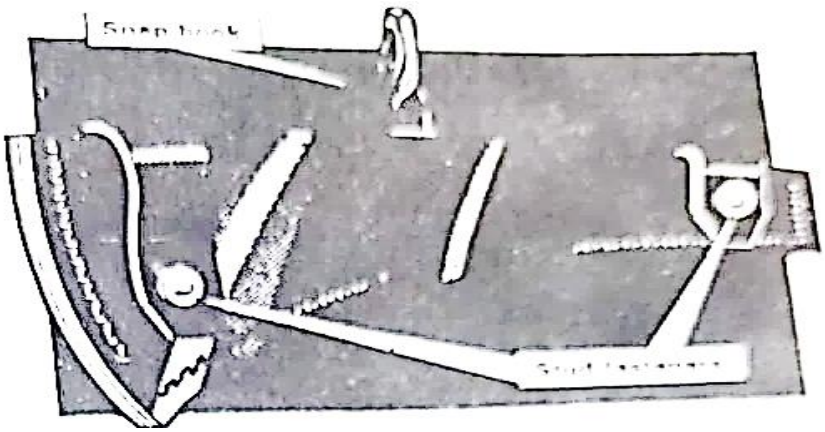
The wooden handle shall not be considered as a complete protection against electricity.



(b) **Fireman's axe with insulated handle**: A head with specially hardened steel having a tang. Black rubber handle with chequered grip moulded on to the tang and vulcanised for insulation.

The overall length is 15 inches (37.5 cms) and weight between 2 to 2½ pounds (1.5 kg). They are subjected to an electrical test of between 20,000 volts to 25,000 volts but shall not be used against current higher than 3,000 volts.

Uses: To cut live electric wires. After observing all precautions to twist off padlocks, to cut through wooden obstructions in emergency to break glass side panels.



Maintenance: The insulated handle shall not be unnecessarily exposed to heat. It shall not be allowed to come into contact with oils, grease, turpentine, motor spirit, acids or any other type of solvents. Should It get soled at all. It shall be washed Immediately with soap and water and then dried. Should tar or paint fall on the insulated handle, they shall be removed by Carbon-Tetra-Chloride and washed off with soap and water and properly dried.

They shall be visibly examined once in six months or after use in an incident for damage like cuts, scratches and punctures. If any damage is detected, it should be got re-tested, for insulation.

(ii) **Celling Hook:** It is wooden pole of 7 to 8 feet length (2.5 m or 2.75 m) fitted at the top with a steel point, having a spur at right angle to it. The point and spur are 4 inches long each.

This equipment is referred to by the I. S. I. as "Fire Hook". The Fire Hook has a curved hook. in place of the spur in the ceiling hook. The fire hook shall be tested once in a month or after use at an incident by applying the weight of two men (140 kilograms appx.) to the handle while the hook is engaged on the spur. It shall be visually inspected for bend and or dent after the test.

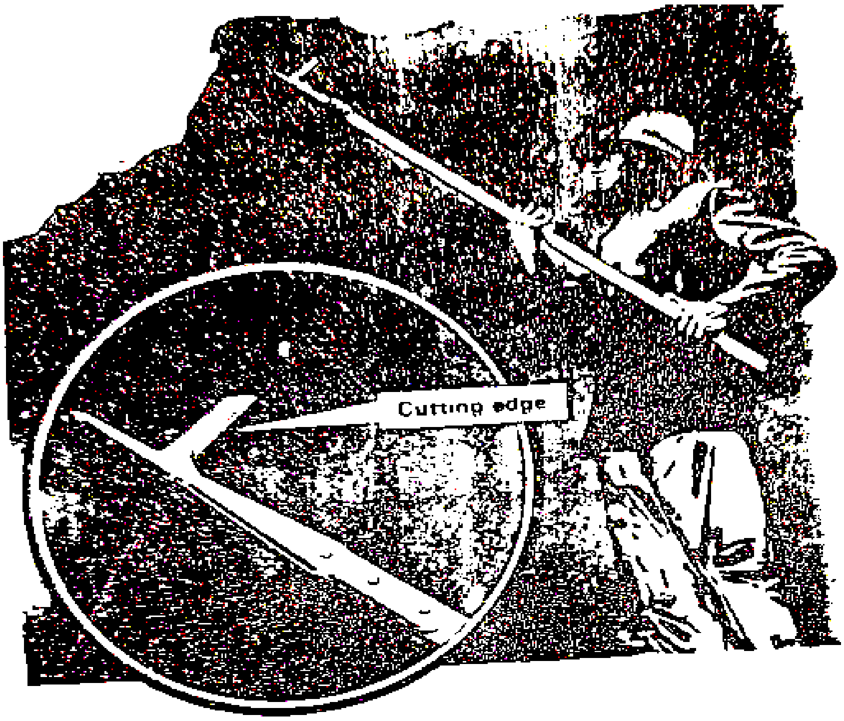


Fig: Ceiling hook

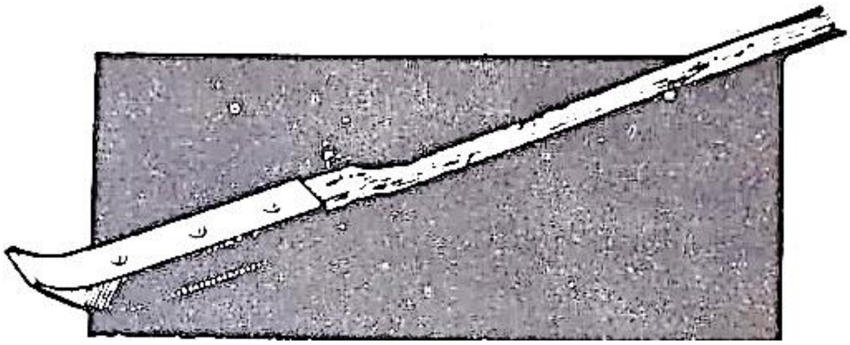
Uses:

(i) To pierce ceiling, so as to drain water from higher floors.
(ii) To pull down thatched roofs.
(iii) To pull down bales or bags, standing at a safe distance.
(iv) To open or close doors of railway wagons and buildings from a safe distance.

(v) To operate the Fireman's Switch.
(vi) To turn over in the fire ground.
(vii) To pull down hay stacks.
(viii) To remove live electrical wires from over casualties.

(iii) **Steel Shod Lever**: A straight wooden shaft of 2 inches diameter with 3 inches square end on one side. The shaft is of seasoned ash. A heavy iron shoe with a slightly upturned chiselled shaped tip rivetted to the squared end.

Uses: To break open steel doors, to get access through any other construction by breaking, or lowering them off, for turning over operation, for lifting heavy object like stones, timber etc.



(iv) **Canvas Buckets:** Buckets made of can vas of varying sizes. Since they are made of canvas, they can be collapsed for easy storage.

Uses: To fetch water from short distances for drinking purposes in the fire ground, to pour water in header tank of pumps or radiators of vehicles, may also be used with stirrup pumps in an emergency.

Maintenance: Shall be properly dried before storage, as they are likely to be affected by mildew.

(v) **Electric Power Tools**: Power operated tools are normally carried in Emergency Tenders, like portable Electric Generator. Some Tools are operated by petrol engines too. They may be:

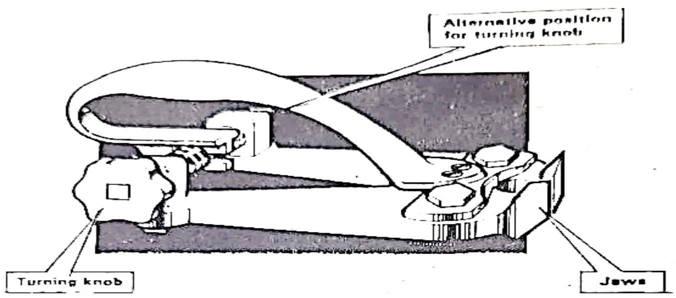
(a) Drills. (b) Chain/Circular Saws. (c) Smoke Exhauster, Blower.

2. .**Miscellaneous Special Tools and Equipments:**

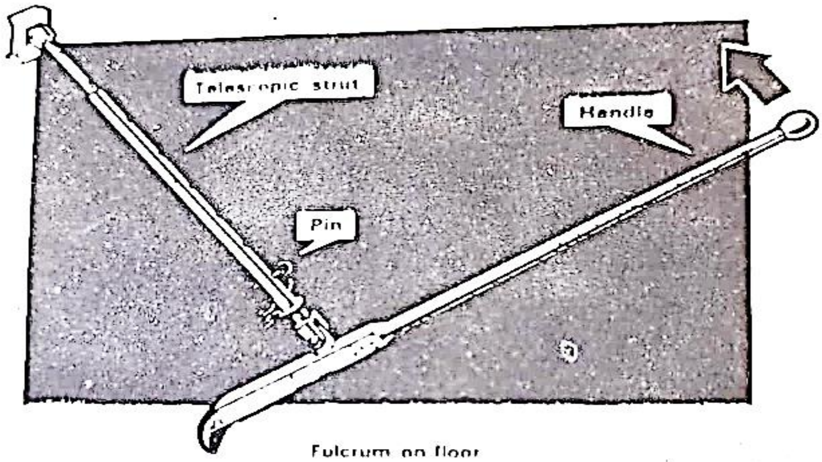
(i) Cutters: To break into locked buildings, premises etc.

(a) **Shears**: Similar to gardeners shears, but having short jaws (bills) for cutting metals, and long handles for better leverage. The jaws may have slots to accommodate larger size of rods. Some shears have the jaws moving on bill joints, to facilitate cutting at right angles. Limitation cannot cut specially hardened steel.

(b) **Bolt Cutters**: A special tool made of steel. The jaws are operated by turning knob. Operates on the principle of threads.
Uses: To cut specially hardened steel.
An alternative is the hack saw.



(ii) **Door Breakers**: A proprietary tool, applying the principle of the "LEVER". One of the types has a steel lever to which head of the telescopic strut is pivoted. A claw plate is pivot ted at the head of the telescopic strut. The fulcrum of the lever is placed on the floor and upward pressure is applied on the lever handle. This exerts sufficient force on the claw plate which is placed on the door, and breaks the door open. There are other types known by the names "Alexander" and "Baderman".



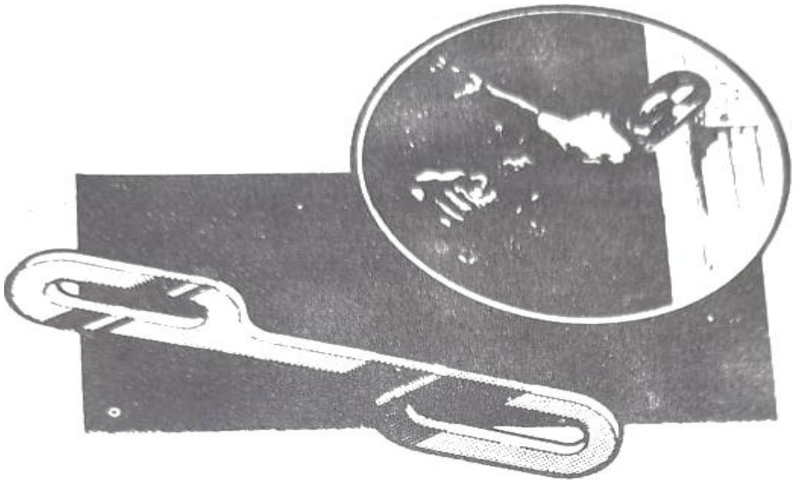
(iii) **Padlock Remover**: A steel plate lever having two rectangular openings to suit padlocks of different sizes. The padlock is inserted into the suitable opening and is twisted to force open the padlock.

Uses: To break open padlocks and hasps.

(a) Insert the end of the crow bar in the hasp and strike the crow bar sharply.

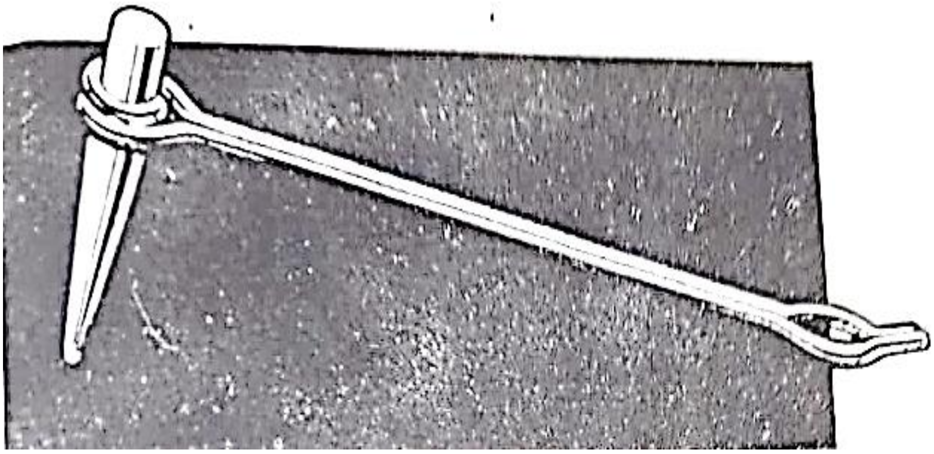
(b) Knock off the staples of the hasp with an axe.

(c) File off the screw nail which secures the padlock and remove the screw.



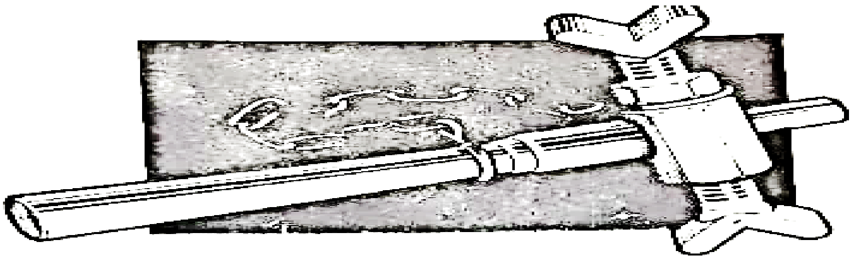
(iv) **Persuader**: A steel piece shaped like a cigar, tapering at one end. It cannot cut metals or other objects as the point is rounded. It is inserted into the loop of the hasp end and the head is struck with a sledge hammer. It breaks the hasp by its expanding effect. A wire handle is attached to held it in position safely.

Use: To break upon hasps, padlocks.



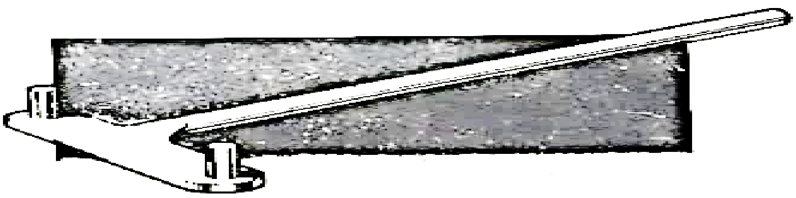
(v) **Spreader**: An internally threaded nut. which carries two "Y" shaped lugs with threaded stems. On the centre of the nut is a hole for the tommy bar. The "Y" shaped lugs are placed against the railings, and the nut rotated. spreading the railings outwards.

Use: To release trapped persons/animals from railings.



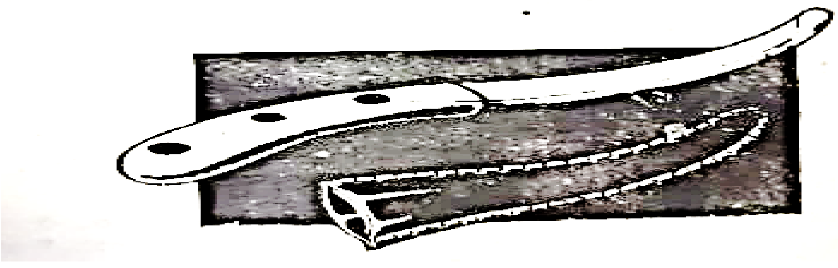
(vi) **Bending Bars or Wring Irons** : A four feet long steel handle have a steel plate at right angles. Two lugs are provided at either ends of the plate.

Uses : To release trapped persons/animals from railings.



(vii) **Quick release knife** : Knife having a slightly curved steel blade which is razer sharp. The tip and outer edge are thick and rounded.

Uses : To release persons from foulded harness or seat belt.



(viii) **Rural Implements:**

(a) Beaters or fire bats.

(i) **Green Branches**: A handle, 3 to 4 feet long, at one end of which green branches are tied securely.

(ii) **Wire Netting**: A frame of 12 inches (30 cms) width and 14 inches (35 cms) length on to which is attached a piece of wire nett. The frame is fixed to the wooden handle.

(iii) **Gunny Packing**: Small single gunny packing inside which a frame is fitted and then a handle is attached.
Uses: To beat out bush fires etc.

(b) **Forks**:

(i) Lag Hook: A wooden handle fitted to an iron fork at right angles. The fork has prongs.

(ii) Pitch Forks: A wooden handle fitted to an iron fork having two slightly curved prongs.

Precautions: When not in use, the prongs to be pushed into the ground and not lying around with prongs upwards.

(c) **Hay Knife**:

There are two types, one has a sharp edged blade, with a wooden handle at right angles. Another has a saw edged blade with two wooden handles. They are carried in a wooden case. A wet stone is also carried for sharpening the sharp edged type blade.

Uses: To cut burnt portions of a hay stack.

Precautions: Should not be left lying on the ground to avoid accidents.

(d) **Bill hooks and Slashers**:

A straight or curved steel blade fitted with a wooden handle. Slashers have long handle.

Uses: To cut small trees, bushes.

(ix) **Chimney Rods**: A number of flexible sticks or cane, with screw joints at either end. The first rod has a "CHIMNEY NOZZLE" used in conjunction with a hose reel or a stirrup pump.

Uses: To extinguish fires inside chimneys.

(x) Hearth Kits: A hearth kit consists of:

(a) 4 inch bricklayer's bolster. (b) cold chisels. (c) 6 inch insulated plier, (d) 4 pound club hammer .(e) Floor saw (Cockerel saw). (f) Screw Driver (g) Hack saw will spare blades.

Carried inside a Casual bag with compartment.
Uses : To fight fires on hearths.

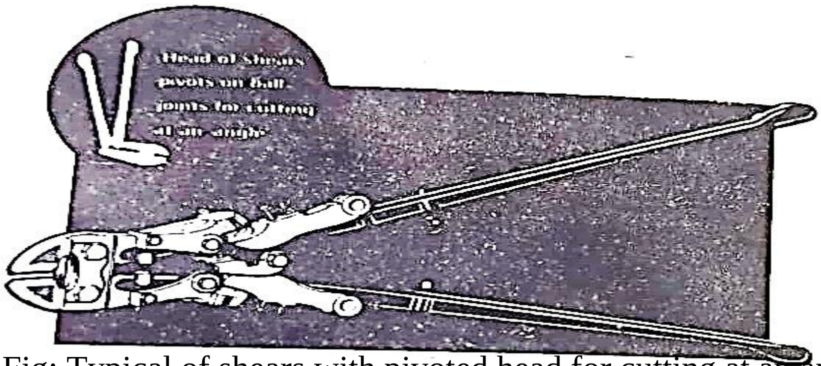


Fig: Typical of shears with pivoted head for cutting at an angle

(xi) **Cold Sets**: Specially hardened cold chisels secured with metal handles. Used in conjunction with suitable hammers.

Uses: To cut metals without heating them.

(xii) **Rubber Gloves**: Gloves made of special rubber. They are tested to 15,000 volts, but are recommended for use up to 3,300 volts.

Uses: To tackle fires involving live electrical equipments.

Precautions: Use liberal quantities of French Chalk to prevent deterioration. All recommended safety measures to be observed while using it. Check weekly by visual inspection. after use in an incident. Get retested once in a year.

(xiii) **Asbestos Equipment**

(a) **Asbestos Blankets**: Sizes vary from 3 feet to 6 feet squares.
Uses: To smoother small fires.

(b) **Protective Clothing**: A complete suit of helmet with visor, coat, trousers, gloves and over boots, made of asbestos.
Uses: To tackle fires on crashed aircraft.

A recent development is a suit made of heat reflecting material. (Aluminised Asbestos Fabric). This is used as an approach or an entry suit for rescue purpose against a very high temperature. It requires careful maintenance to retain the reflectivity of aluminium.

(xiv) **Protective Clothing for use with Breathing Apparatus**

To enter into an atmosphere of Ammonia Gas, needs further protection than Breathing Apparatus. A special suit called as "Ammonia Suit" is used.

(xv) **Lifting Equipment**

(a) **Hydraulic Jacks**: Hydraulic jacks of different lifting capacities are used.

Uses: To rescue from under heavy objects.

(b) **Portable Winches**: Winches of different capacity of pulling hauling are used.

(c) **Pneumatic Jacks**: Instantaneous action to rescue persons from capsized vehicles.

Uses: To recover vehicles or materials which cannot be lifted otherwise, after accidents.

(d) **Mechanical Jacks**: Mechanical jacks of different capacities are used.

Uses: To rescue from under heavy objects.

3. **Lamps and Lighting sets**

(i) **Electric Hand Lamps**: Operating on dry cells, a bulb and a reflector, are very useful

(ii) **Portable Electric Box Lamps**: Operating on Accumulators, are capable of giving sustained and better light.

(iii) **Safety Lamps:** Made with gas light joints, so that they can be used in atmosphere full of burnable vapour or gases and operating on accumulators, give sustained and safe light. Used in conjunction with B.A. sets

(v) **Hurri-cane Lamps**: Burns paraffin using a wick. A frame made of metal has a glass funnel fitted.

Uses: To work in darkness a place with insufficient light, inside deep well, sewers etc.

Precautions: The calls/accumulators where utilised shall be kept in good conditions.

The glass funnel shall be cleaned, wicks trimmed properly and the tank of paraffin kept filled up always.

(v) **Flood Lights and Search Lights**: These are lights used either for flooding an area with light or to focus powerful beam light across some distance. They are powered by either vaporised paraffin with incandescent mantles or by electricity.

(a) Electric Search-lights and flood lights.
(b) Carbide lamps.
(c) Dissolved acetylene flood lights.
(d) Vaporised paraffin flood lights.
(e) Propane Butane flood lights.

Uses: For lighting large areas for fire-fighting purposes or concentrated light for rescue purposes,

4. **Maintenance of Small Gears**

(a) Materials made of iron or steel shall be checked daily for rust or stain.

(b) Storage area shall be such that there is no dampness.

(c) Anti-corrosive paint shall be used to prevent rusting.

(d) Precise workmanship, shall be cleaned and polished carefully.

(e) For parts or equipment made of wood, care shall be taken to see that they are not damaged by white ants.

(f) Care shall also be taken to prevent damage by fungi, etc.

(g) A coat of varnish or paint shall be given for preserving all wooden parts.

(h) Rubber equipment shall be kept under ideal conditions of temperature for storage. They are not to be subjected to excessive heat or a very low temperature.

(i) They shall not be allowed to come into contact with oils, or solvents.

(j) Liberal use of French Chalk shall prevent hardening and cracking of rubber equipments.

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CHAPTER 31

STORAGE OF HAZARDOUS GOODS

1. **Introduction**

The object of introducing the subject matter is to enable the Fire Officer to assess the fire hazards and to take suitable measures to minimise the hazards and to obtain better salvage results when involved in a fire

The term hazardous in reference to fire risks is applied to materials of the most widely differing nature, the list of hazardous goods ranges from dynamite to paint, from celluloid to quick lime, from petrol to camp her. The quality that renders one substance hazardous may be entirely absent from some other hazardous goods. The following characteristics have to be considered in deciding whether the designs Bon, hazardous should be applied.

(a) Explosive tendencies.
(b) Highly inflammable.
(c) Liable to intensify a fire.
(d) Generate intense heat when burning.
(e) Liable to extend the fire zone.
(f) Difficult to extinguish.
(g) Spontaneous combustion tendencies.

2. Hazardous goods may be grouped as follows:

(a) **Oils**: Mineral oils and allied substances: coal and derivatives from foregoing e.g., petrol, Naphtha. Benzene etc.

(b) **Acids**: e.g., Nitric acid, Picric acid etc.

(c) **Oils**: Animal, fish, vegetable, ethereal, and allied or derived substances e.g. Cod oil, Linseed oil etc.

(d) **Alcohols**: e.g., Absolute alcohol, methylated spirits etc.

(e) Organic inflammable liquids. Esters, Ethers and Solvents e.g., certain disulphides, acetone etc.

(f) Explosives and allied substances, e.g., Ammunition Nitro-glycerine etc.

(g) Nitrates and Nitrites e.g., Ammonium Nit rate, Potassium Nitrate etc.

(h) Chlorates and perchlorates e.g., Barium Chlorate, Ammonium perchlorate, etc.

(i) Peroxides e.g., Barium Peroxide, Sodium Peroxide etc.

(j) Metallic powders and metals e.g. Aluminium powder, Magnesium powder etc.

(k) Cellulose products, paints etc. e.g., Celluloid, Cellulose lacquers etc.

(1) Gases e.g., Acetylene, Hexane etc.

(m) Various solids e.g., calcium carbide, phosphorus (white, yellow).

3. **Considerations affecting Storage of Hazardous Goods**

In the case of a great many substances, the conditions under which they are kept such as their environment, association with other goods, storage in bulk etc. need to be considered in the light of their chemical at tributes.

Where a building is reserved for storage, the matter is of importance. It is of still greater con sequence where the building also serves as a factory for carrying out processes which may involve artificial heating, because allowance must then be made for the influence of such processes in relation to hazardous goods.

4. **Main Considerations**

The first point is to avoid a fire being started as the result of storage under inappropriate conditions.

The second point is concerned, with the avoidance of a heavy loss resulting from ill-advised storage arrangement, assuming a fire to originate from any cause whatsoever.

(a) **Inception of Fire**

(i) Spontaneous combustion may result if substances that should be kept separate are allowed to combine and set up chemical action. (Result of contact).

(ii) Combustion of certain substances may result from storage in a damp place or one liable to flooding. (Effect of Moisture).

(iii) Combustion may be induced by storage or by handling in dangerous proximity to artificial light of heat (Proximity to Heat or Light).

(iv) Combustion may result from defective construction of the building or disregard of reasonable precautions (Precautions Neglected).

(b) **Circumstances Contributory to Fire Spread**

- Intensification of tire may result from the presence of

  (i) Oxygen custodians.
  (ii) Matter exceptionally Inflammable.

- Extension of fire zone may result from the presence of:

  (i) Inflammable liquids.

(ii) Inflammable solids having low melting point.

- Normal methods of overcoming fires may be rendered impracticable by reason of the presence of: #

Substances which when well alight, cannot be extinguished by water.

The fire brigade may be impeded in their efforts to extinguish the fire, by reason of the presence of: #

(i) Substances giving off noxious fumes.
(ii) Substances violently explosive.

(c) **Systematic Storage Arrangements**

In order that these initial and contributory causes of loss may be eliminated or reduced to a minimum, endeavour should be made to iso late certain substances, to relegate other sub stances to suitable positions and generally to decide storage conditions by first considering the peculiar characteristics of each hazardous substance.

Inception of Fire

(i) **Result of Contact**: Combustion may be initiated by reasons of-

Nitric Acid (Strong): Saturating hay, straw, powdered charcoal or mixing with oil of turpentine (turbos).

Sulphuric Acid (Strong): Suffusing a mixture of chlorides and organic matter, acting on Barium Nitrate, acting on super phosphates associated with Sodium Nitrate.

Potassium permanganate: Combining with Glycerine and Sulphuric Acid or with Alcohol or Ether and Sulphuric Acid.

Phosphorus: Associated with iodine or Potassium Chloride.

Peroxide of Sodium: An organic matter in contiguity. Temp. conditions are favourable.

Oils: Some vegetable and animal oils particularly linseed Oil and also Turpentine, if allowed to soak into cotton waste, hemp, sawdust, lampblack may initiate combustion.

The breaking of a Carboy of Acid or leakage from a container of acid or oil may permit of hazardous goods being saturated with serious results. The lesson to be learnt is that safety lies in effective separation.

(ii) **Effect of Moisture**: Quicklime generate intense heat when slaked with water, carbide of calcium evolves Acetylene gas when wetted. Potassium Peroxide, Sodium Peroxide, Potassium Per sulphate, and sulphur Heptoxide liberate oxygen whilst being dissolved in water.

Bronze powders, powdered Magnesium. Powdered Aluminium, Powdered Zinc, metallic Potassium, and metallic sodium, all tend to liberate Hydrogen when exposed to moisture. The chemical action develops considerable heat, combustion is liable to be initiated and ignitable matter in close contact may be set on fire.

These substances must be stored where they will be kept dry from damp atmospheric conditions, not liable to be wetted by flooding, and it is also desirable that the place should be cool. as well as dry.

(iii) **Proximity to Heat or Light: -**These sub stances which give off an inflammable vapour at low temperature should be stored so as to avoid the risk of such vapour migrating and coming into contact with a flame or source of heat.

Naphtha, Ether, Carbon Disulphide, Acetone, Methyl Alcohol, Amyl Alcohol, Gasoline, Petrol and similar volatile liquids should claim first attention.

Where handling of inflammable volatile liquid by way of drawing off, filling cans, etc. is done, the need for care is greater. Varnish containing monthly alcohol or similar volatile solvent, oil of turpentine etc. is specially liable to give off inflammable vapours during mixing operations, and vapours, heavier than air may travel to some point where ignition takes place, the flame flashes back and the whole is at once set on fire.

(iv) **Precautions Neglected**: **-**Failure to appreciate the risky characteristics of hazardous goods is largely responsible for reason able precautions being so frequently disregarded.

A stone floor is incombustible, but not therefore so care as a wood floor in some circumstances. A workman wearing iron-tipped or heavily nailed boots may strike a spark on a stone floor. If inflammable vapour such as benzene is present, or if chlorates has fallen on the floor, get mixed with dust, sawdust etc, a spark so struck may cause ignition, possibly an explosion. Overshoes should be worn particularly in the case of dry-cleaning with naphtha.

Contributory Causes

(i) **Oxygen Custodians**: The term Oxygen custodians is applied to those chemical com pounds which comprise a large proportion of available oxygen which held the oxygen in custody at ordinary temperatures: but which are compelled to release the oxygen when subjected to heat. In many instances the release from custody taking place at comparatively low temperatures. The liberated oxygen enters into combination with combustible matter present, greatly intensifying the conflagration.

The following are some of the more important oxygen custodians.

Chlorates: Oxygen is liberated at 698 deg. F. Nitrates: Oxygen is liberated about 950 to 1,000 deg. F.

Lead Dioxide: Liberate oxygen at about 600 deg. F.

Mercuric Oxide: Liberates oxygen when strongly heated.

Manganese Peroxide: Liberates oxygen at 930 deg. F.

Chromic Acid: Induce ignition of organic matter at normal temperature.

Chromic Anhydride: Release oxygen a about 500 deg. F.

Potassium Tetroxide: Release oxygen when heated.

Potassium Permanganate: Release oxygen at about 500 deg. F.

Potassium Perchlorate: Releases oxygen about at 750 deg. F.

Per-a oxide of Barium: Releases oxygen at 1,000 to 1.200 deg. F.

Various oxides of precious metals, oxyacid's, oxy-salts, have the same property of liberating oxygen under the influence of heat.

(ii) **Inflammable Materials**

A fire will be greatly intensified if matter of highly inflammable nature be present, a com bination of such inflammable materials with oxygen custodians will bring about abnormal fire intensification. Generally speaking. those besides that are distinguished by a low ignition point are specially inflammable and the follow Ing substances involve great risk of intensification of a fire:

Guncotton:	O Carbon Disulphide:	Ether
Collodion wool:	Alcohols:	Gasoline
Celluloid	Wood spirit:	Benzol
Picric Acid :	Ethyl Alcohol:	Naphtha
Pyrites	Methylated spirits:	Esters.
Phosphorus:	Acetone:	

(a) **Calorific Value**

During the progress of the fire, the heat developed by burning substances raises the temperature. These rise in temperature is influenced by the calorific value of the substances involved and the intensification of the fire is thereby affected. To institute a comparison equal weight of the bodies is assumed, and dry wood is taken as basis of comparison with unit calorific value. The calorific value of the following may be approximately stated thus:

Dry wood;	1
Alcohol:	1 ½ to 2
Coal:	2
Charcoal:	2 ½
Lard. Tallow:	2 ¼ to 2 ½
Ether. Benzene:	2 ½
Petroleum:	2 ¾
Certain Oils:	2 ¾ to 3

(b) **Spreading Properties (P. Liquids):** A serious extension of the fire zone may be caused by containers being damaged or overturned, so as to permit of their inflammable contents escaping e.g., Alcohol. Acetone, Benzene, Petrol, Naphtha, Tar, Varnishes, Taros and oils in general.

(c) **Spreading Properties of Fusible Solids:** A serious spread of fire will occur in case of inflammable solids which melt readily e.g., Tallow, Lard, Greases. Wax, Sulphur. Resin, Picric Acid.

The Nature of the Hazard: Storage arrangements are frequently the cause of substantial fire losses, and all such arrangements should have as their aims:

(a) to minimise the likelihood of a fire occurring:

(b) in the event of fire, to minimise the possibility of fire spread:

(c) after a fire, to secure maximum salvage results.

The degree of hazard varies according to the nature of the commodities stored and their location, but it should be remembered that all combustible materials present a serious fire hazard when stored in quantity, unless adequate safe-guards are adopted.

(i) Recommendations relating to Buildings:

(a) Accessibility: Buildings should be so located and constructed as to be accessible under fire conditions.

(b) Segregation: Buildings used for storage should be segregated from those in which manufacturing pro cesses are carried on.

(c) Separation: If buildings are not detached, they should be separated from other buildings by Division walls, an opening therein being protected by double fire-resisting doors.

(d) Sub-division: In order to restrict the spread of fire, every effort should be made to sub-divide it into as many sections as possible by the use of brick walls. The vertical sub-division of buildings should be such that the cubic capacity of any one division does not exceed 2.50,000 feet. unless the buildings are entirely of fire-resisting construction.

(ii) **Recommendations relating to Commodities:**

(a) **General**: Goods of different kinds e.g., foodstuffs, goods liable to spontaneous heating, rubber oils, spirits. grain, wool, cotton and other vegetable fibres, paper etc., should be stored separately. Such segregation facilitates fire-fighting: and results in better salvage.

(b) **Food Stuffs**: Such commodities as poisons. dye-stuffs, tanning extracts, gums, soda etc., should not be stored on the same floor, as or on the floor above foodstuffs.

(c) **Corrosive and noxious**: Substances of a corrosive nature, or those which, evolving large quantities of smoke or noxious fumes, would hamper the efforts of fire-fighters, should be kept in separate well-ventilated stores.

(d) **Materials which liquify when heated**: Certain goods such as lard, tallow, fats and waxes, sulphur, resin, bitumen and pitch which are solid at ordinary temperatures but liquefy under heat, should be so stored as to provide against the extension of fire from point to point and from floor to floor through stairs, lifts, pipes and other ducts in buildings used for storage. The same applies to rubber, and to oils and spirits and inflammable liquids, generally

(e) **Fibres**: In fibre stores, the size, stability and spacing of stacks is particularly important, owing to the risk of flash fires and the liability of stacks to collapse through the bursting of ties either by burning or by the swelling of the fibre when water is applied in fire-fighting.

Bales should be laid with broken joints. as in brickwork, and a clearance of at least three feet should be maintained between stacks and the walls of the building. Swelling of stacks of fibre through water absorption has frequently brought about the collapse of a building through pressure on its water.

(f) **Inflammable Solvents and Liquids:** These should be stored in: detached buildings entirely of fire-resisting construction and only a sufficient quantity for one days' use should be taken into the factory.

(iii) **General Recommendations:**

(a) (i) Stacks should be kept in such manner as a to be wholly and easily accessible:

(ii) Individual stacks or piles should be reasonably small with clear spaces round each;

(iii) Dunnage should be provided to keep goods clear of floors;

(iv) Stacks should not be piled so high as to be beyond easy reach of fire fighters, and in one case, not within three feet of the ceiling of the storage space:

(v) Alternate stacks of combustible and incombustible or less hazardous materials will also help to reduce fire spread.

(b) Racks, shelves, etc. should wherever possible, be made of incombustible materials.

(c) In concrete floored buildings, damage by water can be lessened by the provision of surface in the external walls.

(d) Smoking should be prohibited in storage buildings and notices to that effect.

(e) Unnecessary accumulations of packing materials such as straw, sawdust, empty boxes, paper, old lumber etc., should not be allowed.

5. **Circumstances Retarding Fire Extinction:**

(a) **Water**: The presence of certain sub stances may make it undesirable or dangerous to use water for extinguishing a fire.

When a large volume of oil, melted wax or grease, fats, tar. varnish, resin, benzene, alcohol, ether, acetone, inflammable spirits on fire, it is difficult to extinguish the blaze with water, water should not be used on inflammable liquids of less specific gravity than water.

In a fire involving a quantity of chlorates or nitrates the temperature may become extremely high, the chlorates etc. forming a molten mass at white heat. To pour water on such a fire is dangerous, as explosions may result and the fire zone be extended. The effect of water on potassium and sodium are well known.

(b) **Noxious Fumes-Acids**: There are certain substances, which when burning give off dense fumes which prevent firemen from breathing and there are other bodies, the fumes of which are highly dangerous to life if inhaled.

The fumes from Bromine are of very noxious character, and burning Resin emits a smoke of an acrid and penetrating nature. The fumes arising from burning casks of sulphur have been responsible not only for bleeding at the mouth and nostrils but actually for the death by asphyxiation. Fumes from burning charcoal, will overcome a man.

The presence of sulphuric acid and certain other acids hampers extinguishing operations. There is the risk of the acid itself suddenly and unexpectedly flowing down on to the fire lighter, the corrosive effects being of a most serious nature. The fumes arising from acids subjected to the heat of a burning building are of a very noxious character and have been responsible for the death of many firemen. Nitric Acid, Hydrochloric and Sulphuric Acid all emit highly dangerous fumes particularly the Nitric Acid. Some chalk is used on Nitric Acid but chalk on mixture of Nitric and Sulphuric Acid would cause more violent evolution of Nitric fumes. Breathing sets are to be used as a protective measure.

Remedies of Fumes inhaled

Drink milk or cream. Inhale Alcohol or Ether. Drink small glass of water containing 3 drops of chloroform every 10 minutes, 120 drops in 24 hours.

(c) **Fire Fighting Operations**: Cannot be conducted with unreserved freedom. if it is known that the burning building contains explosive material.

The risk of explosion arising when molten chlorates and nitrates are there so also when water is used on a fused mass of potassium nit rate but it will be much more intense in the case of Ammonium Nitrate.

Sulphuric Acid may affect contact with Potassium Chlorate, oil of turpentine with iodine, bronze powders with Nitrate, and the result of the chemical action set up under conditions of great heat arising from the conflagration, may give rise to an explosion or series of explosion.

These various considerations should be borne in mind, when arrangements are being made for the storage and handling of chemicals and materials that under certain circumstances. may be the cause of a small fire developing into an extensive conflagration.

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CHAPTER 32

ROPES AND LASHINGS

1. **Introduction**:

Ropes form an important item in rescue equipment as number of problems can be solved by proper use of ropes. Experience has proved that incidents occur where persons have to be rescued from above or below the ground level, there by involving lowering or hoisting. Under such circumstances, an insecure or a wrong rope or a bad splice or a bad splice or wrong knot incapable of carrying the required strain/may result in consider able delay in operations and also involve rescue. The proper selection and right use of ropes therefore gains importance in rescue work

2. In rescue work, knotting’s and lashings are required for joining and securing ropes and for fastening ropes around object and persons and to lower, hoist or secure with safety. Knots must be tied tightly.

3. As knotting and lashing are to be done on the spot, where the party is fighting against time, in darkness, in smoke, when people are killed dying and when civilian population is panic stricken, it is very necessary for everyone in the Rescue Party to learn knotting and lashing, so thoroughly that it becomes a habit and they should be able to do this under all such abnormal conditions.

4. Rescue parties may be equipped with the undermentioned types and sizes of ropes.

(a) Two 200 feet (60.96M.) length of 3" (76.20mm.) rope-these are principally used along with tackles and pulleys for raising or lowering persons or articles etc.

(b) Ten 40 feet (12.19 M) length 1½" (38.10mm.) lashings-these are used for securing casualties to stretchers, as guy ropes to the construction of derricks and sheers, as guide ropes etc.

(c) Eight 15 feet (4.57 M.) length of 1" (25.40mm.) sash cord-used as short lashings for all general and light works.

(d) One coil of steel wire rope 100 feet (30.48mm) long 5/8" (17.30 mm.)-used for heavy work such as demolition of dangerous buildings etc.

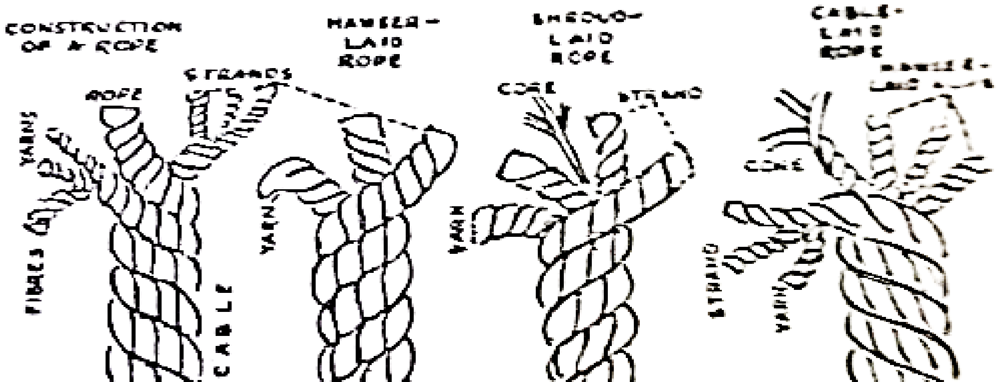
ROPES

5. **General**

The term 'rope' is used for both fibre and wire ropes, while the term 'cordage' is used to denote fibre ropes only. Cordage and ropes which are in general use are made principally of Hemp and Manila, and to a lesser extent of sisal, coir and cotton and other vegetable fibres. Rope is also made of steel wire. Hemp when wet is less likely to swell, and for reasons of softness of its fibres and flexibility has longer life and can be used over short radial curves. Manila is practically waterproof and as such is also used for making net for fishing industry. The strands of these ropes will maintain their lay when opened out. This makes them easy to handle in splicing and are, therefore, particularly suited for rescue work. Sisal, though of the same strength as Manila. swells when wet and becomes slippery. Coir. owing to its buoyancy, will float on water. It is noted for elasticity but lacks in strength. Cotton is more susceptible to damage from chaffing. It is also most difficult to splice and its strands will not retain their lay when undone.

6. **Construction and Laying of Ropes**

The first process in the manufacturing of ropes consists of combing of fibres on a series of special machines, so that they are arranged roughly parallel, in which stage it is known as 'Sliver'. The next process is spinning when a permanent twist is mechanically imparted to the sliver which is then known as 'Yarn'. It is the smallest divisible part of a laid rope. A series of yarns twisted together form Strands, and three or more strands twisted together form a Rope. Rope is normally made in lengths not exceeding 120 fathoms or 720 feet (219.46 M.). The manner in which yarns, strands or ropes are twisted together to form larger units of cordage is known as 'laying'. Rope may be 'laid up' right hand or left hand, and is then known as having a 'right hand lay' or 'left hand lay' respectively. The lay can be determined by looking at the rope. Most rope is three stranded and usually laid up right-handed i.e., the strands run from the bottom left hand to the top right hand in clockwise direction. This is called 'hawser-laid rope'. A hawser-laid rope is the strongest rope. The central core is made up of short strands and acts as a former only. Three hawser-laid ropes laid up together left-handed, with or without a central core, is called a 'cable laid rope. Cable laid and shroud-laid ropes are weaker than hawser-laid ropes (refer sketch below):



7. **Strength of rope**:

It must be remembered that any knot tied in a rope weakens that rope and a bad or unsuitable knot weakens a rope considerably more than a well tied one. Knots turns and hitches weaken a rope by forming a bend which distributes the strain on the fibres unequally. An eye splice weakens a rope by 10%, a short splice by 20%, a timber hitch by 35% and a reef knot by 50%. Ropes are always described by the measurement of their circumference that is an inch rope or 3-inch rope etc. Strength of rope and its ability to withstand strain and stress depends upon the material of which it is made, how it is made, how is it used and care and preservation during and after its use. As a guide to the breaking strain of a hemp rope, the following will be found to be a fairly accurate formula:

(a) Breaking strain $= \dfrac{\text{(Circumference)}}{3}$ tonnes

(b) Safe working strain $= \dfrac{\text{(Circumference)}^2}{18}$ tonnes

8. A safe working strain is always less than the breaking strain.

TYPES OF ROPE

9. Ropes may be of either fibre or metal or sometimes mixed construction. "The general description applied to all forms of fibre rope, line and twine is cordage. Ropes made of metal are referred as Steel Wire Rope (SWR). Broadly, all ropes can be grouped under three categories:

(a) **Natural fibre ropes** -These are principally made of:

(i) **Hemp** -It is a rough rope but a very strong one and is used in pioneering and in-board of ship to a great extent.

(ii) **Italian hemp**-It is a fast fibre obtained from stalks of the hemp plant. The fibre is soft and stronger than the other hemps. It does harden when wet and is the strongest of all vegetable ropes.

(iii) **Manila** -It is made out of a fibre obtained from the leaf sheath of the abaca plant. It is more expensive. strong, smooth and is used in yachting.

(iv) **Sisal** -Fibre obtained from leaves of sisal plant, it is as strong as hemp and is sea water resistant.

(v) **Coir** -A fibre obtained from husk of coconut. It is a very light rope, elastic and floats on water. Its strength as compared to hemp is 4 (Refer sketch).

(vi) **Cotton** -It is the fibre obtained from the seed pods of the cotton plant. It is rather weak but smooth.

(b) **Man made fibre ropes** -The two principal fibres used are:

(i) **Nylon-** A fibre with a complex form structure of carbon, nitrogen, oxygen and hydrogen.

(ii) **Polyester -**It is derived by chemical synthesis from the products of mineral oil cracker. It is also known as treeline.

Properties -These ropes are flexible and run well over blocks or pulleys and can be knotted, seized or spliced. Tensile strength is an important property of such ropes. They are approximately twice as strong as compared to ropes made of vegetable fibre. Other major properties are:

(aa) Can absorb shock loads.

(ab) Withstand repeated loading of a high order.

(ac) Little swelling on being wet.

(ad) They can be stored when wet without any degradation.

(ae) They are resistant to most of the dilute forms of acids and alkalise.

(c) **Steel Wire Rope (SWR) -**Wire rope is a combination of steel wires arranged around a central fibre core. Steel reaches the wire mills in the form of rods, which are first cleaned in acid to remove rust. After heat treatment to ensure uniformity in tensile strength, ductility etc. they are cleaned again before being drawn cold through a series of dies, each of which gets successively smaller until the required size is reached. After drawing. the wire may be galvanised according to requirements. The breaking load of wire rope is considerably greater than that of fibre rope of equivalent size. but it is for less flexible and more difficult to handle, its use by fire brigades is, therefore generally limited to equipment which is operated by means of a winch, such as wheeled escapes, turn able ladders and some extension ladders. Steel wire rope are about nine times as strong as corded ropes of the same thickness. The wire bonds ("scaffold lashings") used by the Rescue Section are inch diameter (inch circumference) hemp core galvanised wire ropes. If in good condition, they will take a load of approximately ¾ x ¾ x 9=5cwt. (refer sketch)-The recommended minimum diameter about which a steel wire rope can be bent without causing harm to the rope is six times the circumference of the steel wire rope: e.g., $^{5}/_{8}$-inch diameter steel wire rope equals 2-inch circumference which six times equals 12 inches minimum diameter. It is not advisable to use steel wire ropes with fibre rope pulley blocks

CARE AND MAINTENANCE OF ROPES

10. Rope is expensive but with proper care will last for a long time. Some of the aspects requiring attention with regard to their care and maintenance is as follows:

(a) **Fibre Ropes**

(i) Keep all fibre rope as dry as possible. When damp, they should be dried in shade before coiling and stacking to avoid danger by mildew. No rope should ever be stored wet.

(ii) A stiff and hard rope gives trouble. Stretch a new rope throughout its length before using it. Remove the twists and pull at both ends.

(iii) Remove kinks out of a new rope before using it, by uncoiling it and recoiling it in the opposite direction. for two to three times as kinking tends to draw the fibre apart and weakens them.

(iv) Always coil a rope in the direction of its lay. e.g., a hawser-laid rope is coiled in the clockwise direction. After coiling, tie with hemp at least in three places.

(v) Keep all rope coils hung on poles or bamboos. Keep each type labelled. so that the correct size of ropes can be taken out of the stores when necessary. All lashings should be kept in bags or bundles.

(vi) Avoid permanent knots in a rope as this reduces the strength of a rope. Do not attempt to force a thick rope through a block made for smaller size. This produces strain and reduces the strength of the rope. Also avoid sudden jerks.

(vii) Ensure that ropes do not come in contact with any chemicals or materials containing chemicals of strong alkali such as Creosote. Also protect the ropes from rots.

(viii) Avoid dragging the rope along the ground, as it drives grit into the fib res and subsequent internal movement between the strands will cause the grit to cut into the fibres and seriously weaken them. Also avoid chaffing against sharp edges.

(ix) Oil and grease must not be put on ropes as the fibre material produces their own lubrication. Moreover, application of lubricants prevents oil from getting to the fibre.

(b) **Steel Wire Rope**

(i) Steel wire rope should be cleaned with a rag after use and well-oiled before keeping it in the store.

(ii) When a steel wire rope has to be coiled, ensure that the coil must not be below the recommended diameter i.e., six times the circumference of the steel wire rope. otherwise, strands may get damaged.

11. **Inspection of Ropes**

Ropes should be regularly inspected to ensure that their condition is good, since the risk involved in rescue work is already great and bad ropes will make the matters worse. Therefore, look for the following defects while inspecting the ropes: -

(a) **Surface Defects:**

(i) Broken fibres	These can be seen by visual inspection.
(ii) Wear	Thinner than the usual circumference-uneven surface.
(iii)Cuts	These can be seen and felt while coiling.

(b) **Internal Defects**:

(i) Broken fibres	At places where there is a bulge in the rope, untwist and see for this.
(ii) Mildew or Mould	When the ropes are used in wet weather or when they get wet and if they are not properly dried before storing mildew or mould sets in-untwist and smell mildew can also be seen from outside deposited on the affected points.
(iii) Change in colour	Seen from outside usually the colour changes to grey or bluish grey- untwist the strands tuned out the damage.

12. **Testing of Lines**

Rescue lines should be tested monthly, after use at an incident and before use at a live rescue drill. One end of the line should be secured in such a way that any splices incorporated in it will be subjected to the test. Six men should take up positions spaced out at intervals of about five feet (1.52 M) at free end of the line. When all are in position the front man should apply a steady pull until the line is being tested by the combined strength of all six men. This should be maintained for about 20 seconds and then, in succession, the men should release the load. The test should then be repeated with the line reversed. Each leg of lowering line with spliced leg should be tested separately. Guide lines should be tested in a similar manner except that the pull of only two men should be applied. On completion of the test the line should be minutely examined for any defect.

TERMINOLOGY CONNECTED WITH ROPES AND LASHINGS

13. Like most arts or practices, knotting has a language of its own. Some of the important forms used are:

(a) **Anchored -**Fastened to any immovable object like large tree, post or picket well driven into firm ground for this purpose.

(b) **Running end -**The free end of a rope with which the knot is made. Refer sketch below.

(c) **Standing part-**That part of the rope which is taking the load. Refer sketch below.

(d) **Bight-**An open loop of a rope. Refer sketch below.

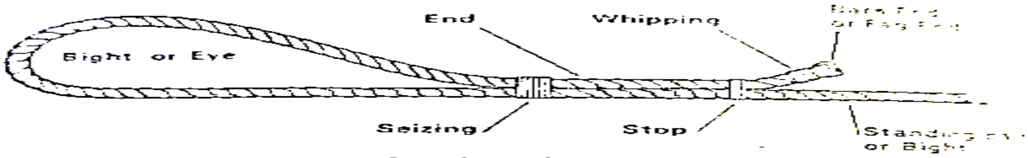


Fig. Terms used in describing bends and hitches.

(e) **Frapping-**The binding together of a rope of lashing between two poles.

(f) **Haul -**The act of pulling on a rope.

(g) **Hitch-**A loose loop on a rope. It means simple fastening of a rope around any object by winding and crossing one turn over another turn so that one binds on the other without actually knotting the rope.

(h) **Chaffing -**Cutting/damage to rope.

(i) **Round Turn -**This is a complete turn of the rope round the spar or another rope.

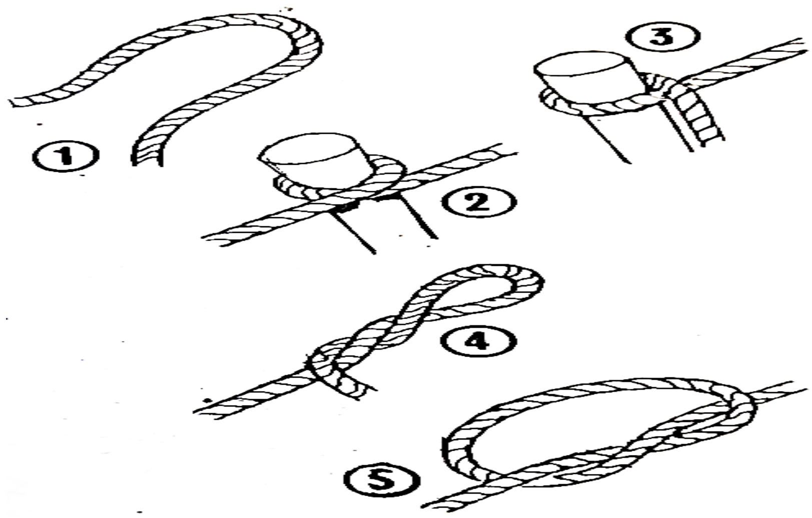


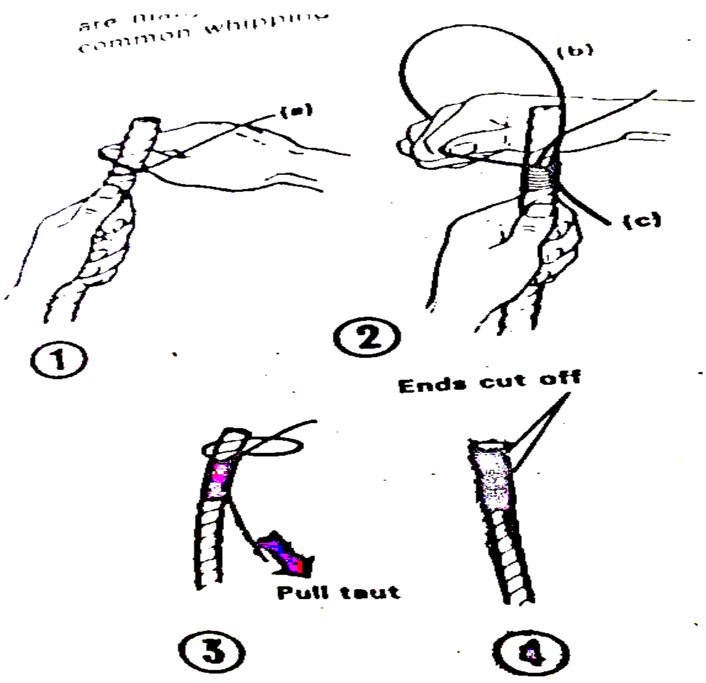
Fig: Elements of bends and hitches

(k) **Parcelled -**When any rope or part of it is parcelled/wrapped usually with strips of canvas to prevent chaffing is called parcelled.

(1) **Paying out -**To ease off or slacken a rope.

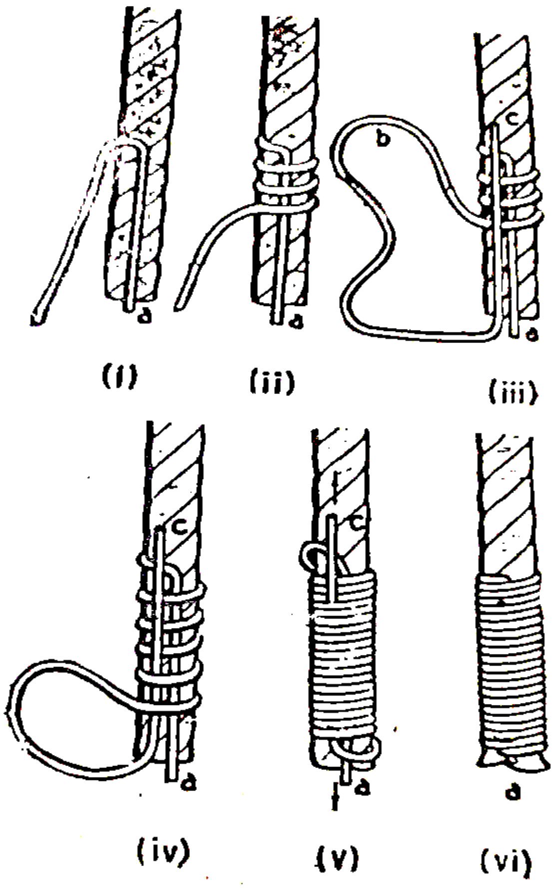
(m) **Reeve -**The act of threading of ropes through pulley or blocks.

(n) **Whipping -**Ropes should never be cut. as a rule. When it is cut as a mere necessity, its ends should be preserved. It is important that the ends of all ropes and lashings used in the rescue work are properly secured, from unlaying and untwisting. This may be done, temporarily by a thumb knot, a figure of eight knot or a back splice. Then such ropes look clumsy with unusually thick ends. For thicker ropes use back splice as this is much useful and superior. Whereas ends of ropes of lesser circumferences should be secured by whipping. There are many ways of whipping. The most common whipping used by rescue parties



Method of applying a ‘Common’ whipping

is the simplest to put on. Take a length of waxed seaming twine about 18 inches in length. Lay one end of this along the rope's end, hold it in place with the thumb. Now wind tightly the loose part of the twine round it and the ropes end. Carry on these turns until within half an inch of the bare end of the rope. Then lay back the other end of the twine, along the rope's end and take another four or five turns round it and the rope. Finally, the outer end of the twine is put inside the loop formed and the two ends of the twine are pulled and made taut.



Whipping

and the best and the most durable method of whip ping is the method adopted by Sail maker's. Under this method the two ends of the twine is passed through the rope in such a way that a loop is formed and a strand of the rope remains within the loop. The loop and the ends of the twine are then adjusted in such a way that the lengths of the loop and the lower end of the twine become slightly more than the end position of the rope to be whipped. The round turns are then taken along the end of the rope going upwards with the larger end of the twine. When the end of the rope is reached, the loop is taken up along the direction of the twist of the strand which is within it and put around the strand. The loop is then made taut by pulling the lower end of the twine. Thereafter the same end is also taken up along the twist of a strand and putting over the free end of the rope it is brought to a position where it can meet the other end of the twine, should be secured whipping. There are many ways of whip ping with which round turns were taken A reef knot is then made inside the strands taking the ends and the spare ends of the twine are cut off.

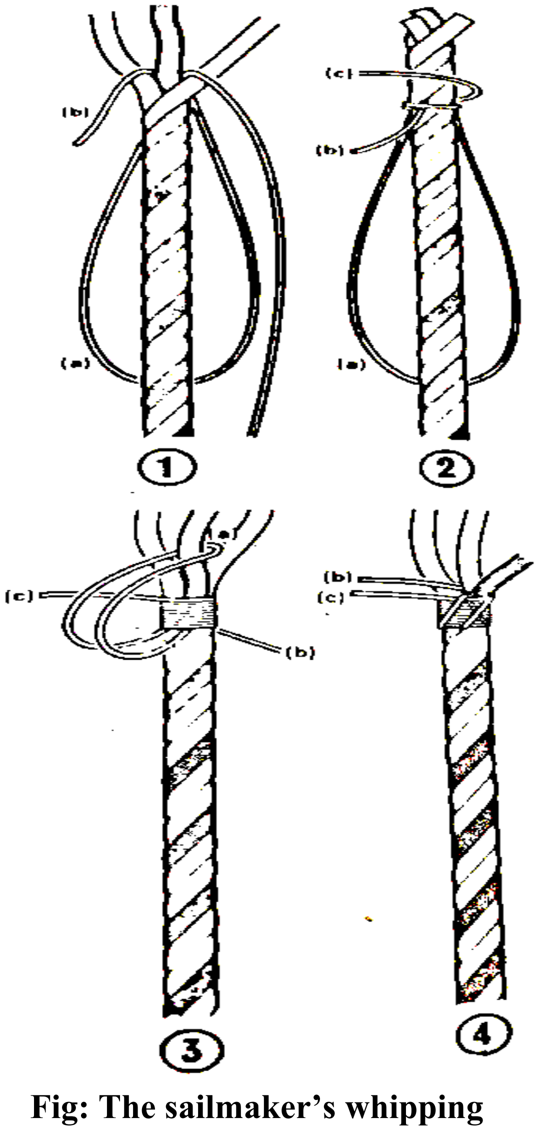


Fig: The sailmaker's whipping

(0) **Mousing-** In rescue work when ropes are used along with blocks, many times the ropes are hitched and to prevent such a hitch from working up the hook. or to prevent on any occasion a hook from becoming unhooked, the hook is moused. Turns of yarn are passed round the bill and back of a hook and then knot ted in a place. This is called 'mousing'. (Refer sketch below):

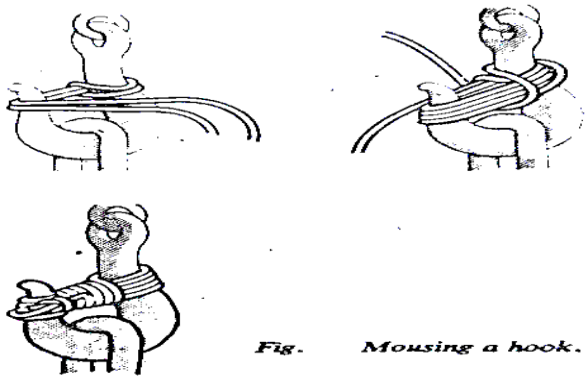
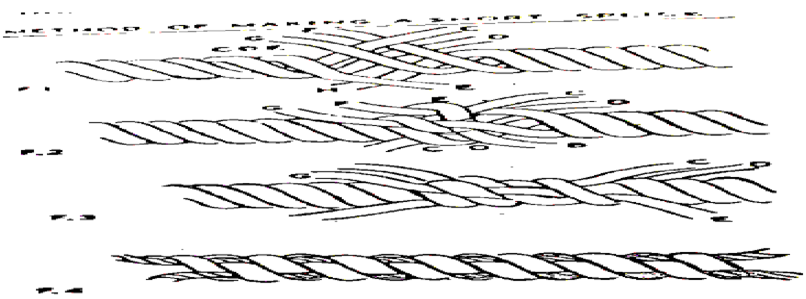


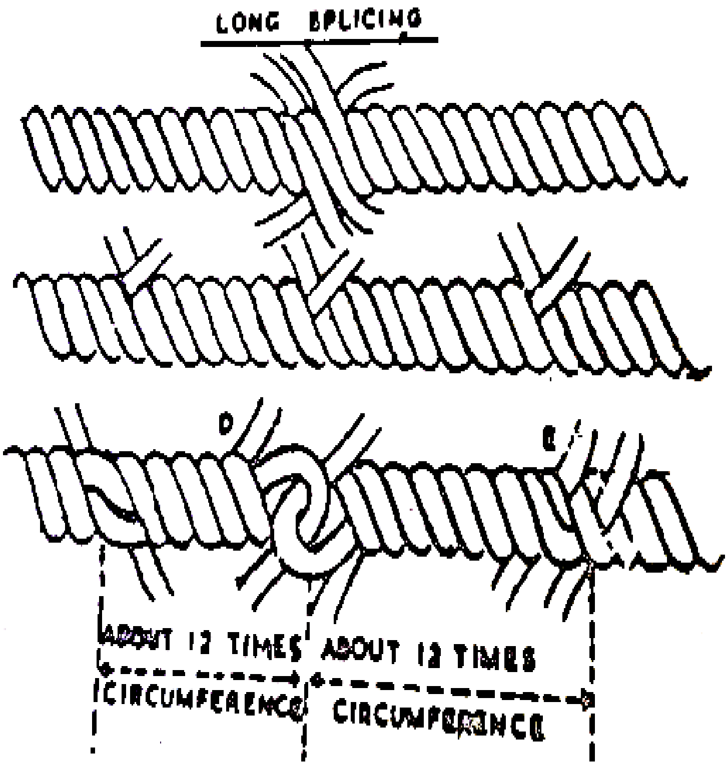
Fig. Mousing a hook.

(p) **Splicing-** Splicing means to join rope by interweaving strands. Splicing differs from knotting. In splicing, strands are interwoven, whereas in knotting the rope as a whole is used. Rope joined by splicing can pass through a block and splicing weakens the rope by 10 percent only. Whereas rope joined by knotting cannot be passed through a block and its weakening effect is sometimes up to 50 per cent as in the case of reef knot and single sheet bend. Cordage and ropes sometimes require to be joined in such a way that there should be no substantial difference in their diameter and no weakening of their strength. This can only be done by splicing. No splice can be as strong as a rope of which it is made. However, a well-made splice is stronger than a knot. The principles underlying all splicing work is that of interweaving of strands of a standing part in such a way that as soon as any strain comes upon either, the strands of the standing part will whip the inter locked loose ends and prevent them from drawing out. The tools required for splicing are few-a knife for cutting and spike or 3-inch nail for opening the strands of the rope.

(i) Short splice-A short splice is used where there is not much strength required, and when there is not much time to make a long splice. To make a short splice, unlay the strands of each rope for a length of about 6 times the circumference of the rope. Marry the strands i.e. bring the ends together so that the separated ends fit into each. other, one strand being in the space bet ween two strands of the opposite rope (See figure). The strands of the line (a), are then tucked into those of lines (b) and those of the line (b) into line (a) working all the time against the lay. Other figures show the other stages of a short splice. If the rope has to pass through a block, this splice is unsuitable and a long splice must be used.



(ii) **Long splice-**This splice is stronger than the short splice, but uses more rope and has the advantage of not increasing the thickness of the rope. For three stranded rope, the minimum length of rope unlaid should be 6-7 times that of the circumference of the rope and for the four stranded rope 10 times the circumference. For normal use, in making a long splice unlay the ends of both the ropes for a length 12-14 times the circumference. Marry them as for short splice. Without disturbing the other strands, choose one strand and begin to unlay it. filling up the room it leaves with the corresponding strand of the other rope, working to within a few inches of its end. Repeat with another pair of strands but working the opposite way. Let the remaining strand stay putout. The ends of the strands now have to be locked as shown in the figures (c), (d) and (e). A long splice should be well stretched and rolled before the ends of the strands are finally cut off.



(iii) **Eye splice -**This is used in rescue work most frequently. It is used for making an eye in a rope round a timer or block and is formed by unlaying the end of a rope for short distance and then interweaving the three unlaid ends, with the standing part so as to form the size of eye required. To make an eye splice in three stranded rope, unlay the strands for short distance and bend the rope to form an eye, placing two end strands acres at

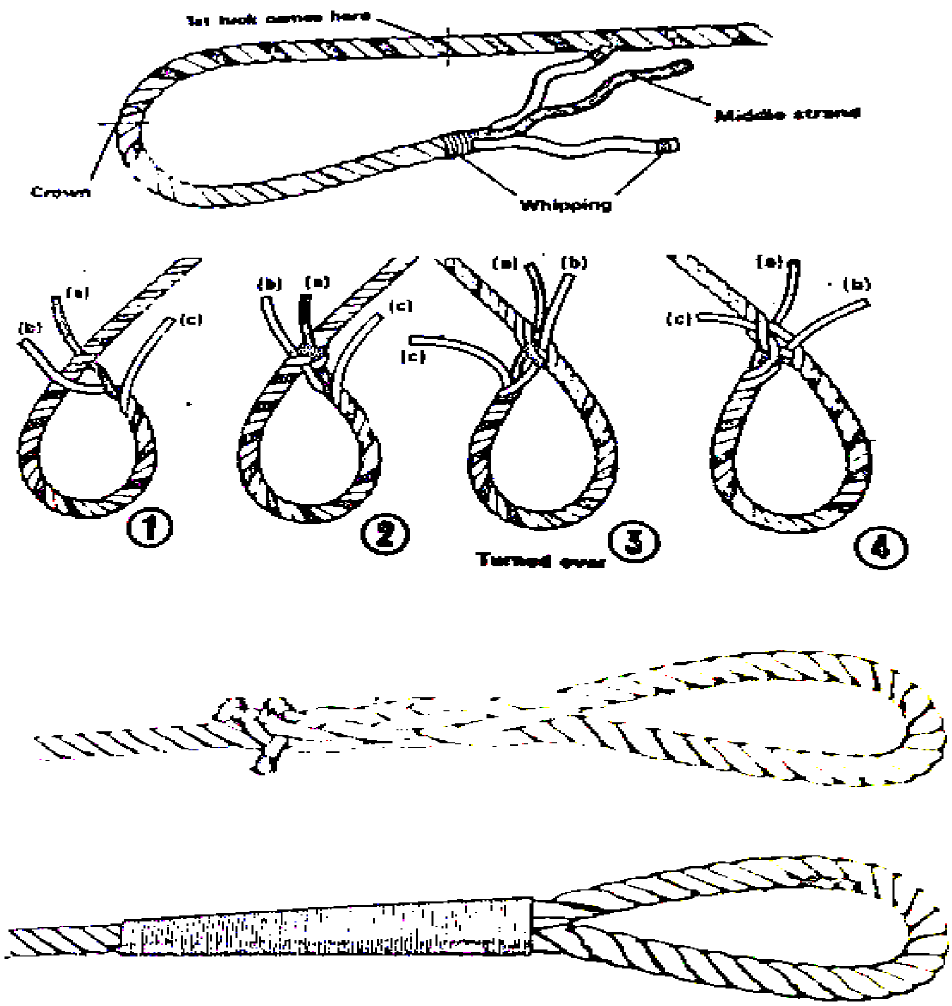


Fig: Above: An eye splice finished
Below: Tapered and served

right angle to the lay of the standing part of the rope and the other strand behind (a) Then take the centre strand under the nearest strand of the standing part (b) under the remaining strand of the standing part, going in where the first strand, comes out (d) You now have an end strand projecting from each space of the standing part (e) With this, the first tuck is over. Take the first end strand under the next strand going in where the second strand comes out (c) Turn the rope over and tuck the third strand. Tuck each strand in turn over and under one and make two tucks and two tapper tucks. An eye splice is valuable on the end of rope e.g., when erecting blocks and tackles on sheer legs, if the straps or slings have eye spliced ends, it is simply necessary to pass hook of the tackle through the eye and save much time. Stretcher slings can be made from two short pieces of rope with spliced eyes at each end. All that is required is that they have to be placed over the ends of the stretcher. This saves time and labour and increases efficiency, which is important in rescue operations.

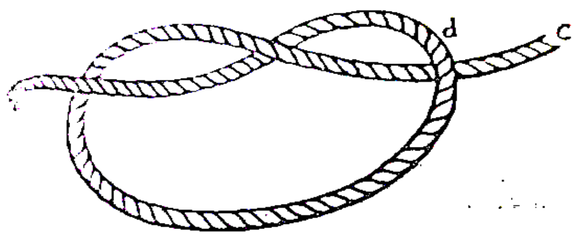
iv) **Running splice -** This means replacing a damaged or chaffed strand in a rope, by inserting a fresh strand. This enables the rope to be passed through the block and the rope is almost normal. The strand for repairs should preferably be taken from one end of the rope as this makes the job easy.

(v) This is for finishing the end of a rope which is not required to be rove through a block, to prevent it unlaying.

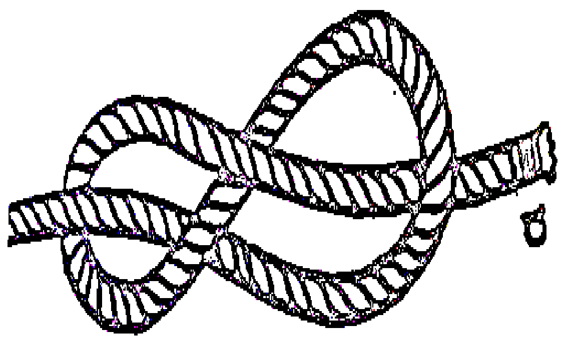
14. **Knots and Lashings -**Rescue Party personnel should be familiar with ropes, knots and lashings and with constant practice must learn how to make and adopt them with speed and proficiency. Details of various type of knots and lashings are given in subsequent paras.

KNOTS

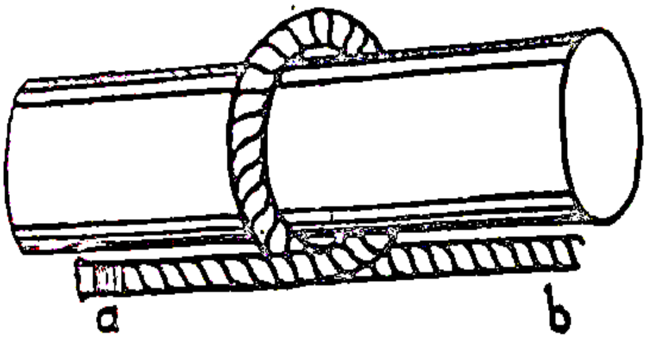
15. (a) **Thumb Knot-**This is a simple knot tied in the end of a rope to stop the rope passing through a pulling block or temporarily to prevent fraying of an end. The knot is formed by making a loop and passing one end through it.



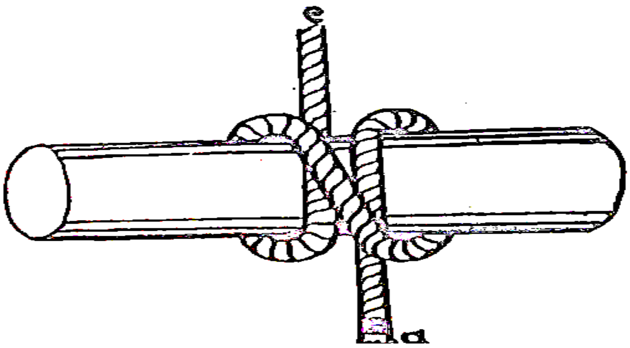
(b) **Figure-of-eight knot -**With the rope "away" from you, take the standing part in the left-hand palm upwards and the running end in the right hand. Pass the running end over the top of the standing part making a loop. then carry on with the running end round behind the standing part over the top, then down through the loop which you have formed. Draw the running end tight and the knot should resemble the Figure of 8. This knot is useful as a stop and is often used to prevent the end of a rope from running further through a block. It can also be used temporarily to prevent the end of a rope from fraying when the whipping has been lost. In general, it is more useful than the Thumb knot as it is easier to undo.



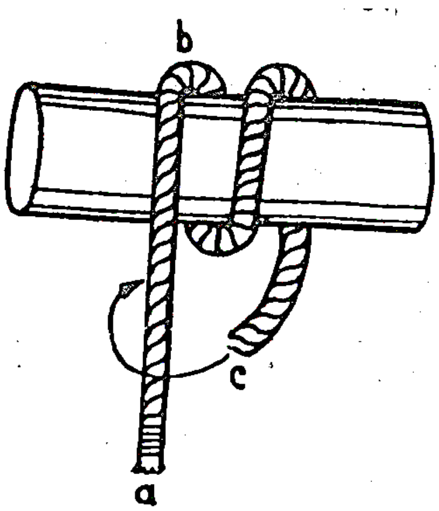
(c) **Half-Hitch -**This is formed by passing the short end of a rope around the spar (or around rope) and under the standing part, so that, when pulled, one part of the rope binds the other.

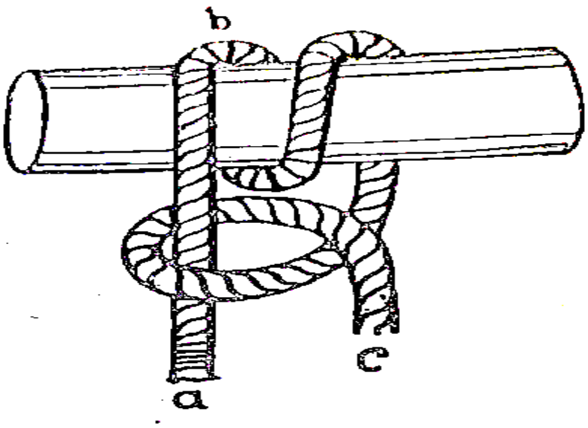


(d) **Clove Hitch-**This forms the basis of many securing knots and can be used at the end of a rope or in the centre. To tie at the end of a rope, pass the running end round a pole bringing it out underneath the standing rope. Pass the running end round the pole again above the first half hitch, bringing the running end under itself to tighten, pulling both the running end and the standing rope. When tied thus at the end of a rope, it is a good anchoring knot and is easily untied. To tie in the centre of a rope, two loops are formed, one in the left hand (anti-clockwise) and one in the right hand (anti clock wise), the latter being passed in front of the left-hand loop. Both loops are then passed over the pole and drawn tight.

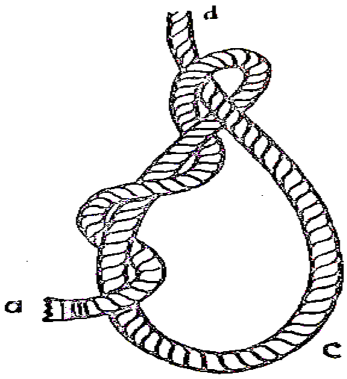


(e) **Round Turn and Two Half Hitches-**This also is used for securing a rope to a spar or ring and is formed by a round turn on the spar or ring with two half hitches on the standing part of the rope.

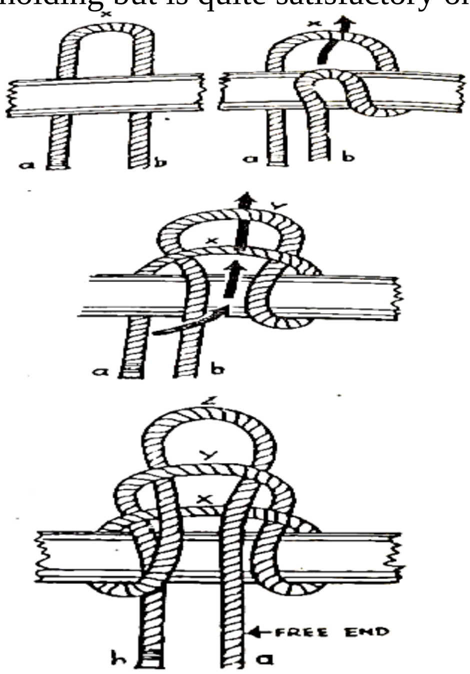




(f) **Timber Hitch -**This is quickly made temporary knot used to secure a rope to a plank or pole and is formed by making a half hitch on the standing part of the rope, leaving a long end which is twisted back again around its own part of the hitch. When used for lifting spars, planks or poles, this hitch should be used in conjunction with a half hitch at the upper end of the spar.



(g) **Draw hitch -**This hitch will stand a considerable strain on the standing part and yet can be easily released by jerking the free end. It enables the rope to be recovered from places where the knot cannot be reached and untied by hand, e.g. where the rope has been used by a person to lower himself from a height. It is formed as follows, a bight is passed around the spar and a second bight, which is then formed or and passed through the second bight and the whole tightened up by pulling on the standing part. The bights should be tightened as much as, possible at each stage. The draw hitch is not considered reliable when used on a square holding but is quite satisfactory on a round spar or ring.



(h) **Reef knot** – for joining two ropes of equal thickness, this is best described as two thumb knot tied in revers directions, left over right then right over left. It is quickly untied and is a useful knot for general purposes. It should be used for all bandaging and for tying two dry ropes of the same size when the pull is constant. A reef knot can be tied and will remain tied when there is an Initial pull on the ropes.

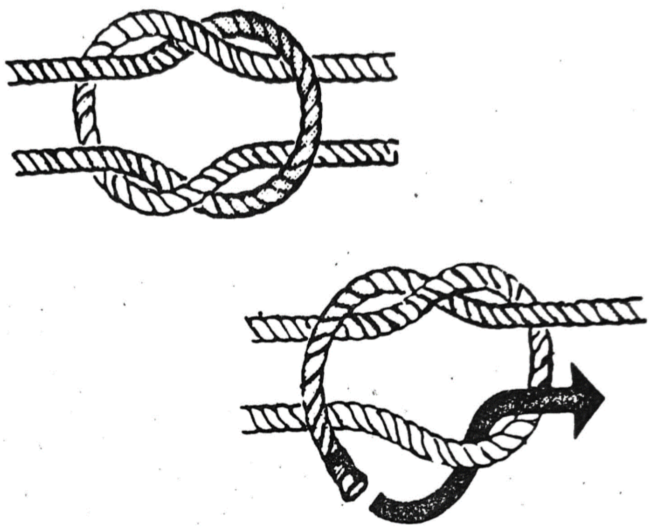


Fig: Method of making a reef knot.

(i) **Single sheet bend -**There are two types of Sheet Bends: the Single Sheet Bend and the Double Sheet Bend. Both are used for uniting two ropes of different thickness and have the advantage that they do no slip when the rope is wet. The Single Sheet Bend is formed by making a loop in the thicker of the two ropes and holding this in the left hand, the end of the thinner rope is passed upwards through the loop forming a half hitch round the two thicknesses of the thicker rope.

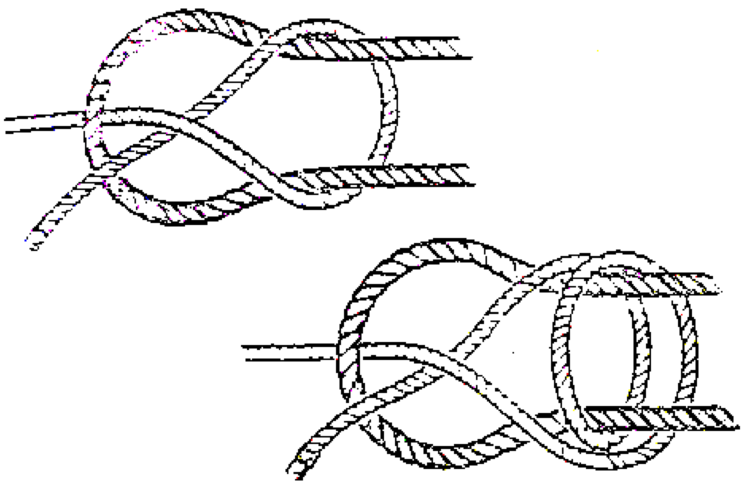
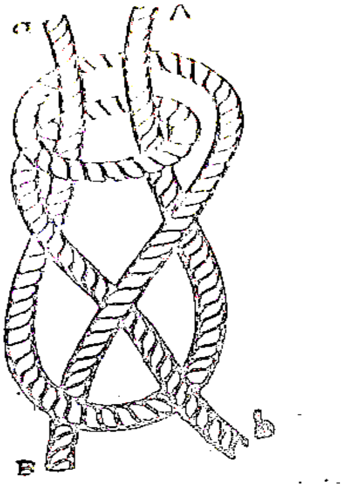
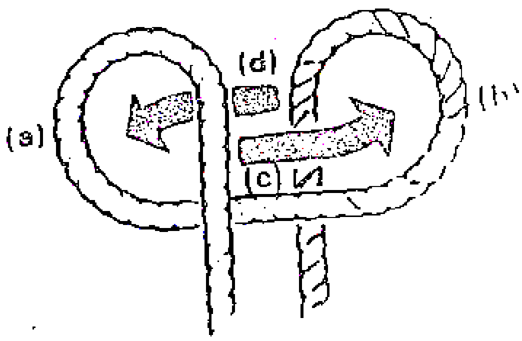


Fig: Method of making (left) a single sheet bend and (right) a double sheet bend,

(k) **Double sheet bend** -The Double Sheet Bend is more secure than the Single Sheet Bend and is used when there is great difference in the size of the ropes. It is formed in a manner similar to the Single Sheet Bend except that after having made the half hitch with the thinner rope, continue turning its short end to make another round turn around the two thicknesses of the thick rope and towards the bight.



(1) **Chair knot** -The chair knot is a good general-purpose knot and one which is very important for emergency rescue work. One of its main purposes is to form an efficient and quickly made sling in which person may readily be raised or lowered. The sling formed by this knot gives support to the chest and legs of the person being rescued. It is formed by grasping the rope, near its centre, in the left-hand palm down. Approximately a yard from the left hand takes the rope in the right-hand palm uppermost. Turn the left-hand palm upwards forming a loop (anti-clock-wise), turn the right-hand palm down forming a loop. Pass the standing ropes through the loops of the opposite hand pulling them through, thus forming two loops with a knot in the centre. These loops can be adjusted to the required size. A half hitch is then made on each loop to keep them at their required size. One loop will be slightly larger than the other to keep the person being raised or lowered in a. "Chaired" position. To place the person properly in the knot the small loop must go under the armpits, and the longer loop at the back of the knees. When properly fixed in this knot and slung the person cannot get out however much he may struggle. At the same time no undue pressure is caused upon his body.



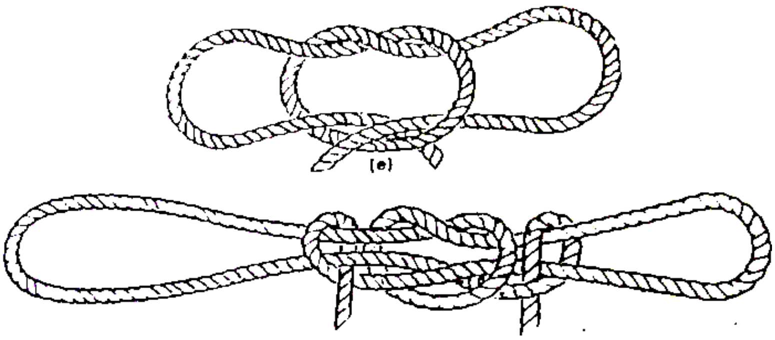
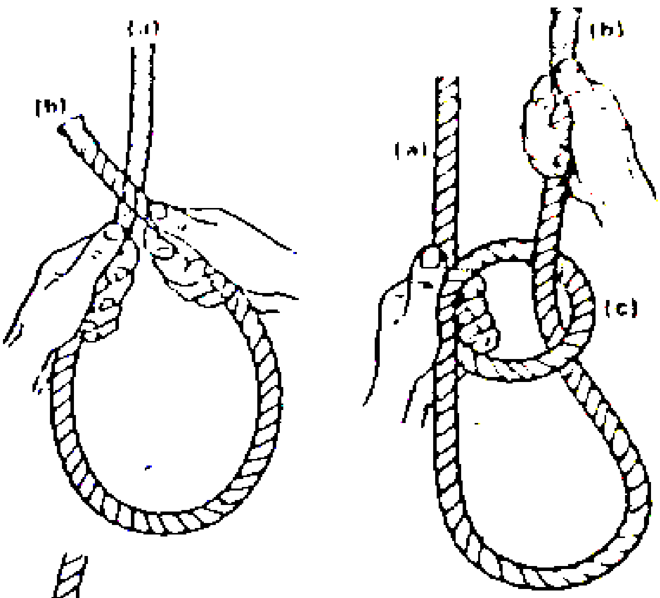


Fig: Method of making a chair knot

(m) **Bowline** -There are several methods of making a bowline, but the simplest and quickest is as follows: the standing part (a) of the line is held in the left hand and the running end (b) in the right. The running end is then laid across the standing part and a half hitch (c) formed round it by twisting the standing part with the right hand. The knot will then appear as shown below:



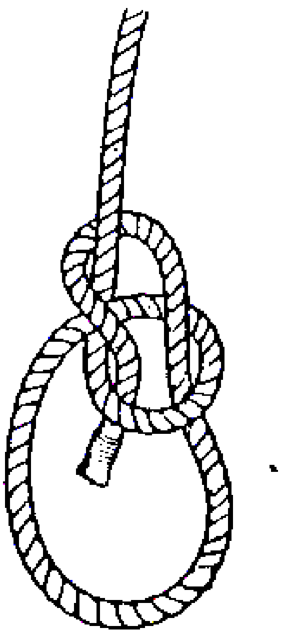
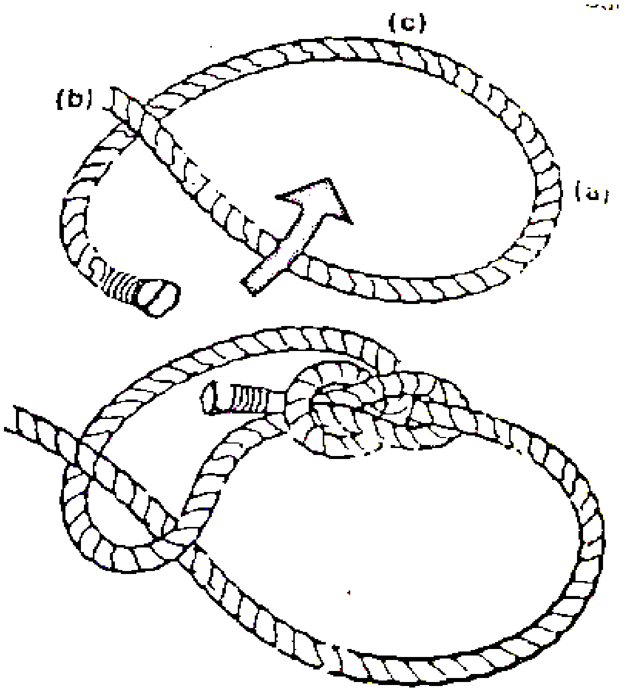


Fig. Method of making a bowline.

The half hitch (c) is now secured against the standing part (a) by passing the running end (b) behind the standing part and back down through the half hitch (c). The knot is then drawn taut.

The bowline forms a non-slipping noose and is useful for lowering or raising purposes, and can also be used to make a temporary eye in lines of all sizes. Another purpose of the bowline is to attach a line round the waist when it is necessary to trail a line, and every fireman should be able to tie a bowline round his own waist with his eyes closed.

(i) **Running bowline -**A running bowline (shown below) is made by forming a bight (a) in the end of the line by passing the end of the line under the standing part (b). A bowline is then made with the end at the point (c) on the bight so formed thus making a running noose.



Method of making a running bowline.

A running bowline can be put on a ring. bolt, spar or other object, the ends of which are secured so that the noose cannot be slipped over, by passing the line round the object, leading it under the standing part and back, and then tying a bowline on the top so formed A running bowline should never be placed round a person's body.

(ii) **Bowline on the bight-**A bowline on the bight is first formed by making a bight (a) in the end or centre of the line. The bight is then used in the same way as the free end is used when making an ordinary bowline, and a half hitch (b) is formed on the standing part (c) of the line. The part of the bight (a) which has been passed through the half hitch is then opened out. and taken in the direction indicated by the arrow (i.e., behind the remainder of the knot) and brought up to the two standing parts (c). The knot is then hauled taut.

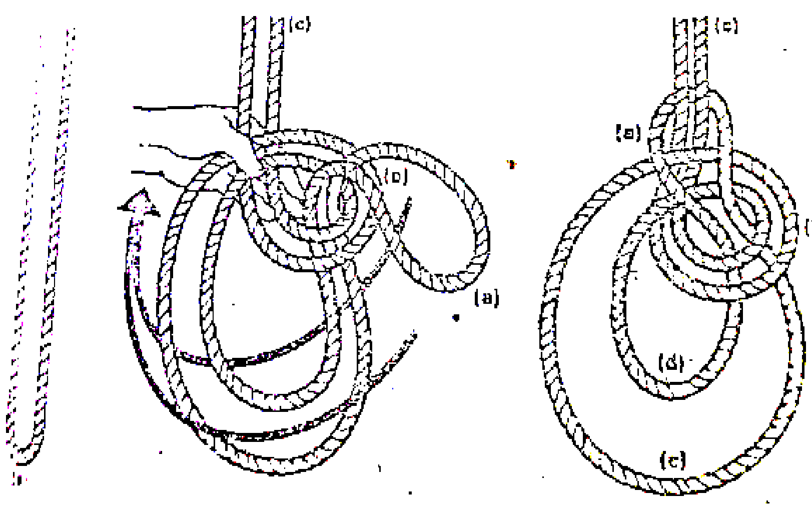


Fig: Bowline on the bight.

This knot is used as a sling for rescue purpose. For this, the two bights (d) and (e) which are formed are passed one under the knees and the other under the armpits of the person to be rescued. The knot should be made so that the loop to go round the body is somewhat smaller than the loop for the legs. The respective lengths can be adjusted as required by slackening the knot and pulling the loops to the desired size.

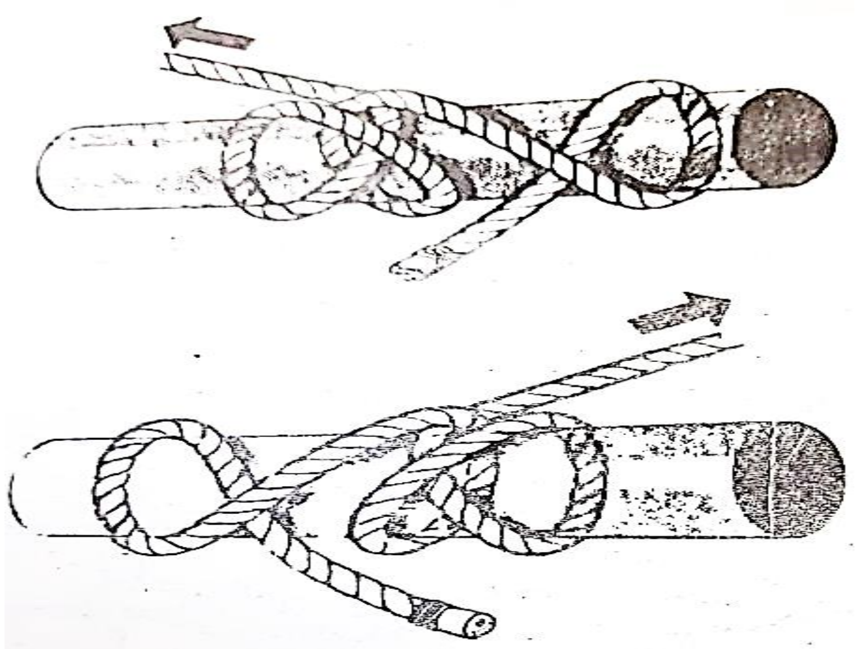


Fig: The rolling hitch, showing the direction of strain.

(n) **Rolling hitch -**The rolling hitch is a variant of the clove hitch and is started and finished in the same manner, but as inter mediate round turn is made between the two half hitches; this intermediate round turn passes over the standing part. This knot has the advantage that it will not slip in the direction in which the double turn is applied if it is subjected to a sideways pull. When tying a rolling hitch it must be constructed for the specific strain which has to resist. Rolling hitches made to take to the left and to the right are shown. No difficulty should be experienced in tying the knot correctly if it is remembered that the round turn should be made on the same side of the standing part as that on which the strain is to be applied, i.e., if the strain is to the left, then the round turn should be made on the left of the standing part and vice versa.

(o) **Fisherman's bend -**The fisherman's bend is an alternative to the round turn and two half hitches, and is made by forming a round turn on the spar or other line to be secured, then making a half hitch round the standing part in such a way that it passes through the round turn. A further half hitch is then made with the and on the standing part. The end should be stopped to the standing part. This knot, like the round turn and two half hitches. is used to secure a line to spar or to another. It is more generally used by fireboat crews to secure a line to a ring bolt.

(p) **Sheepshank -**A sheepshank is used to shorten the bight of a line temporarily without cutting it. It is made by gathering up the amount of line by which it is desired to shorten the line as shown below. Half hitches are then placed around the ends of each bight.

Sheepshank

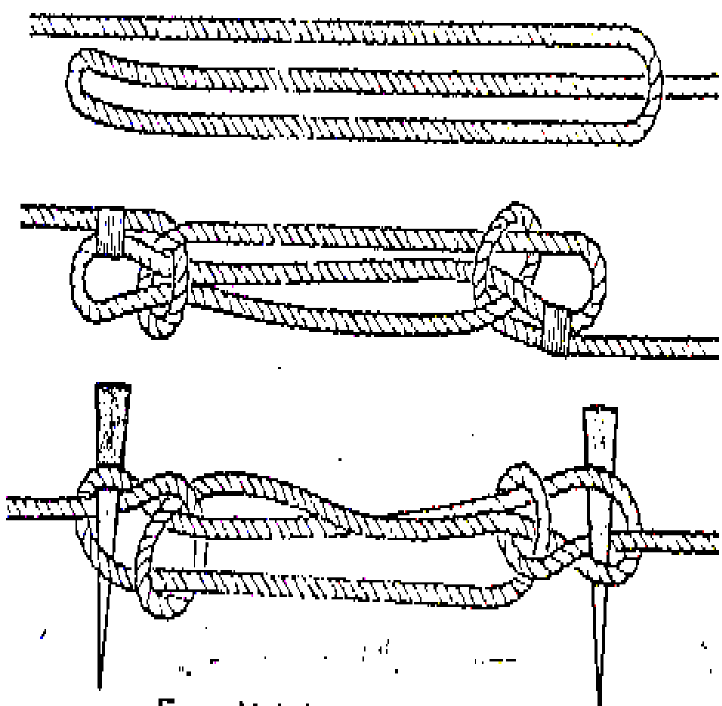


Fig. Method of making a sheepshank

(q) **Waterman's hitch -**The waterman's hitch (sometimes called the lighterman's hitch) is made by taking several turns round a bollard or bitt, passing the running end over and under the standing part and then pulling out a bight (a) which is dropped over the bollard, thus forming a figure of eight. The line is then hauled taut. Fireboat crews generally use the washerman's hitch to secure a skiff to the towing bit of a fireboat. Its virtue is that it can both be made and cast off when under a strain on the standing part.

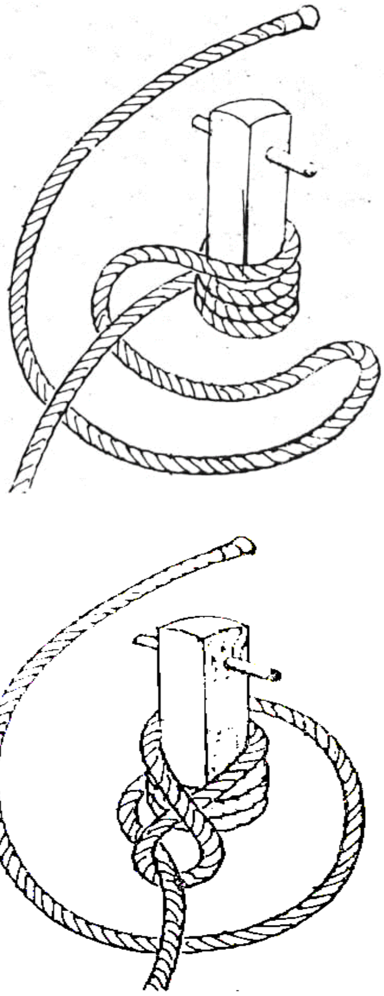
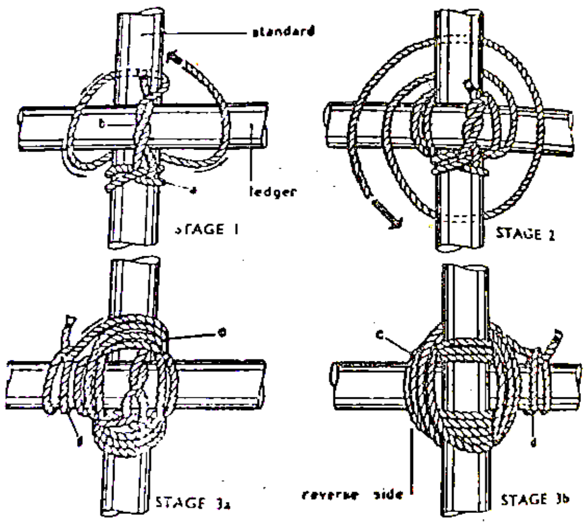


Fig: Method of making a waterman's hitch

LASHING

16. Lashings are used mainly to secure two or more poles firmly together. It may be made by using 40ft.X 1 ½ " lashings carried by rescue party. There are four types of lashings as under:

(a) **Square lashing -**This is used to lash together two poles that touch and cross at right angles. The stages of lashing are shown below:-



(i) Stage1- Start with a clove hitch (a) round the standard below the ledger. "marrying" the ends at (b). Take the "married" ends up and around both standard and ledger as depicted by arrows.

(ii) Stage 2- Repeat this circuit three or four times, drawing the rope as taut as possible.

(iii) Stage 3a.-Take three or four frapping turn (c) around the whole lashing between the spars, draw taut and finish with a clove hitch (d) on the ledger or on the standard above the ledger.

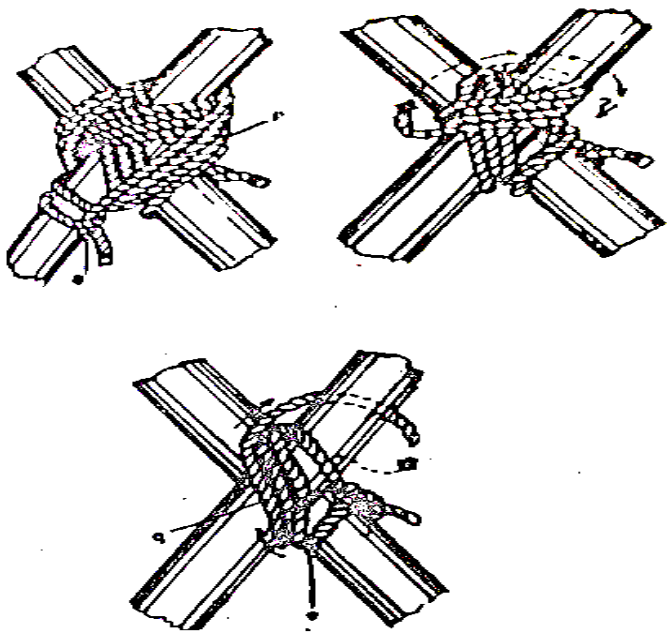
(iv) Stage 3b-The square lashing complete as viewed from the back.

(b) **Diagonal lashing** -This is used to lash together two touching poles at an angle especially within their mode of use may cause them to spring apart. This is carried out in three stages:

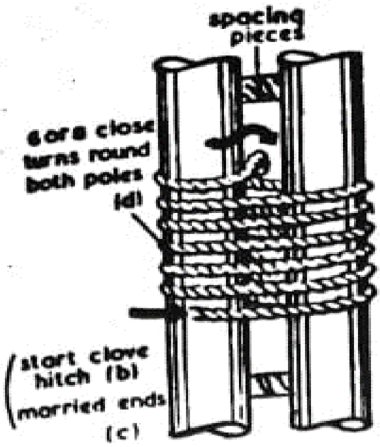
(i) **Stage 1**-Start with a timber hitch (a) round both poles horizontally, then take front vertical turns (b) and draw all taut.

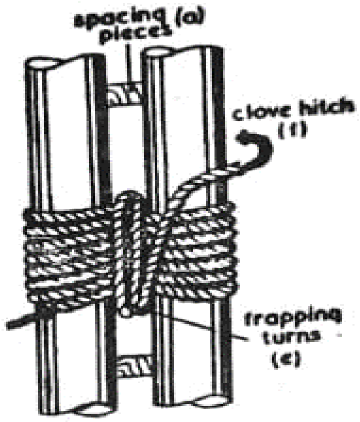
(ii) **Stage 2**-Take four horizontal turns (c) and draw taut.

(iii) **Stage 3**-Finally, put your frapping turns (d) over the lashing. between the spar, draw well taut, and finish with a clove hitch (e).



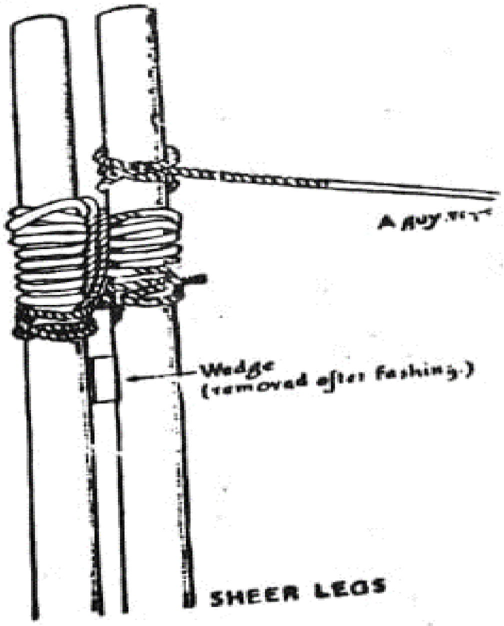
(c) **Round lashing** -This is used to lash together two poles which lie parallel to each other. It is carried out as per the following steps.





Round lashing.

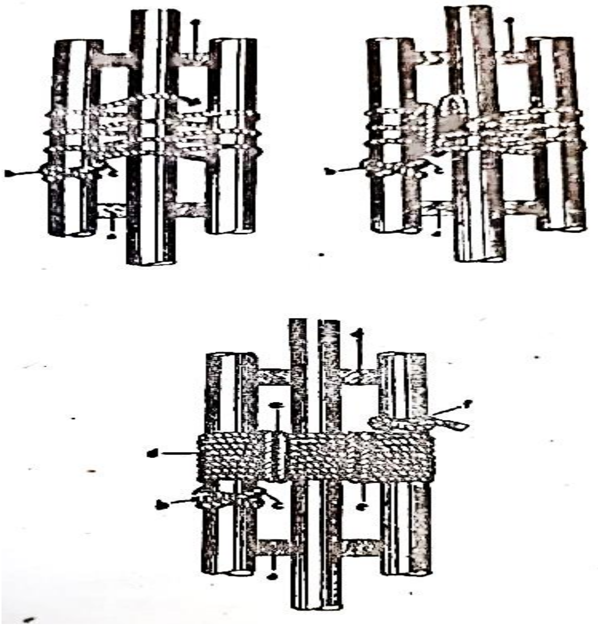
Before starting, insert spacers between the poles. The thickness of the spacers should be



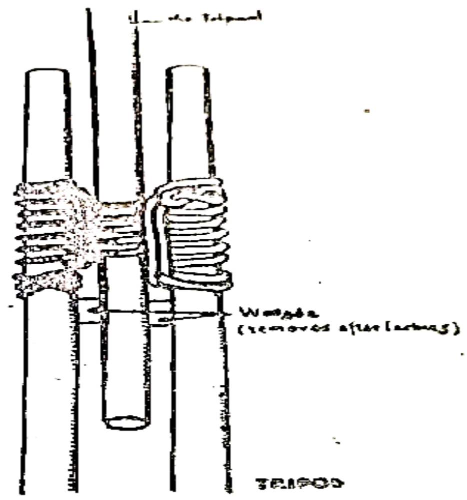
SHEER LEGS

approximately half the diameter of the poles. Put a clove hitch around one pole, marry the ends and continue with 6-8 close turns round both the poles going upwards. Add two or three frapping turns round the lashing and between the poles. End with a clove hitch above and on the opposite pole to the starting pole.

(d) **Figure of Eight lashing**-This is used to lash three parallel poles together, as may be necessary to form a tripod or gyn.



Spacing pieces, approximately half the diameter of the spars, should be inserted (a). Start with a clove hitch (b) round one of the poles, with the end "married". Working upwards all the time from the first clove hitch, continue lashing in figure of eight fashion with 6-8 turns (c). Make two to three frapping turns (d) round the lashing, repeat at (e). Finish with a clove hitch (1) on the opposite pole to the beginning of the lashing.



LANDING FOR TRPOD

SLINGS

17. **General -**For slinging heavy loads to be lifted by apparatus set up by rescue parties, chains and wire slings are carried on company equipment vehicles.

18. **Chain slings -**The chain slings supplied are of the single leg type with a hook at one end and a ring at the other, and are rated at a safe working load of 1000 kg.

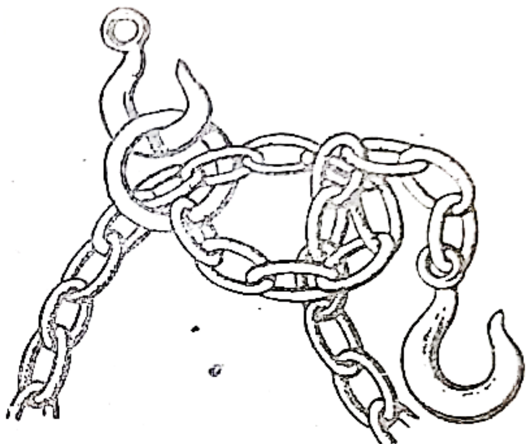
(a) **To Lift a load with a chain sling -**The following methods may be adopted:

(i) The ring of the sling can be placed on the hook of the lifting tackle and the sling hook placed in the ring. or

(ii) The ring of the sling can be placed on the hook of the lifting tackle and the sling hook placed around the chain after passing the chain around the article to be slung. When the latter method is used, the bight should be forced down as low as possible to ensure a firm grip on the load.

(b) **Shortening a chain sling -**Chain slings should never be shortened by tying a knot in the chain as this will cause excessive bending stresses in some of the links and may result in damage or fracture. If it is necessary to shorten a chain sling the method shown in Fig. below should be adopted. (See fig. on next page).

19. **Wire rope slings -**Wire rope slings sup plied with rescue equipment are of the single leg type, capable of dealing with loads up to 1000 kg. They are lighter in weight than chain slings of equal S.W.L., but are more susceptible to accidental damage and require greater care in use.



The links of the upward and downward passing parts of the chain interlock in the ring.

20. **General precautions in use of Slings-** The method of slinging any given object must vary according to circumstances, but certain general rules and precautions should be observed to ensure safe working.

(a) The size and therefore the strength of the sling selected, will be governed by the weight of the load.

(b) The efficient use of a sling is governed by the angle between the legs of the sling or the position in which it is used.

(c) Timber packing must be inserted between the sling and the edges of the load to prevent the sling coming in con tact with sharp edges.

(d) Hooks must be moused.

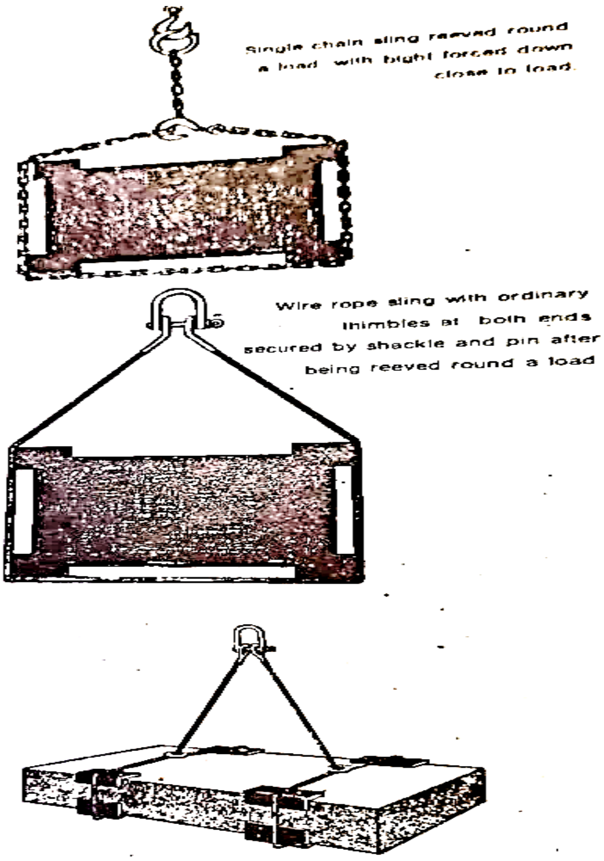
(e) Wire rope slings must not be bent round too sharp an angle and, to prevent this, timber packing must be used to ensure an even curve.

(f) The shackle of a wire rope sling" must not be placed around the sling to provide a bight.

(g) Carelessness in hoisting. e.g. shock lifting or snatching. must be avoided.

(h) Slings should not be dragged along a floor or the ground, and should never be pulled from under a load which, when lowered, is resting on the sling.

21. Method of slinging - In the event of being unable to obtain the necessary chain or wire rope sling, the rescue man should be able to improvise by using the 40 ft. lashing line.



Two slings in use (chain or received wire sling) Horizontal distance between points of attachment to load should not exceed the free length of sling leg Angle at junction of sling legs should be approximately 60 bags.

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CHAPTER 33

LADDERS FOR RESCUE WORK

1. **Introduction-**Ladders are emergency equipment and play an important part in rescue operations. The members of Civil Defence rescue parties must therefore be fully acquainted with their construction and handling. Ability to carry, raise, climb, and handle ladders quickly, safely and proficiently is an indicator of a well-trained rescuer. Apart from speedy work, this proficiency leads to freedom from accidents and supplements efficiency.

TERMINOLOGY

2. The following terms are commonly used in connection with ladders:

(a) **Ladder-**A piece of equipment which may be made of wood/bamboo/aluminium/rope ladder and used for climbing.

(b) **Beams -**These are the sides of the lad der: this is also called sides or strings.

(c) **Rung -**These are crossbars meant for assisting in climbing. They may be made of wood, bamboo, metal or rope.

(d) **Short Ladders -**A ladder which is 8' long.

(e) **Extension Ladder -**A ladder built in sections.

(f) **Bed -**Lower section of an Extension Ladder.

(g) **Fly -**Upper section of an Extension Ladder.

(h) **Heel/Butt-**Bottom or ground end of a ladder.

(i) **Top/Tip-**Top of the ladder.

(j) **Heel Plate -**Metal at heel of the ladder.

(k) **Fly Rope -**Rope used to hoist fly.

(l) **Pulley -**Small grooved wheel through which fly rope is drawn.

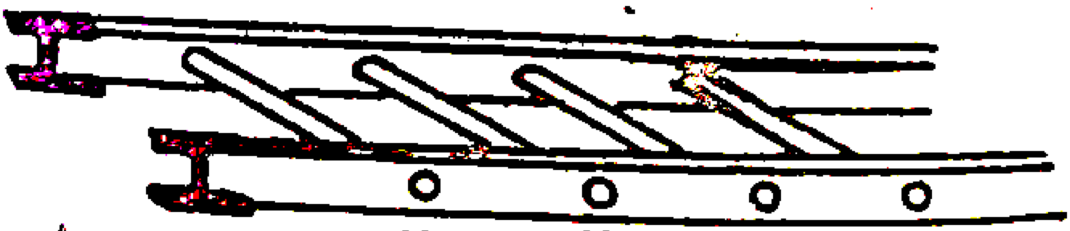
(m) **Pawl or Dog -**The mechanism on the lower end of the fly ladder that secures it to the bed ladder and holds the rungs at desired elevation.

(o) **Straight Ladders -**This is also called walled ladder. It consists of one section only.

(p) **Hook Ladder -**Also known as roof lad der. This type of ladders have hooks mounted on a socket.

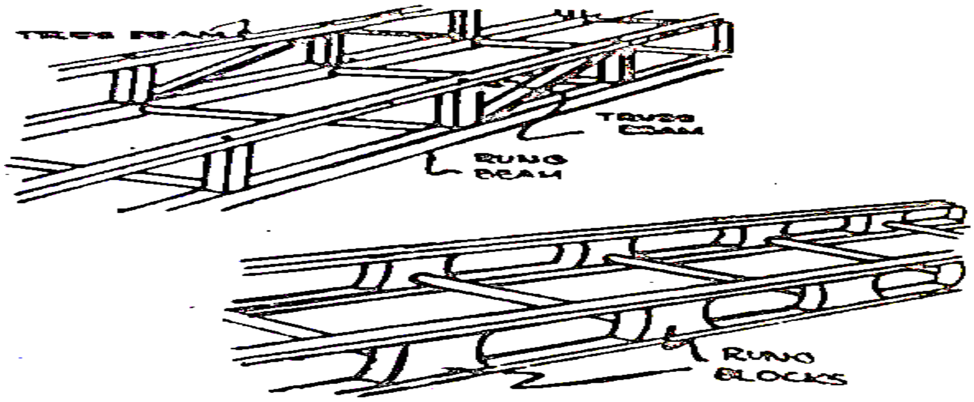
DESIGN AND TYPES OF LADDERS

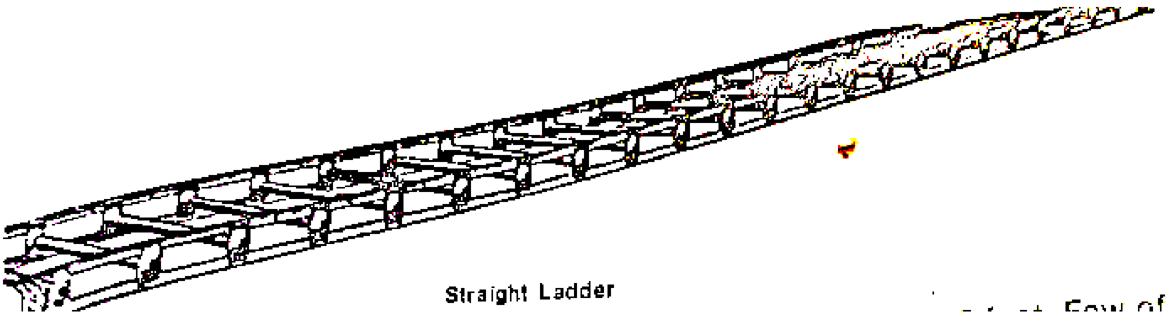
3. General -Seemingly the matter of "lad der design" would be of concern only to the manufacturers, yet wide-awake rescuers should know the details of construction in order to use a ladder efficiently and safely. The principal parts of a ladder are the sides, called beams, and the rungs. The rungs are of similar design consisting of a round bar of a size to provide the required strength and to be easily grasped. Metal rungs may be fluted horizontally to provide surer grip and footing.



Sold Beam Ladder

Ladder beams are either solid or trussed. As the name suggests, the solid beam is a solid piece of material of such shape and size to provide the required strength. The rungs are set in at the centre of the solid beam. Trussed construction is employed in the larger sizes to make ladders stronger.





Straight Ladder

4. With advancement in technology, aluminium alloy ladders have come in to general use in rescue service. They are of light weight and when constructed as three section ladders, a 45 to 50' length may be achieved.

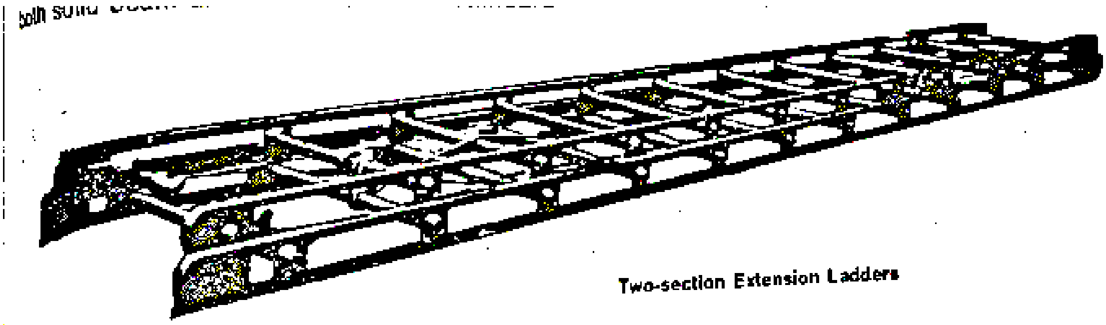
TYPES OF LADDERS

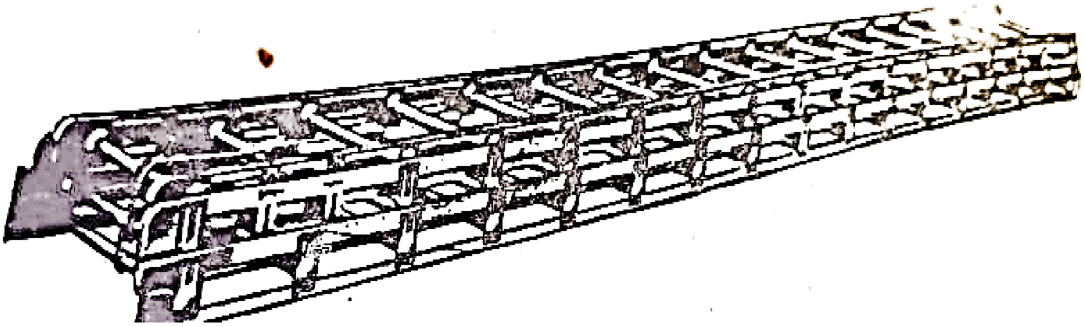
5. (a) **Short Ladders**.-The types of short ladders used by the Rescue Parties are of 8 to 10 feet in length. Two short ladders each 8 feet long coupled together form a ladder approximately 13 feet long. A ladder of this size can reach first-floor windows of most dwelling houses and also into basements, and will prove valuable when making a reconnaissance. These short ladders may also be employed when getting over obstacles, damaged walls, gaps and so on. For bridging a gap. ladders can be used by placing one (or two side by side) over the opening (reinforcement if any, on the underside) and laying a board or boards flat on the rungs. Wherever possible, one length of board should be used on one ladder, but if this is not practicable, care must be taken to overlap the ends of the boards where they meet in such a way that the rescuer will not trip when carrying a casualty. The ladder or ladders must be long enough to bridge the gap and to have adequate support at either end.

(b) **Bamboo or Wooden Ladders -**These are ordinary bamboo/wooden ladders of 20 feet in length. In emergency, two such ladders can be lashed together with an overlapping of 3 feet to give a maximum length of 35 feet. A 15 feet long ladder also can be used instead.

(c) **Straight Ladders -**Sometimes called "wall ladders", of one section only, are made of both solid beam and trussed, and in standard Ladder lengths ranging from 10 to 28 feet. Few of 30 or more feet in length, are in use.

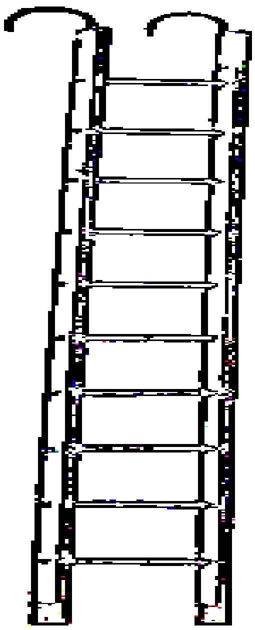
(d) **Extension Ladders -**These ladders are generally made of two/three sections with length ranging from 14 to 100'. However, the normal issue to a rescue party is the 35' extension ladder which is in two sections, the upper section sliding on and between the sides of the lower section. Pawls are fitted to the lower end of the sliding section and operate on a rotating shaft; pulling lines are taken through shelves fixed near the top of each string of the lower section, brought down and fastened to hooks or cleats at the bottom of this ladder, one cleat being attached to the pawl shaft, thus providing endless lines by means of which the top section can be extended, and the pawls which are mounted on the sliding section can be engaged and tripped or released. The metal tongues fit ted to the top section of the ladder slides into grooves cut in the strings of the bottom section. To make it easily distinguishable in the dark the strings of the bottom section should bear a white line to indicate the "limit of safety" when extended for use-the over-lap of the ladders is normally five rungs. Similarly, the "bottom" of the ladder should have a 6-inch band of white paint. The ladder is strengthened on the underside of all strings by galvanised wire which is stretched tautly in the groove along the edge of the strings, being secured at the top and bottom and kept in position by staples. The ladders are further strengthened by cross-ties of wrought iron rod from string to string at intervals. Ladders should not be painted as paint would hide incipient defects. Clear varnish or treating the bare wood with linseed oil usually prove satisfactory.





Three section Extension ladders

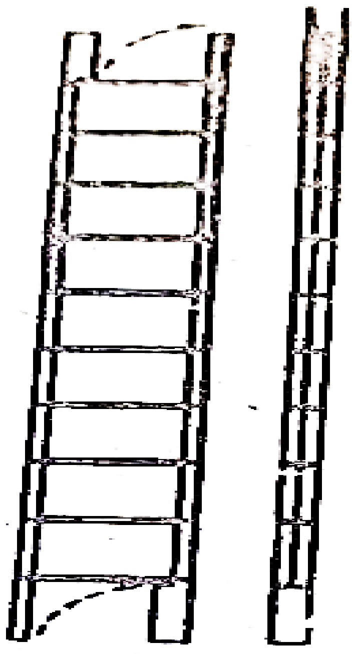
(e) **Hook Ladder/Roof Ladder -**It is an adaptation of the wall ladder to a special purpose. There are several types of roof ladders, most of which have the hooks mounted on a movable socket which permits them to fold inward when not in use. A few old roof ladders with rigid hooks are still in use. The roof-ladder is employed in getting to peaks of gabled roofs to permit rescuers to cut holes for ventilation. It can also be used to good advantage in entering scuttle-holes or holes cut through flooring and sidewalk openings. The hooks of the ladder may be placed over roof peaks, sills, walls, or coping to secure the top of the ladder. Hooks may be set so that they do not protrude beyond the ladder beams, thus permitting the ladder to be used as a wall ladder. Other uses are as an improvised "pompier" or scaling ladder, as an "improvised cellar pipe". as part of the framework for an emergency suction basin, and as an improvised nozzle holder. Roof ladders of the hook type range in lengths of 10 to 20 feet.



Wood roof ladder

They may be either the solid beam or the truss beam type. The ladder may also have a single hook fitted to the top rung in the centre.

(f) **Collapsible Attic Ladder-**The 10-feet collapsible ladder is especially useful for inside work. It can easily be carried up stairways and to places where the ordinary ladder would be cumbersome. To operate, place the ladder in a vertical position and grasp each beam, pushing them apart. A baby extension ladder may also be used as an attic ladder.



Collapsible attic ladder

(g) **Rope Ladders -**Rope ladders as the word denotes is made of ropes. The strings are made of ropes and rounds/rungs are made of bamboos/wooden members. This ladder is a very versatile one and can be improvised on the spot itself. This type of ladder has the added advantage of being light in weight and easy to store. These ladders are mainly used for climbing on to an improvises bridge which is fixed at a height.

JOINING AND TESTING OF LADDERS

6. Sometimes two ladders may be joined together to form one longer ladder. To do this, one end of the ladder is placed on and overlap ping one end of the other ladder. A clove hitch is given around the strings of both the ladders on one side. The loose ends are then married together and the rope taken around the strings of both the ladders and coming downwards one or two rounds and then crossing over to the other side. On the other string it proceeds in the same way but upwards and is finalised with a clove hitch parallel to the first one. The points to be noted are:

(a) Start with a clove hitch and finish with a clove hitch.
(b) The lashing should be tight.
(c) Keep sufficient over-lapping between the two ladders.

7. **Standard Test of 35-feet Extension Ladder -**Extension ladders should be tested monthly or more often if necessary. The first test is a usual examination followed by a practical test of the strings and rungs. Examine the condition of the strings, rungs, pulleys and pawls and lubricate working parts. Look for obvious defects, especially any displacement of anchoring of reinforcing wires, cracks or shakes in the strings or rungs, loose rungs or missing wedges, riveting of cross ties and position of washers, bent or twisted pawls or pawl shaft, bent cleats, loose guides, frayed ropes, and defective fastenings of ropes to pawl shafts. Pay particular attention to the condition of the strings at the bottom of the lower half of the lad der. If the examination is satisfactory, lay the ladder flat on the ground with the strengthening wire on the strings towards the ground; extend it to the length shown by the white marking lines on the main ladder, lift it on to two trestles (or boxes, etc.) positioned about two feet from either end; measure the distance of a point in the middle of the span from ladder to ground. A man of approximately 80 kg should sit gradually on the centre of the ladder and after it has reached its limit of sag, he should spring off smartly, when the ladder should resume its previous position. If there is a discrepancy between. the first and second measurements, further inspection should be made, paying particular regard to the anchoring or stretching of the reinforcement. If it appears that serious stretching has taken place in the reinforcing wire, or other defects becoming apparent during this test, the ladder should be returned to store. After this test, the ladder should be halved and each half raised so that the weakest parts of the rungs and sockets may be tested. Each rung should be "jumped" by a man who has ascended the ladder. The correct method is to transfer the man's weight sharply downwards from each rung to the next with the feet separated as far as the strings permit. The height of the jump should not be increased nor used to deliver a violent blow to the rung. The ladders should be erected as nearly vertical as safety conditions permit, the head being secured and two men stationed at the loot. The ladders should then be reversed and the remaining rungs "jumped".

8**. Test of the Extending Rope -**The extending rope is to be tested by applying the weight of two men. This is carried out by pitching ladder without extending against the wall. The weight of two men is then applied to the rope as far extending the ladder, as low as practicable, while two other men apply their weight to the extension to prevent it moving. The remaining part of the rope is tested by applying the weight of two men as earlier but with the ladder fully extended.

USING STRAIGHT LADDERS

9. Ladder practices include the job of taking the ladder from its resting place, carrying it to the location where it is needed, placing and raising to the climbing position, securing the ladder, climbing or using the ladder, lowering. carrying to the place were kept and depositing it there. This will be covered under following sub-heads: -

(a) Securing ladder.
(b) Carrying and placing.

(c) Erecting and lowering.

(d) Climbing.

10.**General -** Different parts of an Extension Ladder and their functioning is shown below:

(a) Close up showing top of lower half and half of upper half partly extended and sliding through sides of lower half and two metal guides.

(b) Pawl in clear or sliding position.

(c) Close up of pawl in extended and locked position.

(d) View of underside of ladder, showing pawl engaged in lock position also showing reinforcing wires under the strings and wrought iron ties under rungs

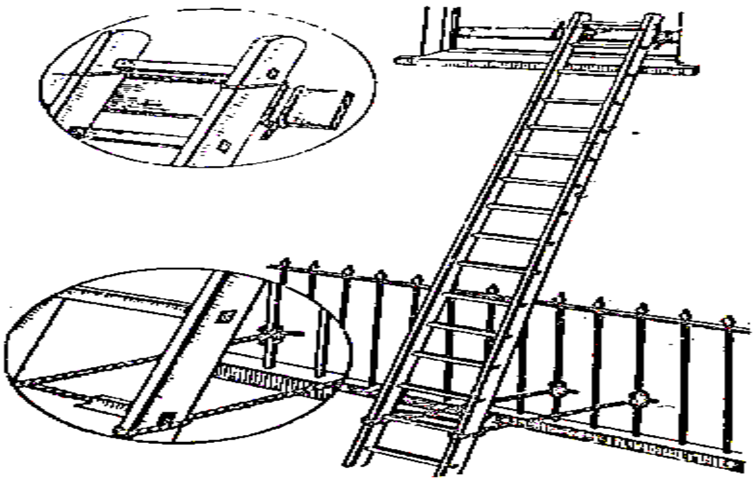
(e) Top half being raised showing pawl in clear or sliding position.

(f) Top half partly extended and paw engaged to stop sliding.

11. Securing-If the ladder is to be unattended and to be made more secure and steady the heel and the head of the ladder should be secured by ropes as follows:

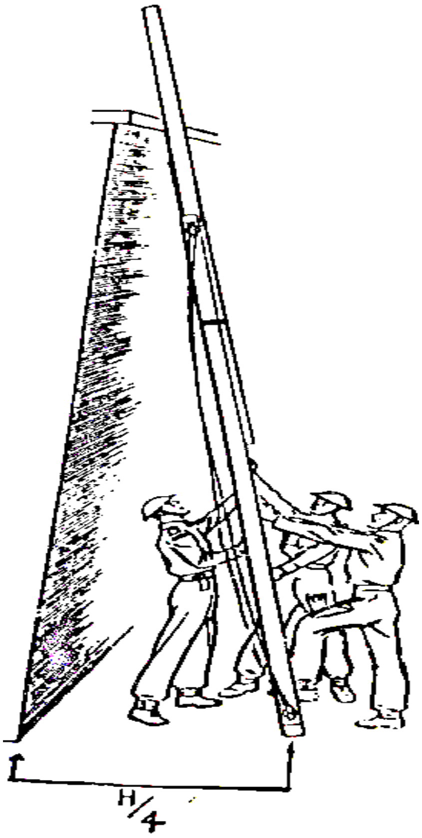
(a) **Heels -**Drive in two small iron pickets into the ground by the side of the heels of the ladder one on either side. Take a sash cord [15 (4.54 m) long 1" (2.54 ams) rope] and make a clove hitch on the picket, marrying the ends of the rope and giving about six turns over the heel and the picket in the form of Figure of Eight. finishing with a clove hitch on the heel of the ladder, thus securing the heel of the ladder to the picket. Similarly, the other heel of the ladder is also to be secured.

(b) **Head -**Fasten the end of a rope to a rung on the head of the ladder by means of a clove hitch and then tie the other end of the rope to some suitable object on the higher floor by clove hitch, thus securing the head of the ladder.



Securing Head & Heel of Ladder

(c) **Angle of Ladders when raised** -When a ladder is raised the angle which it makes with the ground should not be too great or too acute. As a general rule, the bot torn of the ladder should be placed at a distance from the base of the wall about equal to one quarter of the height to be reached and the ladder should be extended so that the top of the ladder should not be less than 4 feet above the stepping-off point. This would mean that to reach a stepping-off point 28 feet above the ground, the bottom of the lad der should be 7 feet from the wall. distance of the bottom of the ladder from the wall should never be more than half the height to be reached.



12. **Carrying and Placing**:

(a) **One-man Carry**

(i) Facing top of ladder, rescuer grasps centre of rung next below centre of ladder. Picking up ladder, he pivots extending free arm through ladder.

(ii) Ladder is carried on shoulder secured by grasping a rung with the hand that is through the ladder, leaving the other hand free. The front end of ladder should be tilted down to clear the vision of the carrier and also to prevent catching in overhead obstructions.

(iii) When at the desired location place butt of ladder against building or some other secure object.

(iv) Using both hands, raise the ladder to a vertical position by walking toward the foot of the ladder, grasping rungs.

(v) Grasp the ladder by the rungs with hands about three rungs apart, and set at a climbing angle. A good general rule is to place the butt of the ladder away from the building a distance about one-fourth of the height to which the ladder is extended.

(vi) To lower the ladder, reverse operations.

(vii) When lowered to shoulder height, it may be placed on the shoulder and carried to desired resting place.

(b) **Two-man Carry -**The practices for handling a longer straight ladder with two men are as follows:

(i) If ladder is on the ground, men take positions facing the opposite direction to which they expect to go. They grasp a rung with palms to the front as shown and lift to shoulder height (opposite hands placed on thighs assist with lift) turning as it is raised and thrusting free arm through the ladder. With the hand that is through the ladder grasp a rung or beam forward. If the ladder is on the truck, it may be loaded directly on the shoulders.

(ii) To carry, proceed, stepping in unison and using the free hand to guard against traffic and obstacles. Spot butt of ladder where desired.

(iii) To put ladder back on ground, reverse operations.

(iv) To raise ladder, the man on the butt places foot on heals of beam and reaches forward grasping convenient rung. The second man takes his place. alongside ladder, facing top and grasps a rung. He lifts ladder, turning under it and steps forward.

(v) If ladder has been raised at right angle to the building, it may be lowered into place against the building. If raised parallel to the building, it must be pivoted on one beam and lowered into building.

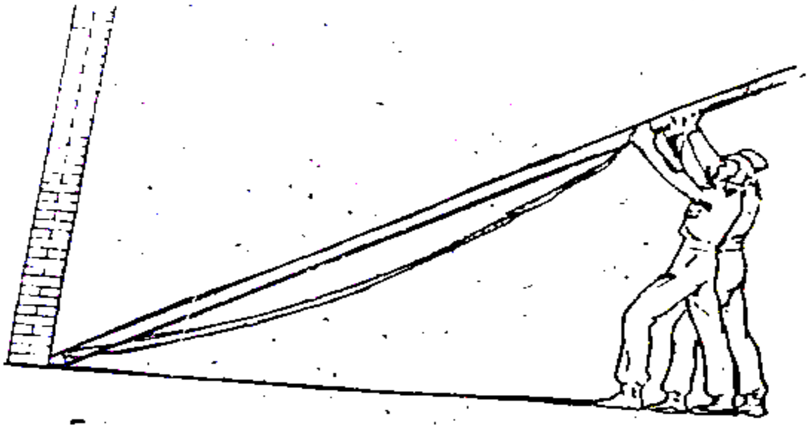
(vi) A straight ladder may be raised on the beam by two men as shown below. The heel man places right foot on spur and both hands on beam. The beam man grasps centre of 4th and 5th rung, raises and pivots under ladder as heel man steadies ladder and helps with, raise.

(vii) To lower ladder, reverse operations.

ERECTING AND LOWERING

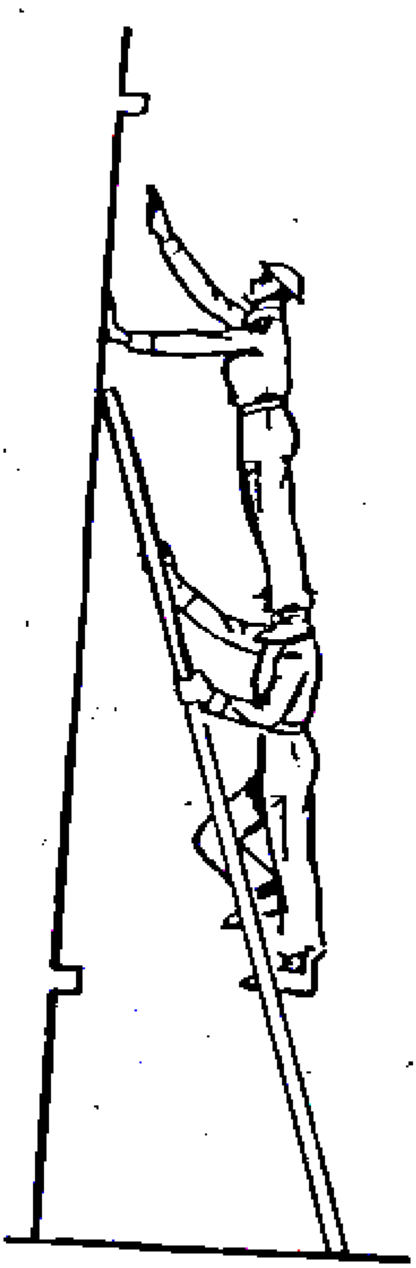
13. (a) **Erecting and Extending the Ladder (three men)** -Normally three men are required to form a ladder team. No. 1 is responsible for the bottom of the ladder, both in carrying and positioning where necessary: Nos. 2 and 3 support the uppermost string of the ladder on their shoulders. On arrival at the site required for erection No. 1 places the bottom of the ladder with the reinforcing wires uppermost as near as possible for its required position and anchors it by "footing" it. Nos. 2 and 3 working on their respective sides raise the ladder from the underneath side to the vertical position, assisted by No. 1 as soon as it has reached a suitable slope to enable him to grasp the sides and exert his pull. If the reinforcing wires are not now facing towards the building the ladder should be turned in the required direction, ensuring that the reinforcing wires of the ladder will be on the underside. Provided that it has been correctly placed before raising, it should be unnecessary to handle or carry it far in this position. Nos. 2 and 3 face the ladder, each "footing" it, then pulling on the ropes, extend the ladder to the required height ensuring that the pawl is properly engaged on the rung. The ladder is then laid back into position by No. 1 who walks back ward until the top of the ladder comes to rest where required-i.e. against sill. wall or floor.

(b) **Erecting and Extending the Ladder (two men)** -When no third man is available to "foot" the ladder, the bottom of a ladder should be placed against a wall, kerb or some other fixed object. The ladder is underrun in the usual manner by the two men, extending to the required height, and the foot of the ladder drawn outwards to the correct distance from the wall.



Erecting and extending a Ladder (two man)

(c) **Shoulder Stand** -On rare occasions when the short ladder is a little too short to reach a desired height, and the extending lad der is not available-e.g. when the short ladder can only reach to about two or three feet below parapet or the sill of a window, it may be necessary to adopt the "shoulder stand" by which one man is enabled to reach the desired position by being mounted on the shoulders of the man underneath him on the ladder. This method should only be taught as advanced training. Two men mount the ladder, one above the other. Near the top, the upper man steps back and guided by one hand of the lower man. places his insteps in turn upon the shoulders of the lower man who continues to ascend slowly with the first man on his shoulders until the upper man reaches the necessary height. After he can no longer grasp the sides of the ladder the upper man must cling to or palm up the wall with his hands, leaning lightly forward to obviate falling backwards or sideways. For drill practice the "shoulder stand" can be carried out by erecting confidence in the use of the topmost part of the ladder and the practice should be repeated so that all men in a party have a turn at acting the "upper" and "lower" man.



Shoulder Stand

(d) **Lowering-** For lowering a ladder follow the reverse drill of extension.

14. **Climbing and Leg Lock -**Climbing a ladder comes naturally to some, while others must learn through practice. The two essentials in climbing are rhythm and safety. It has been found that for most men the best rhythm is obtained by taking every rung with the feet and hands. Some prefer taking every other rung with the hands, but by doing so

the ladder may start vibrating or a rung may be missed in the dark which can prove hazardous. However, climbing habits are something that will vary with the stature of each individual. The hands should be on the rungs except when carrying with one hand and then the other should be on the beam. sliding it along to prevent losing a hold. Climbers should practice taking a firm, quick hold on each rung which will safeguard them in the event their feet should slip. The feet should be at the centre of the ladder to prevent wobbling. The body should be kept nearly upright by keeping the arms straight. Use the ball of the foot in climbing and do not run. Climb steadily and smoothly.

When working from a ladder, it may sometimes become necessary to keep both the hands free to haul up any sundry tool of equipment. A rescuer should not release his hold unless he had secured himself by taking a "leg lock". The locking leg should be opposite the side where the work is to be done, and the opposite foot should be against the beam. This method leaves both hands tree for handling ladders, and tools. Or a man may secure himself to a ladder with a ladder or "pompier belt" or with a rope tool placed around the waist with a hook over the rung. Anchoring thus to a ladder is done when one must remain in that position for some time.

USE OF EXTENSION LADDER

15. **One Man Drill -**If an extension ladder is no longer than 35 feet, it may be carried and raised by one man. Place one foot on ground at side of beam with knee against beam to steady it. The fly must be raised as follows: Grasp halyard, letting top of ladder lean toward building slightly to balance it and extend fly. When fly is raised and the halyard is secured, the ladder is lowered into the building and the bottom properly spaced. To lower ladder, place one foot on bottom rung to steady it, bring to a vertical position and reverse operations. If the ladder is on a truck or on hangers, it may be loaded directly upon the shoulder of the one to carry it, in which case he will release any ladder locks holding the ladder, determine the centre of the ladder, lift it from the hooks, and proceed as described. If the ladder is to be set on concrete, it may be necessary to place the heel against the building or some other object, then set it at the desired distance before raising the fly. If the ladder is to be placed in a window, it should be placed at one side and not in the centre.

16. **Two Men Drill -**If the ladder is of the length of 35 feet it can be raised by two men. With the ladder on the ground. the procedure is the same as for a straight ladder. The ladder is placed on the ground at the desired location parallel to the building. When raised, the ladder is pivoted on the beam to bring the fly ladder next to the building. When the ladder is raised directly toward the building rather than parallel with the wall, the fly ladder should be on top before raising to bring the fly next to the building. To raise the fly in a two-man raise the inside man steadies the ladder with his hands, and the outside man raises the fly. When at the desired height, both men lower the ladder into the building. To lower the ladder, reverse the procedure. A few factors should be noted. The foot or heel man should guard the ladder with his free hand but must be careful not to have his hands

or feet where they will be caught and injured by the movement of the fly ladder. The man heeling the ladder can aid materially in raising by throwing his weight back to balance the ladder. To do so he should be in a crouched position. He

should watch the top of the ladder. Again, if the ladder is on the truck or on hooks, the men can load it directly on their shoulders after releasing locks, making sure they are in the correct positions for carrying. Likewise, it can be loaded on the truck from shoulder position.

17. **Three Men Drill**.-To raise a regular extension ladder with three men, the following procedure is recommended:

(a) Remove ladder from truck and carry it to location, placing heel at proper distance from building before ladder is raised. (The heel man determines proper position).

(b) The ladder is laid flat, with fly on bottom.

(c) With his back to the building. No. 1 man stands on first rung, reaches forward and grasps a rung with both hands and assists in raising ladder.

(d) Facing the top of the ladder No. 2 and No. 3 men space themselves about one-third of the distance from the top of the ladder. They reach down with their inside hands. grasp rung and raise ladder, turning their bodies under it while raising, thus facing heel of the ladder.

(e) Both men then walk toward the heel of the ladder, pushing upward on the rail hand-overhand, until ladder is in an upright position. All men should watch the top of the ladder.

(f) No. 1 on the building side and No. 2 on the outside steady the ladder while No. 3 raises the fly. No. 1 then steps back. allowing the ladder to lean slightly toward the building to counteract the strain made by pulling on the fly rope.

(g) No. 1 man locks the pawls (or dogs) by pulling down on the rope from the under side.

(h) The ladder is then eased against the building by all 3 men, while each of the 2 men on the outside places his inside foot on the lowest rung to steady it.

(i) To lower the ladder, reverse procedure.

USE OF ROOF LADDERS

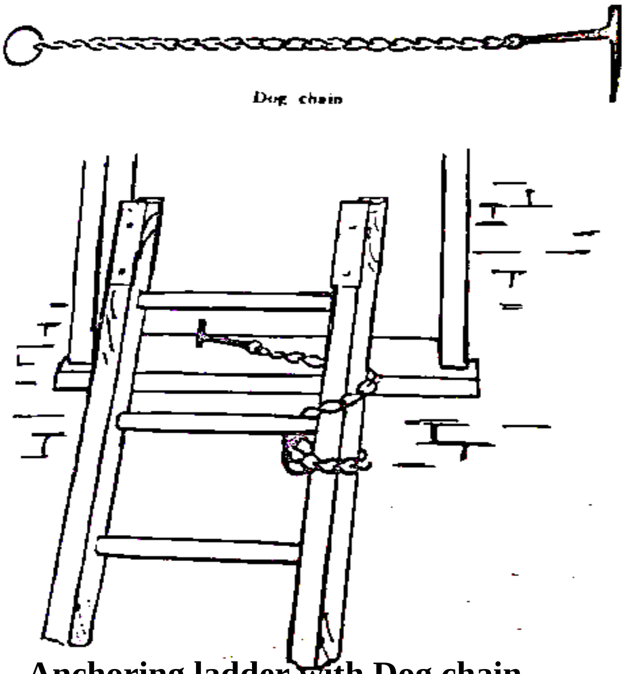
18. A roof ladder usually is carried up another ladder to be used. The evolutions consist in carrying it to and up the other ladder and placing it in position on the roof. The position for carrying a short roof ladder is the top end ahead and lower than the shoulder for safety. The man carrying the roof ladder opens the hooks before climbing. He then carries the

roof ladder up the main ladder with hooks turned outward. The roof ladder is pushed up the roof with hooks downward until they are secured over the ridge pole.

If a long roof ladder requiring two men is used, both men carry the roof ladder up until the front man reaches the eve of the building, where he locks in and proceeds as before, the second man assisting. To lower the roof ladder, the operations are reversed.

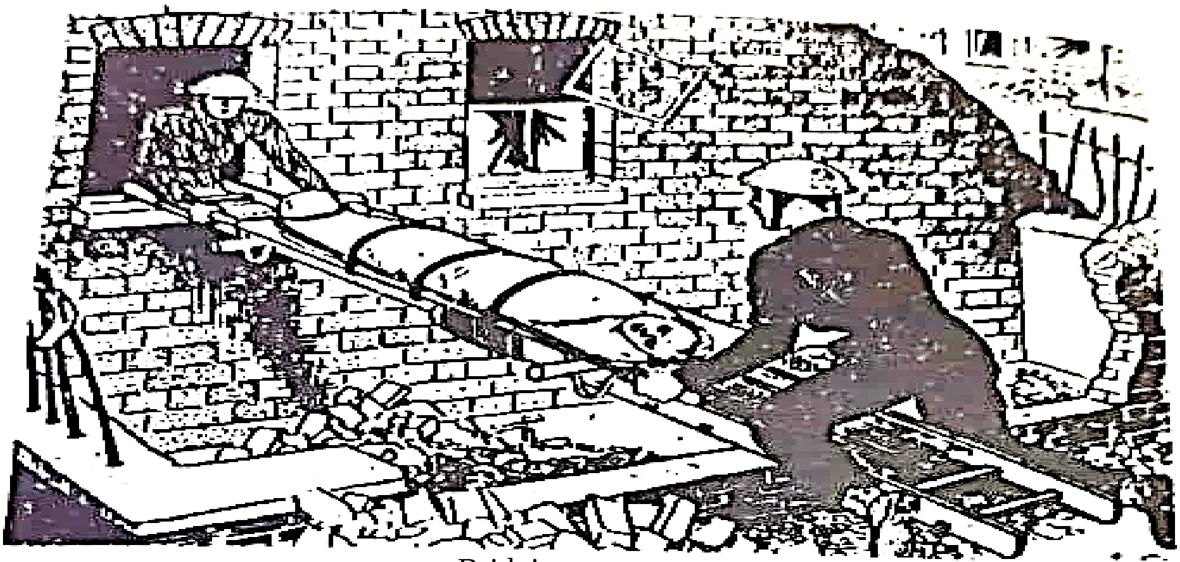
ANCHORING LADDERS

19. An important safety feature is that a lad der should be anchored to the building especially during icy or windy weather or when a hose line is to be operated from the ladder. This may be done with a ladder "dog" chain. rope hose tool, hose chain, or strap as shown. Metal "dog" chains which are passed around the ladder beams and spiked with a hammer or axe into the window-sill provide the most secure method of dogging a ladder.



Anchoring ladder with Dog chain

20. **Bridge the Gap**: At places of incident, rescuers may sometimes have to go over from one position of a damaged building to another where there is a gap in between these circumstances, a ladder would prove t be very useful in bridging the gap. To do this ladder would be placed across the two ends the ladder resting on the two structures of the buildings over the gap on either side with sufficient overlap, end the rescuer may then craw walk over the ladder thus crossing the go between. Boards may be placed over the range to improve the footing.



Bridging a gap

CARE AND MAINTENANCE

21. Ladders must be maintained in first class condition. The manufacturers have selected each part with infinite care. The wood or metal has been properly aged, seasoned or alloyed to stand up under rigorous use. In time however, wood used in ladders may become hard and lose elasticity. Fibres may become damaged. The beams may splinter and rungs become loose if periodic attention to maintenance is not given. Weakening of a ladder from any of these causes or from overloading may cause ladder failure. The loosening of rung or blocks presents additional hazards. and usually results from neglect. Constructional joints of the wooden ladder should be kept water resistant Ladder should be varnished but never painted so as not to conceal defects. The greatest stress on ladders usually results from overloading them. Ladders are commonly overloaded when placed at an improper angle

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CHAPTER 34

CASUALTY HANDING IN RESCUE OPERATIONS

1. **Introduction**

All seriously injured casualties will require transportation from the point wherefrom to the forward medical aid unit. There is nothing better on which to convey a badly injured casualty than a stretcher. However, when there is shortage of stretchers it would be better to improvise one rather than man handling the casualty. Finally, situations may arise wherein the rescuers would have to use emergency methods involving their bare hands and feet. In order to make the casualty comfortable the technique of blanketing casualty must be mastered.

STRETCHER HARNESS, LASHING AND SECURING OF CASUALTIES

2. **General**

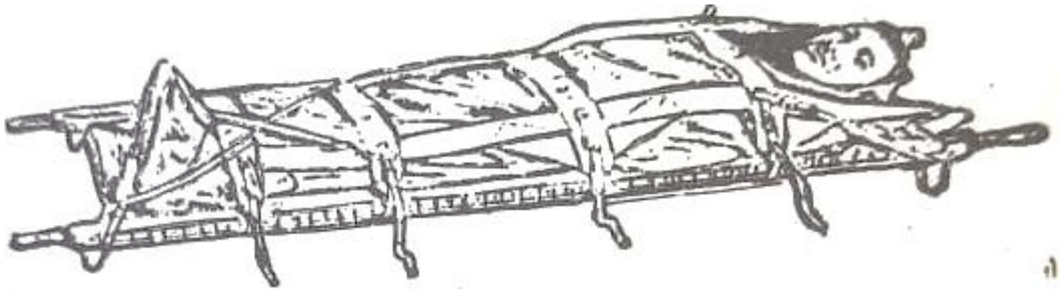
When casualties are required to be removed on stretchers from confined places, high buildings, through narrow passages, over rough ground or with lesser bearers, it becomes necessary to adopt additional measures to ensure safety of the casualty during its removal on stretcher as well as making it convenient for the bearers. Use of stretcher harness and lashing the stretchers are two important measures that can be adopted for such purposes. All members of the Rescue Parties and First-aid Parties must be fully con 'versant with the use of these.

3. **Stretcher harness**

During rescue operations there is a possibility of the bearers stumbling and of the debris moving, with a con sequent risk of the casualty being thrown off the stretcher. In some instances, the stretcher will have to be turned on to one side, or up-ended. to pass some obstruction, and on these occasions, it is necessary for the casualty to be securely fastened to the stretcher. This is done either by using the manifold stretcher harness or by improvising with a 40 ft. lashing line. There is a recognised drill for the application of the "Manifold" Stretcher Harness as follows. (Two bearers are required to adjust the harness).

(a) Casualty is laid on the prepared stretcher.

(b) (i) No. 1 places the harness (see Fig.) on the casualty so that the widened part covers the trunk, with cross strap marked "1", one hand's breath below the chin. No. 2 assists No. 1 and bunches the free ends of the transverse straps at the side of the stretcher.



Application of manifold stretcher harness

(ii) (For casualties of abnormally small size. Five feet four inches and under.) The harness is placed on the casualty with the wide part covering the trunk, and No. 1 threads the casualty's head through the top window and pulls it down so that the cross marked "1" fits snugly behind the neck. No. 2 assists No. 1 and bunches the free ends of the transverse straps at the side of the stretcher.

(c) Nos. 1 and 2 lift the stretcher to knee level and move it to the side until the transverse straps protrude on the buckle side.

(d) No. 1 now passes the upper longitudinal head straps OVER the top of the stretcher, UNDER the handle, THROUGH the runner and makes secure by fastening to the buckle on its own side on the cross strap marked "1".

(e) At the same time No. 2 is loosely bucking off the four transverse straps, working from the head to the feet.

(f) (i) Both bearers now adjust the feet straps by crossing them below the soles of the boots, passing them OVER the side of the stretcher, BACK through the runner, up OVER the lower edge of the stretcher canvas crossing them diagonally over the patient's legs and fastening them to the opposite buckle on the cross strap marked "3".

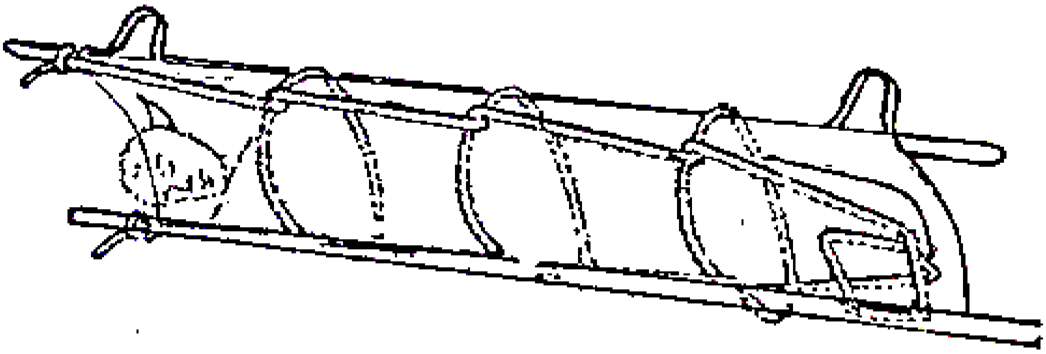
(ii) (For casualties of large size-Six Feet and Over.) Both bearers adjust the feet straps by passing them below the soles of the boots. BACK over the insteps OVER the side of the stretcher, BACK through the runner, OVER the bottom edge of the stretcher canvas and fastening them off the buckles on the same side, or the opposite side if length of straps permits.

(g) Nos. 1 and 2 then tighten up all straps. working from feet to head.

(h) The stretcher is then tilted to test for security, and all buckles inspected to ensure that there is no loosening.

4. **Improvised stretcher harness**

(a) **Securing-** In the improvised method with the 40ft. lashing line, the only knot used is the clove hitch, which is as simple to tie in the darkness as in daylight, and which will never fail. It is formed by making two loops in the rope, both anti clock wise, the second loop, which tends to come in front being placed behind the first. It can also be formed by making a loop on the handle of the stretcher, so that the running end is imprisoned by the standing part, followed by another loop. Form the first knot on a handle near the head of the casualty, pass the rope down the side of the stretcher, taking a complete turn under the stretcher and back over the casualty's chest, forming a half hitch. At least three turns must be used, two above the knees and one below. The rope is then passed round the casualty's feet brought up on the opposite side of stretcher and fastened with a clove hitch. (See Fig.) Care should be taken to prevent the turns and the half hitches of the lashing from pressing on injuries to the casualty.



Improvised harness by lashing

(b) **Releasing the casualty**-To release the casualty quickly from the stretcher, two men, one on either side of the stretcher remove the clove-hitches from the stretcher handles. Working is unison, they proceed towards the casualty's feet, gently releasing by a slight pull on the lashing turns around the casualty. They then remove the turn around the feet and release the lashing from under the stretcher.

(c) **Precautions**

(i) The lashing should not be secured so tightly around the casualty as to hurt the injured part or to interfere with the breathing.

(ii) The hitch around the feet and ankle must be sufficiently tight to hold the casualty firmly when the stretcher is held up vertically.

5. **Improvisation of stretcher carriage**

If proper canvas stretcher harness is not available, this can be improvised as follows:

(a) Using pieces of ropes with 'spliced eyes or bowlines' to provide loops for slipping over the handles of the stretcher. This can be done as under:

(i) **'Spliced Eyes'**-Serviceable pieces taken out of 40'-1 ½ " (12.10 M-38mm) lashing rope, sufficient to be worn by the stretcher bearer across his chest from one shoulder to the other side with both ends of the rope 'spliced before-hand to provide two loops for slipping over the handles of the stretcher. A pair of this is required by each of the two bearers.

(ii) **'Bowlines'-** In place of 'spliced eyes', as described above, bowline knots can be made the ends of ropes. on the spot, to provide similar loops for securing to the handle of the stretcher.

(b) **Using triangular bandages -** A few triangular bandages joined together can be used likewise for securing to the stretcher handles by using clove hitches. and worn by the stretcher bearers.

BLANKETING OF CASUALTIES

6. In all cases of serious injuries "shock" is likely to develop. Rest, fluids and warmth are useful measures for prevention of the same. Warmth can be given with the help of blankets and hot water bottles. It must be remembered. however, that in hot humid climate, the application of too much of warmth will cause the patient to sweat and make his condition of shock worse. One, two or three blankets can be used with a patient. It is worth white to know how to make best use of the blankets available to provide maximum amount of warmth

(a) **One Blanket method**

(i) Place the blanket diagonally on the stretcher,

(ii) Place the patient on the blanket.

(i) Fold over the leg end of the blanket tucking it between feet.

(iv) Wrap the two sides over the patient. the right side first and tuck in.

(v) Wrap the head end of the blanket round the neck of the patient and secure the neck of the patient and secure the end in-front with a safety pin.

(b) **Two-blanket method**

(i) Place the first blanket breadth-wise across the top of the stretcher.

(ii) Fold the second blanket length-wise into three and place it on the first blanket folding back the corners at the lower end.

(iii) Place the patient on the stretcher.

(iv) Wrap the opened out portion of the second blanket over the patient's feet, first the lower end and then the right and left flaps, tucking them in.

(v) Wrap the end of the first blanket over the patient, at the same time turning back the upper corner to form a coat collar over the chest.

(c) **Three-blanket method**

(i) Prepare the stretcher as for two blanket method.

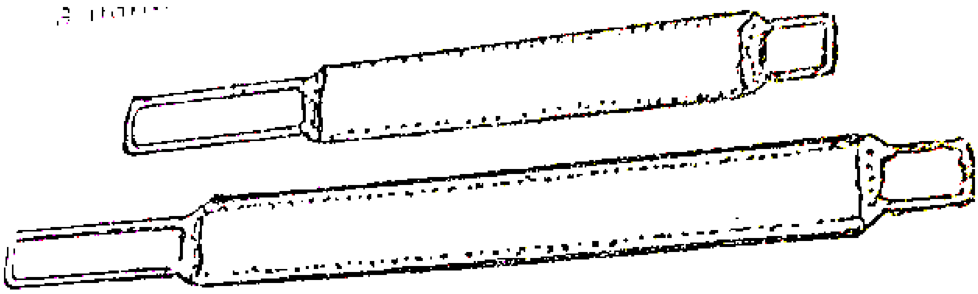
(ii) Fold the third blanket length-wise into two equal folds and place it over the patient. before the other two blankets are folded back, thirty cms. over the chest and the lower end tucked in under the feet.

CARRIAGE OF CASUALTIES

7. A casualty may be loaded on to a stretcher or may be carried for a short distance by means of webbing bands, blanket lift or by bearer themselves without the use of equipment. These drills are explained in sub sequent paras:

8**. Webbing bands**

Sets of webbing bands are carried by rescue parties and are used for Lifting a patient from the ground on to a stretcher, or lifting and carrying a casualty from a place where it is impossible to use a stretcher. Each set consists of four bands made of stout canvas webbing 4% inches wide and of two different lengths, two being 2 feet long and two 3 feet long. The shorter bands are intended to go under the head or neck and the feet, and the longer ones under the chest and hips (or small of the back). Each band has a long handle at one end and a short handle at the other. The handles are made of % inch drawn steel wire welded at the joint, the long handle being 12 inches long and the short 4 inches. The long handles are used for pushing under the body of a casualty lying on the ground, after which the webbing band is pulled through so that there is a handle at each side.



Webbing bands

Some of the advantages of webbing bands are:

(a) Comfort for the casualty.
(b) Little effort for the bearers.
(c) Speed if necessary.
(d) Slow movement if advisable.
(e) Heavy casualties can be lifted ease.
(f) A casualty can be turned over.
(g) No undue pressure need be put on any injured part.

9. To insert a band the bearer grasps the long handle with his right hand at the point. where the handle joins the canvas and slightly raising the casualty with his left hand, he pushes with the handle under him. The bearer on the other side raises the casualty slightly with his left hand and pulls the handle and band through with his right hand. The casualty need be raised only a quarter of an inch, i.e. the thickness of the metal handles. When a casualty is lying close to a wall or other obstruction it is not possible to pull the long handle and pushed through by it: the short handle is then pulled through and the long handle withdrawn simultaneously. To turn. a casualty from the prone to the supine position. or vice versa, the bearers proceed as for a nor mal lift but ensure that the four handles on one side are close to the body. The bearers then lift the casualty off the ground with the handles on one side low and on the other side high, the low handles are raised and

the high handles lowered, and by this movement the casualty is gently turned over. The drills for the normal lift. the heavy lift and the wall lift, using webbing bands are described below:

(a) **The normal lift**

(i) **Position of bands**

(aa), Short band under head (supporting band only).
(ab) Long band under shoulders.
(ac) Long hand under pelvis.
(ad) Short band under calves.

(ii) **Inserting of bands**

(aa) First Stage

No. 1 bearer to left of casualty at shoulder with long band pushes through.

No. 2 bearer to right of casualty pulls above band through.

No. 3 bearer to left of casualty at calves with short band pushes through.

No. 4 bearer to right of casualty pulls above band through.

(ab) **Second Stage**

No. 1 bearer pushes short band under head.

No. 2 bearer pulls short band under head.

No. 3 bearer pushes long band under pelvis.

No. 4 bearer pulls long band under pelvis.

NOTE: All band in the lift must be centralised in order to get a level lift.

(iii) **Position of bearers**

No. 1 and No. 2 take head shoulders. No. 3 and No. 4 take feet and pelvis.

(iv) **The casualty is now raised and placed on the stretcher**

(aa) **Orders** -By No. 1 bearer.
(ab) "**Prepare to Lift**" -Bearers take appropriate handles in each hand, standing close to casualty.

(ac) "Lift" -Bearers lift together and take a short pace forward, close up to the casualty to prevent his swaying.

(v) The stretcher is now loaded.

Inserting bands

(b) **The heavy lift -**For lifting very heavy casualties where five bearers are available.

(i) **Position of bands**

(aa) Long band under shoulders.
(ab) Long band under small of back.
(ac) Short band under thighs.
(ad) Short band under calves.

(ii) **Inserting of bands**

(aa**) First Stage**

No. 1 bearer to left of casualty at shoulders with long band, pushes through.

No. 2 bearer to right of casualty, pulls above band through.

No. 3 bearer to left of casualty at calves with short band. pushes through.

No. 4 bearer to right of casualty, pulls above band through.

(ab**) Second Stage**

No. 1 bearer at small of back, with long band, pushes through.

No. 2 bearer pulls above band through.

(ac) **Third Stage**

No. 3 bearer at thighs with short band, pushes through.
No. 4 bearer pulls above band through.

(iii) The bands are centralised, unless the casualty needs turning and dropped to the ground.

(iv) **Position of bearers**

(aa) Nos. 1 and 2 bearers take bands (a) and (c).

(ab) Nos. 3 and 4 bearers take bands (b) and (d).

NOTE: Another bearer is co-opted to support the head.

Heavy lift

(v) The casualty is now raised and placed on the stretcher.

Orders.-As in the normal lift.

NOTE: This method may be adopted for moving a spinal casualty in which case the bearer at the head maintains gentle traction (on the head). Where it is certain, or suspected, that the fracture in in the lumbar region, a sixth fully trained bearer is necessary to apply gentle traction to the feet and legs, while the fifth bearer supports but does not maintain traction on the head.

(c) **The wall lift**

(i) **Position of bands**.-Three only as in the normal lift...

(ii) **Inserting of bands**

(aa) **1st Stage**

No. 1 bearer at shoulders, long band pushes through.

No. 2 bearer at shoulders. assists and pulls through.

No. 3 bearer at calves, short band, pushes through.

No. 4 bearer at calves, assists and pulls through.

(ab) **2nd Stage**

No. 3 bearer at pelvis. long band, pushes through.

No. 4 bearer at pelvis, assists and pulls through.

(ac) Bands are centralised unless the casualty needs turning.

(i) **Position of bearers**

(aa) No. 1 bearer supports the head.

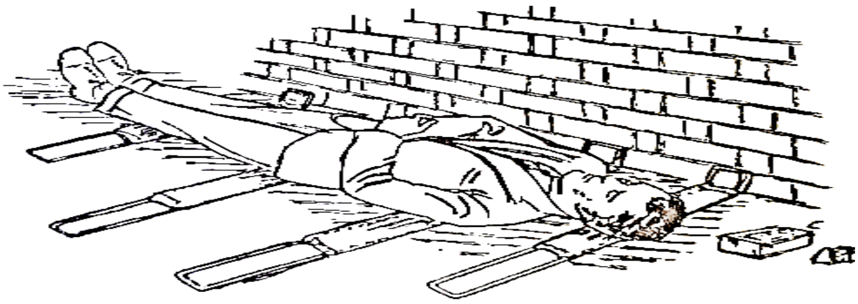
(ab) No. 2 bearer at shoulders.

(ac) No. 3 bearer at pelvis

(ad) No. 4 bearer at feet facing head of casualty.

(iv) When the appropriate orders have been given each bearer takes up the handles of the band in front of him, the casualty is raised and may be turned, or moved, as required.

Wall lift—inserting of bahds



Bands in position

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CHAPTER 35

EMERGENCY METHODS OF RESCUE

1. **Introduction**

When casualties are in danger of receiving further injuries, it is necessary to remove the cause of danger from the casualty or the casualty from danger. If it is vital to remove the casualty to safety, he must be moved regard less of his injuries. Only when the casualty is in imminent danger of death by remaining where he is, does removal take priority over the stop page of bleeding. Some of the methods of removing casualties are mentioned in subsequent paras.

2**. Methods Suitable for one rescuer**:

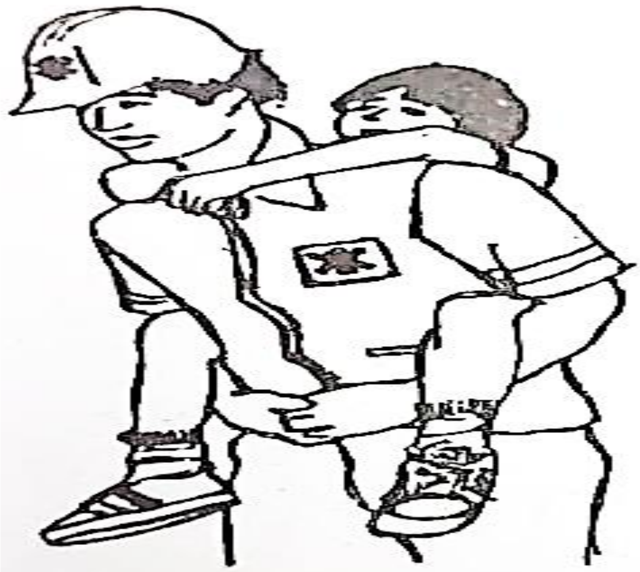
(i) Pick-a-back-Carry the casualty in the ordinary pick-a-back position. This is the best way if he is conscious and able to hold on.

(ii) **Pick-a-back (Reverse)**

(a) The rescuer and casualty stand back-to-back.

(b) The rescuer passes both his hands backwards and grips around the waist of the casualty.

(c) He then leans forward and lifts the casualty off the feet and upon his back Pick-a-back (reverse)



Pick a back (reverse)

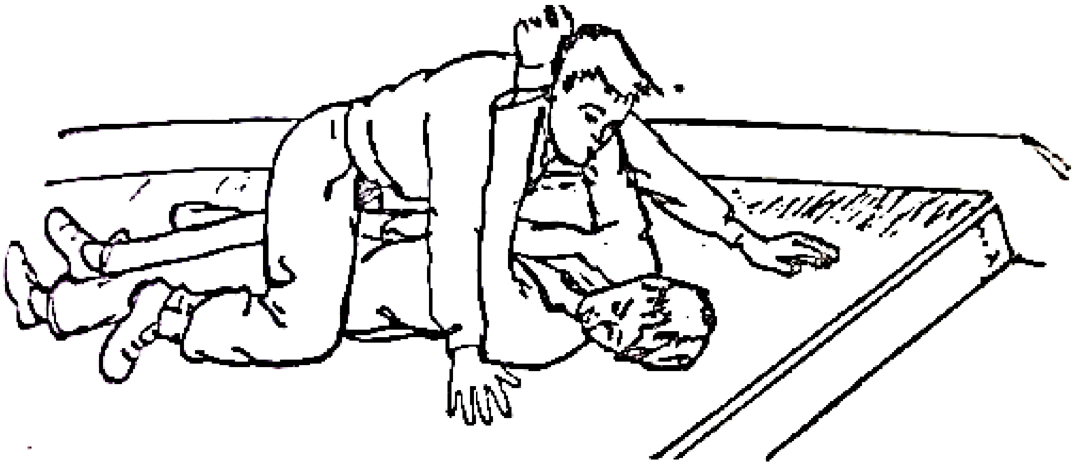
(iii) **Human crutch** -Where the casualty can help himself the rescuer stands at his injured side and places the casualty's arm round his shoulder grasping the wrist with his hand. At the same time he passes his other hand round the casualty's waist gripping his clothing at the hip and thus assists him by acting as a crutch. Each person should step off with the outside foot-the rescuer using his nearest to the casualty as a prop-as in a three-legged race.

Human crutch

(iv) **Fireman's lift -**This is one way of carrying a helpless or unconscious patient and allows the rescuer a free hand. It is easier for the rescuer than pick-a-back, but not so comfortable for the patient. Various stages of the lift are shown in Figure below. If the casualty is lying on his back, kneel on one knee (usually the right) at his head, place your right hand upon his right shoulder, and with your left hand beneath his left shoulder turn him over gently on to his face so that his forehead and face are supported on your right forearm. Place your hands beneath the casualty's shoulders and lift him upto a kneeling position, supporting him against your body with his head on your right shoulder. With your hands in the casualty's armpits stand up and lift him on to his feet, pressing the body close to yours; shift your hands from his armpits and clasp them together round his waist. Keep your right arm round the casualty's waist and grasp his right wrist with your left hand carrying the limb away from the body. Stoop and place your hand beneath his right arm and hoist him up on to your right shoulder, still retaining hold of his right wrist with your left hand. Pass your right arm between the casualty's thighs and grip his right wrist with your right hand at the same time remove your left hand which becomes free. Shift the weight of the casualty well on to the centre of your back and rise to the erect position.

Fire man’s lift

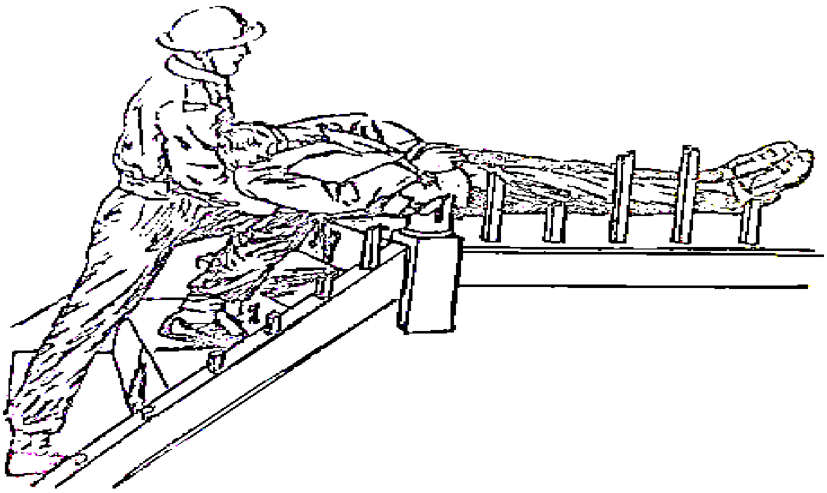
(v) **Fireman's crawl** -If a rescuer finds an unconscious casualty, or one who is unable to help himself, or who is too heavy for one of the above three methods to be applied, the Fire man's Crawl can be used. Turn the casualty on to his back and tie his wrists together. Kneel astride him facing his head and place your head through the loop thus formed by his arms. By crawling on your hands and knees you can then drag him with you, even though he may be heavier than you are.



Fire man's crawl

(vi) **Removal Downstairs-**To move the casualty downstairs, lay him on his. back, head downwards on the stairs, place your hands under his armpits so that his head rests on the crook of your arm and ease him gently downstairs.

As an alternative method, lay the casualty on his back and tie his wrist together. With his head. pointing downwards on the stairs, place your head through the loop thus formed by his arms. Place your hands under his armpits so that his head rests on your chest and ease him gently downstairs.



Removal downstairs

(vii**) Bowline Drag**

(a) Turn the casualty on his back and tie his wrists together using a triangular bandage or a neck tie.

(b) Using one length of 15 feet (4.5 M) sash cord or 40 ft. (12 M) lashing, tie bowline at each end to form the loops.

(c) Place one loop over casualty's chest and under his armpits, with the knot resting under his head, so that it will keep his head off the ground while he is being pulled.

(d) The other loop goes on the rescuer, over his shoulders and under his armpits, to form a harness with the knot in line with. the centre of his back or between his shoulders.

(e) The rescuer crawls on his hands and knees and drags the casualty out.

(viii) **Toe Drag**

(a) Turn the casualty on his back and tie his wrist together using a triangular bandage or a neck tie.

(b) The rescuer sits down at the casualty's head and places his feet under the casualty's armpits.

(c) With both hands free the rescuer pulls himself back and at the same time drags the casualty with his feet.

Bowline Drag

3. **Methods suitable for more than one rescuer:**

(i) **The Fore and aft method-** The patient is placed on his back. One rescuer raises the shoulders and passes his hands under the arms from behind, clasping them in front of the chest. The other rescuer takes one leg under each arm and they carry him feet first. If the leg is broken, both legs should be tied together, or put in splints and both carried under one arm.

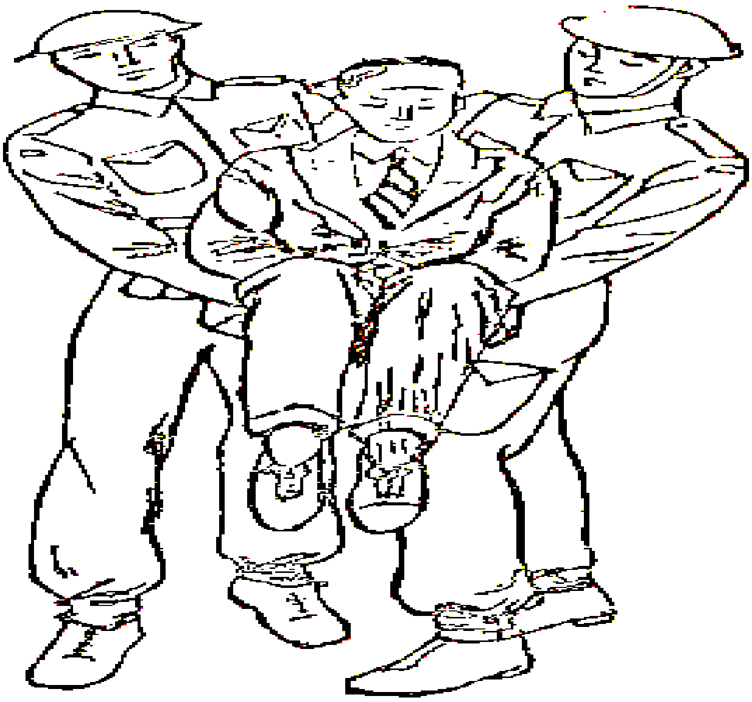
Fore and art method

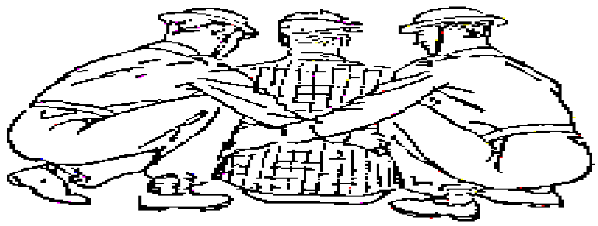
(ii) **Two Handed Seat-**Two rescuers face one another on either side of the casualty and stoop. Each rescuer passes his arm nearest the casualty's head under his back just below the shoulders and, if possible. grips his clothing. They raise the casualty's back and slip their other arms under the middle of his thighs, clasping their hands with a hook grip. The rescuers rise together and step off with short paces.

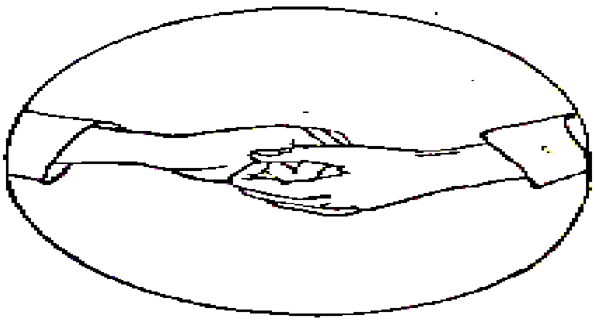
(iii) **Three-handed seat:** This method is used for carrying a casualty and supporting either of his lower limbs. when he is able to use one or both of his arms.

(a) Two rescuers face each other on two sides of the casualty.

(b) The rescuer on the side of the injured limb keeps his hand nearest to the limb free.



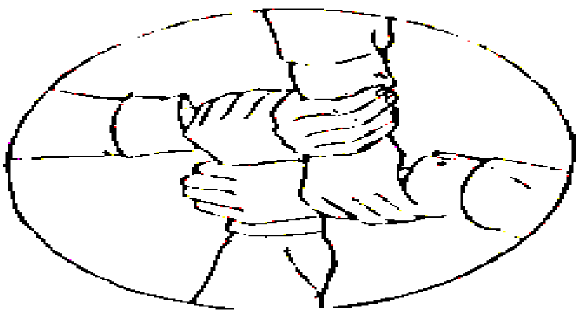




(c) With the other hand he grips the corresponding wrist of the other rescuer, that hand in turn being used by the other rescuer to grip his wrist of the other hand (own). This hand of the second rescuer is then used to grip the wrist of the first rescuer thus forming a three-handed seat.

(d) The casualty sits or these three handed seats supporting himself with his arms. He is carried and his injured limb supported by the rescuers.

(iv) **Four Handed Seat-**The rescuers face each other and each grasp their own left wrist with their right hand. Their hands are then put together. the free left hand grasping the right wrist of the man opposite. The casualty puts one arm or both arms round the neck of the rescuers.



Four handed seat

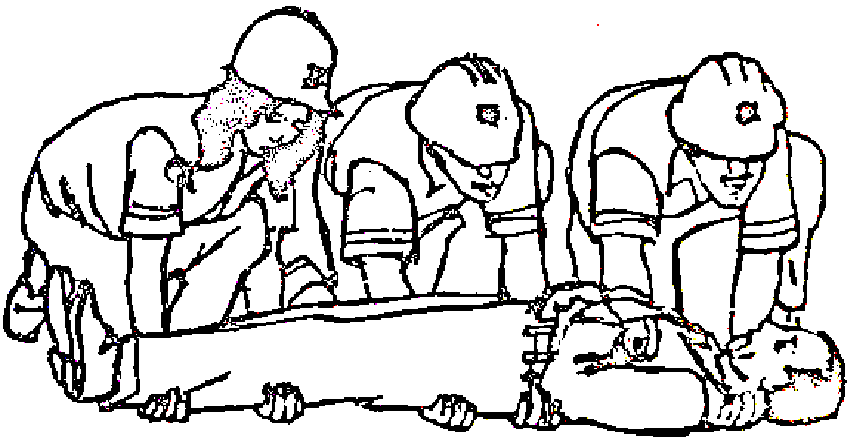
(v) **Chair Carry**

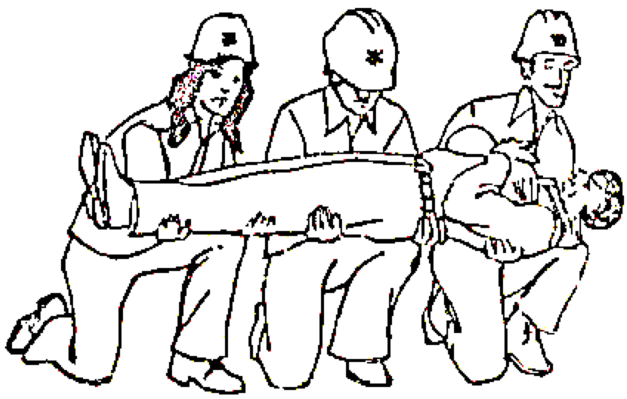
The Chair carry is effective where sharp turns or a steep staring would preclude the use of a stretcher or backboard. A commercial stair chair or an ordinary household straight-back chair may be used is a good idea to test the chair before use to make sure that it is solid and will support the patient.

After the victim has been placed in the chair, the rear paramedic tilts the chair back to enable the other crew members in front to get into position. If the victim is too large to be picked up and placed in the chair. then the person is placed face up. The legs are elevated and the chair back slide beneath the buttocks until the patient is in a seated position. although still lying on the floor. Straps may be used to secure the patient to the chair. The chair is then tilted upright and the victim is ready for transport.

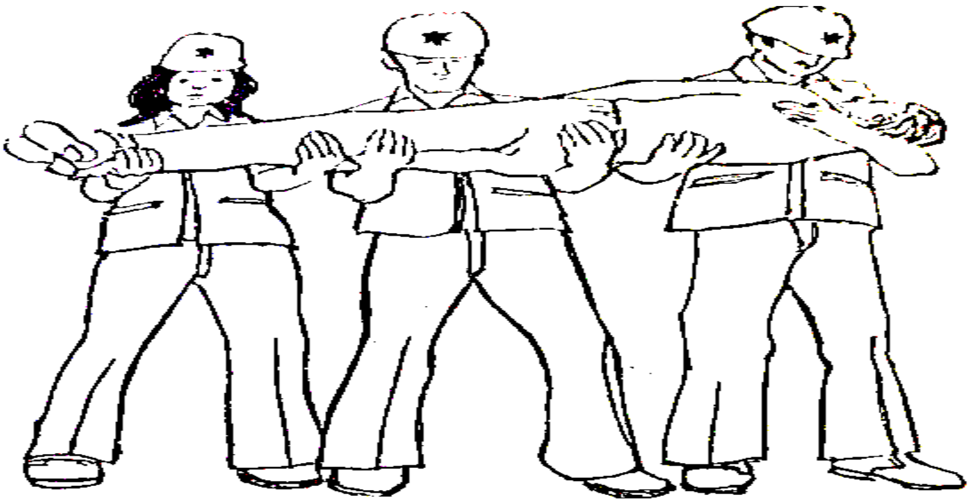
(vi) **Three-Person Lift and Carry-**The three-person lift and carry is often used to handle a severely injured casualty. Even with trained personnel, this technique does not offer adequate neck and back support. When there is any suspicion that spiral injuries may be present, a fourth paramedic should support the patient's head. Three rescuers line up on one side of the casualty. preferably with the tallest person at the shoulders, another at the hips, and the third at the knees. The team kneels on their knees nearest to the victim's feet. The paramedic at the victim's shoulders works both hands under the victim's neck and shoulders, the person at the hip’s places both hands under the pelvis and the hips and the rescuer at the knees responsible for lifting the knees and ankles. At the command lift, usually given by the rescuer at the shoulders, the crew gently lifts and rests the victim on their knees. At a second command, they slowly turn the victim towards them until the casualty rests in the bends of their elbows. At a third command. the crew rises together to a standing position.

When stretcher is not a immediately available, these procedures allow the crew to move with the patient through narrow spaces and down winding stairs. Depositing the victim requires the reverse of this procedure. These steps are also recommended for picking up and placing a victim on a stretcher or cot. The casualty is raised only high enough to clear the stretcher, the stretcher is then slid under the victim, and the victim is lowered.





Three persons lift carry



Three persons lift carry

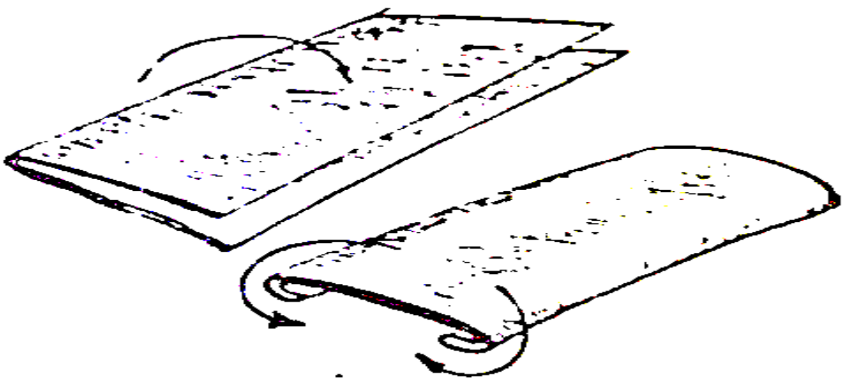
(vii) **Clothes Lift**

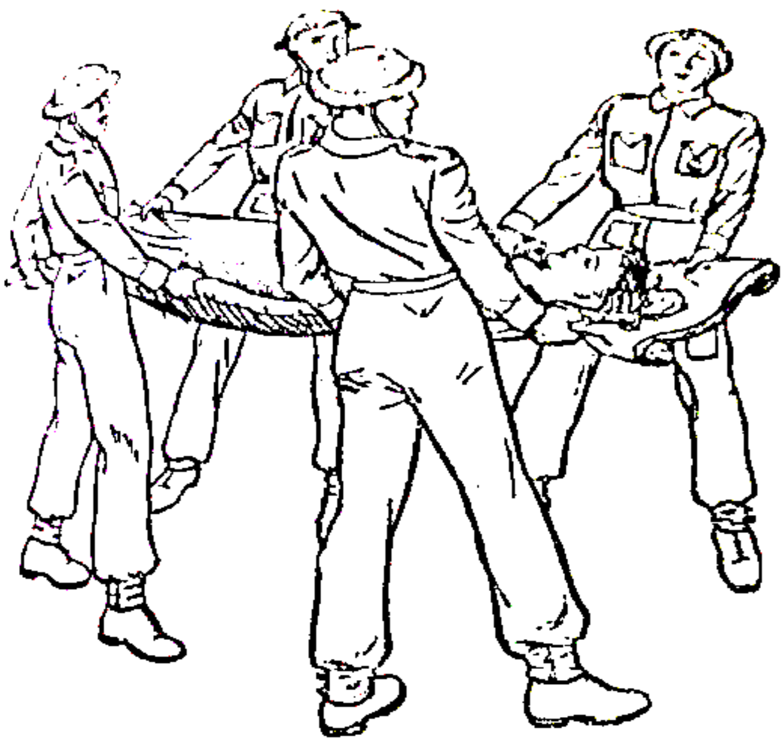
(a) Normally four bearers are required for this lift. Two bearers kneel on each side of the casualty at the shoulders and hips and turn him on his back.

(b) At the command 'Prepare to Lift, the bearers grasp the casualty's clothing. Those at the shoulders will grasp the collar of his coat or shirts behind the neck with one hand and with the other grasp the clothing at his side.

(c) The bearers at his hips will grasp the clothing at the hips with one hand, and at the same time they will insert one finger in his sleeves in order to control the casualty's arms. With the other hand they grasp the casualty's trousers, thus sup porting his legs. The casualty is now ready to be lifted.

(viii) **Blanket Lift**





The blanket lift

(a) A blanket is placed lengthwise on the ground in line with the casualty and rolled up half its width.

(b) The casualty is then carefully turned on his side.

(c) The rolled-up portion of the blanket is then placed close to the casualty and he is gently replaced on his back upon the unrolled portion of the blanket.

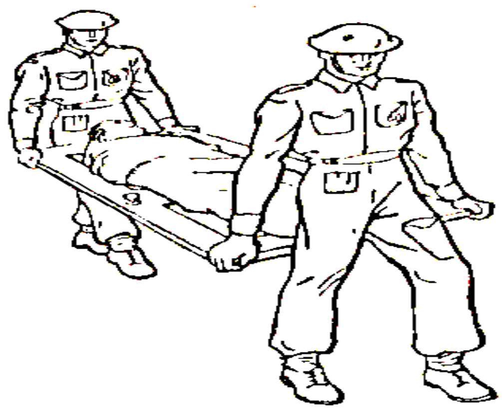
(d) The rolled portion is then unrolled so that he lies in the centre of the blanket.

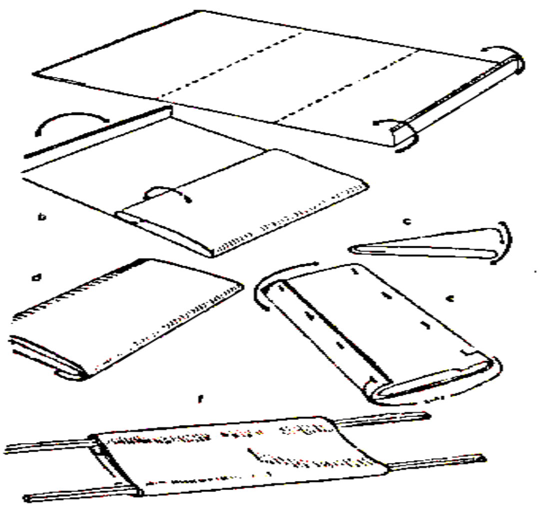
(e) The two edges of the blanket are then rolled-up against the casualty's body. grasped by two bearers on each side of the casualty, thus supporting the head, shoulders, legs and hips.

4. **Improvised stretchers**

When there is a shortage of stretchers, it is better to improvise rather than manhandle the casualty unnecessarily. An old door (see fig. below), a sheet of galvanised iron, a blanket, or a short ladder are all examples of improvisation.

Another method is to fold a blanket into three, using six or eight safety pins (three or four on each side) to pin the edges of the blanket together. Two small poles, broom handles etc., are passed through the folds and the improvised stretcher is ready for use. Refer sketch below.





Another from of improvised stretcher

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CHAPTER 36

HANDLING STRETCHERS IN VARIOUS SITUATIONS

1. **Introduction**

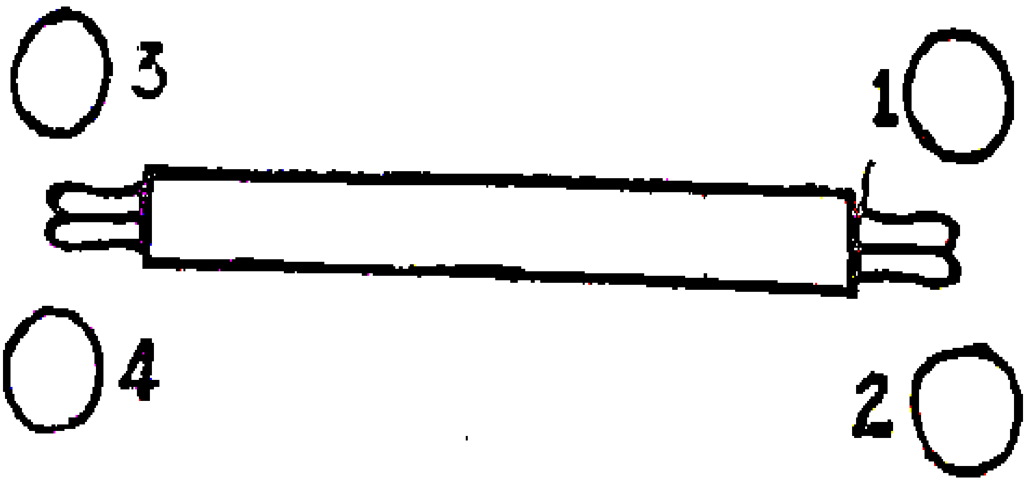
An injured person is normally apprehensive of any movement of his body especially the wounded part. A well-trained squad of first-aid volunteers can, however, reduce the degree of apprehension by their confident yet careful and clever handling of the limb or body and gain the trust and co-operation of the injured. Allaying fears of the injured and reducing movements to minimum, help considerably towards preventing traumatic shock. The knowledge of correct methods of handling of stretchers, removal and loading of casualties on to stretchers and use of blankets and hot water bottles, therefore, will be an asset to all concerned.

2. The most common type of stretcher used in the ambulance is the stretcher with wooden poles and canvas material for holding the patient. Certain figures may be of interest and practical value to all. These are:

Length of pole	-7 ft. 9 inch. (230 cms.)
Length of Canvas	-6 ft. (180 cms.)
Total width	-1 ft. 11 inch. (57 cms.)
Height above ground	-0 ft. 6 inch. (15 cms.)
Weight	-30 lbs. to 32 lbs. (14 kgs.)

(a) Selection and Numbering of bearers

Four bearers will be selected and numbered 1, 2, 3, 4 from tallest to shortest in order to give as even to carry as possible. They will take up the position shown in figure below. No. 1 bearer is the leader of the squad and is responsible for the welfare of the casualty until he is seen by a doctor or handed over to another responsible person. All stretcher bearers must be able to undertake the duties of No. 1 bearer.



(b) Collection of blankets and stretchers

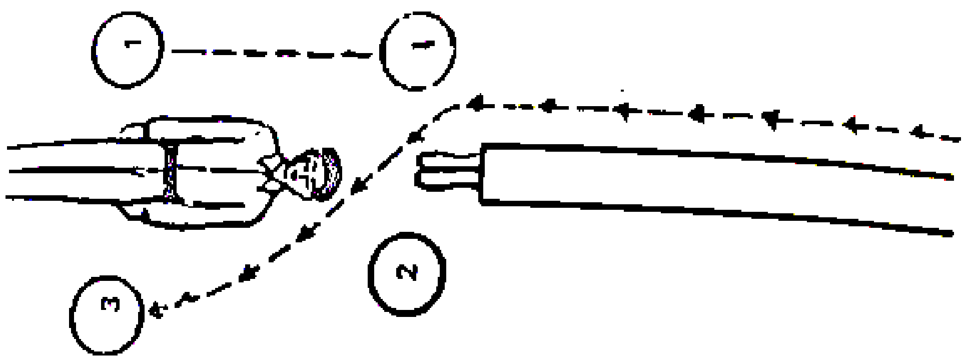
No. 1 will give the command; No. 3 collect blankets. No. 4 collect stretcher "right turn-quick march". The named bearers will collect the blankets and stretchers. No. 3 will fold the blankets neatly and carry them over his right arm and No. 4 will carry the stretcher at the slope on the right shoulder runners to the front. On their return No. 3 will resume his position behind No. 1 and No. 4 will slide the stretcher foot first between Nos. 1 and 2. runners to the right and resume his position behind No. 2.

(c) Lifting stretcher

On the command "Lift Stretcher". No. 2 and 4 stoop together, grasp the handles of the stretcher with their right hands, knuckles to the right, and rise together.

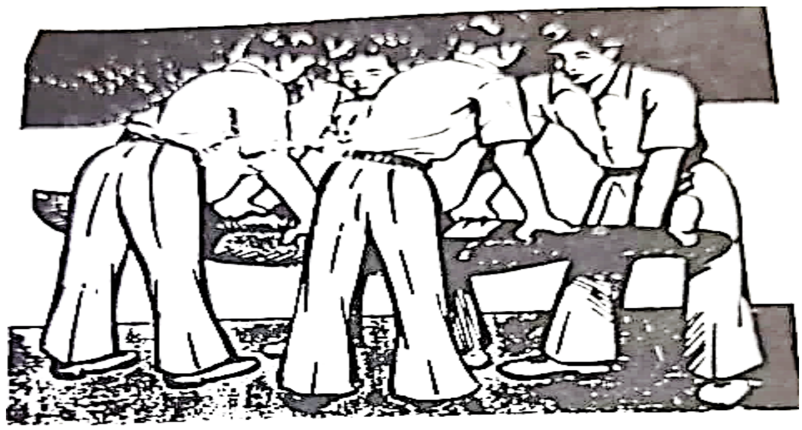
(d) Collecting casualty

On the command "At the Double-Collect Casualty", the squad will double to the casualty and halt when the leading bearers are a short distance from the head. Nos. 2 and 4 will lower the stretcher and place it on the ground in line with the casualty. No. 1 will then double out to the right of the casualty and prepare him for removal. He may instruct No. 3 to assist him.

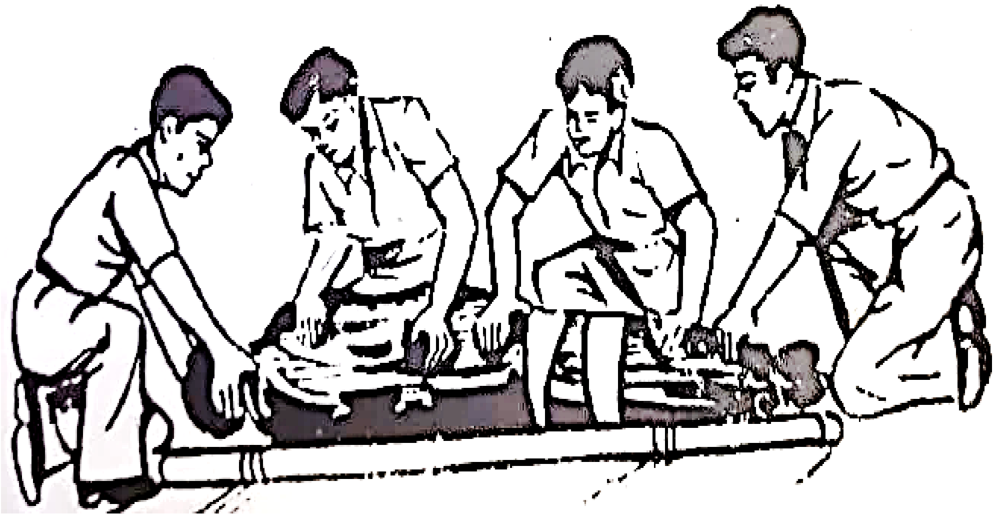


(e) Loading stretcher

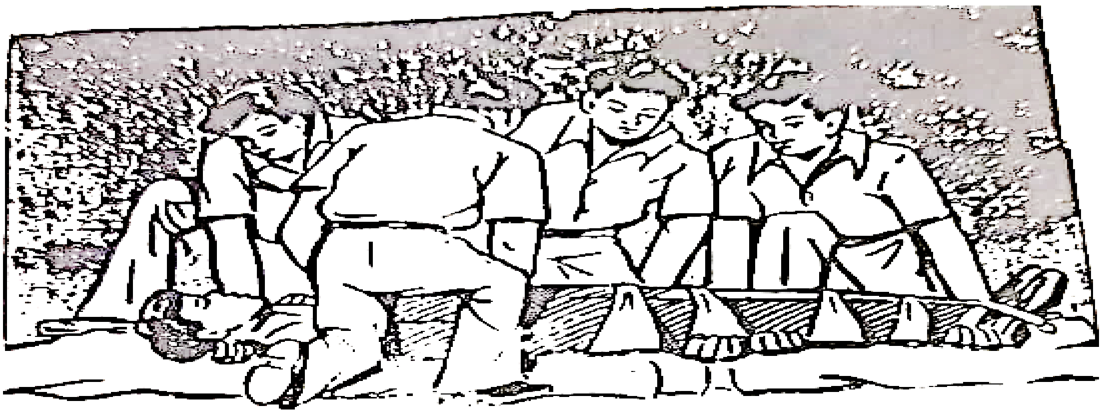
(i) **Casualty lying on blanket/rug-** When the casualty is lying on a blanket or rug the edges of the blanket or rug must be firmly folded close up to the casualty. On the command "Load Stretcher", the bearers, two on either side, will grasp the rolls and unless a fifth bearer is available to slide the stretcher underneath the casualty, will move by side paces over the stretcher and lower the casualty carefully on to it. This is known as the blanket lift.



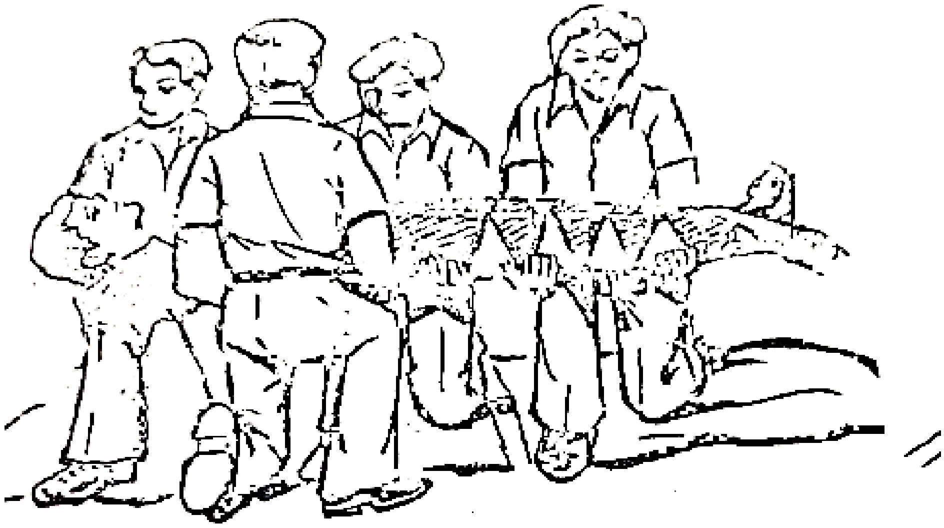
(ii) **Casualty not lying on blanket/rug-** When the casualty is not lying on a blanket or rug and a spare one is available, the casualty must be placed on a blanket or rug, place the blanket or rug on the ground alongside the casualty and roll it lengthwise for half its width. No. 2, 3, and 4 will turn the casualty carefully on to his uninjured side. No. 4 will place the rolled portion of the blanket or rug close to the casualty's back and all the bearers will gently roll the casualty over until he is lying on his opposite side on the blanket or rug. The blanket or rug will then be unrolled and the casualty gently turned on his back so that he lies in the centre of the open blanket or rug. On command "Load Stretcher" proceed as at 2(e)(i) provided four or more bearers are available, the blanket lift or rug lift is the best method for loading a casualty on to a stretcher owing to the smoothness of the whole operation.



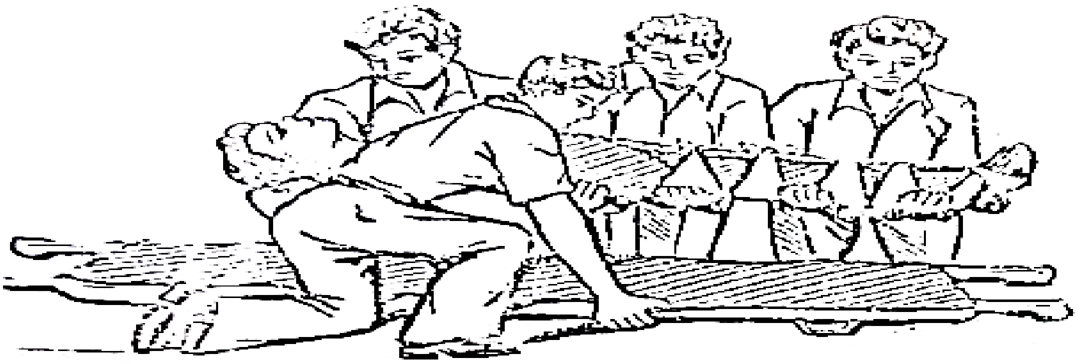
(iii) **Casualty not lying on blanket and blanket not available-**When the casualty is not lying on a blanket or rug and none is available, on the command "Load Stretcher" Nos, 4, 3



and 2 will place themselves on the left of the casualty: No. 4 facing the shoulders, No. 3 facing the hips and No. 2 facing the knees: No. 1 will place himself on the right of the casualty facing No. 3. All will go down on their left knees and place their forearms beneath the casualty. paying particular attention to the site of the injury. Using the hook grip No. 1 joins his left hand with the left hand of No. 4 and right hand with the right hand of No. 3 and 4 supports the head and shoulders. No. 2 the lower limbs.



When No. 1 gives the order "Lift" the casualty is lifted gently and slowly and placed on the knees of Nos. 4, 3 and 2. No. 1 will disengage, take hold of the stretcher (left hand across, resting the near pole on his left nip)



and place the stretcher under the casualty, so that when he is lowered on to it, his head will just be clear of the metal bar at the top. and will rest on the pillow if one is available. No. 1 will then resume the position. When No. 1 gives the order "Lower", the casualty will be raised slightly from the knees of Nos. 4. 3 and 2. lowered gently and carefully on the stretcher and covered with coats. The bearers then rise and turn to face the foot of the stretcher, if it is necessary to lift the casualty from the right side, bearers will go down on their right knees.

(f) Standing to stretcher

On the com mand: "Stand to Stretcher". No. 1 will take up a position level with the handles at the foot of the stretcher: No. 2 will step forward opposite No. 1 and No. 3 will double round the head of the stretcher opposite No. 4. When standing to stretcher the positions of Nos. 1 and 3 bearers will be on the right and those of Nos. 2 and 4 on the left of the stretcher.

(g) **Carrying a loaded stretcher**

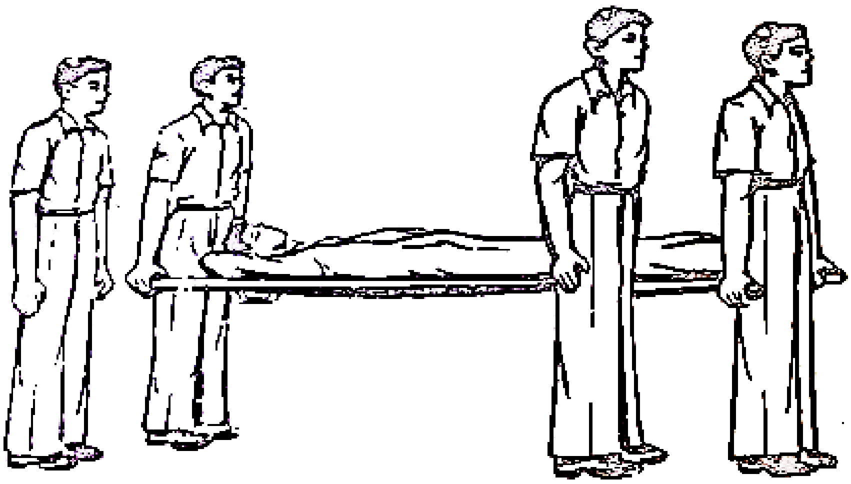
No. 1 will decide whether the stretcher is to be carried by four or two bearers. The drill will be as under:

(i) **Hand carriage by four bearers-**On the command: "Hand carriage by four bearers-Lift Stretcher, all four bearers stoop together, grasp poles with their inner hands, rise together holding the stretcher at the full extent of their arm.

(a) **Advancing-**On the com mand: "Advance" all bearers will step off with the inner foot The bearers must keep their knees slightly bent and walk with a relaxed gait.

(b) **Retiring** -On the com mand: "Retire" the squad will retire by wheeling and not by turning.

(c) **Lowering loaded a stretcher -** On the command: "Lower Stretcher", the four bearers will stoop, gently lower the stretcher to the ground and rise together.



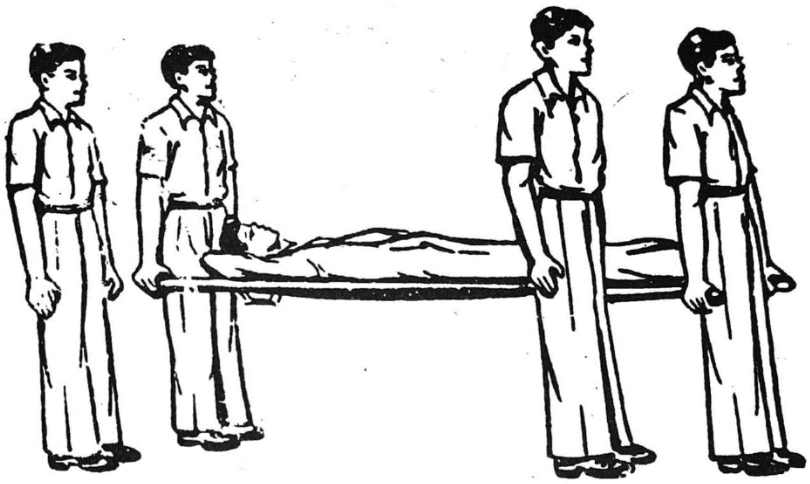
(ii) **Hand carriage by Two bearers** -On the command: "Hand carriage by two bearers-Lift Stretcher", Nos. 2 and 4 will take a side pace over the handles of the stretcher and if they decide to use slings will pick them up place them over their shoulders and on the handles of the stretcher. They will then rise steadily together keeping the stretcher level. Nos. 1 and 3 will turn inwards to assist. No 1. particularly can help to prevent the casualty's feet catching on the but tocks of No. 2. Nos. 1 and 3 will then to turn to face the feet of the stretcher.

On the command: "Adjust Slings", Nos. 1 and 3 turn to the left and adjust the slings of Nos. 2 and 4 respectively.

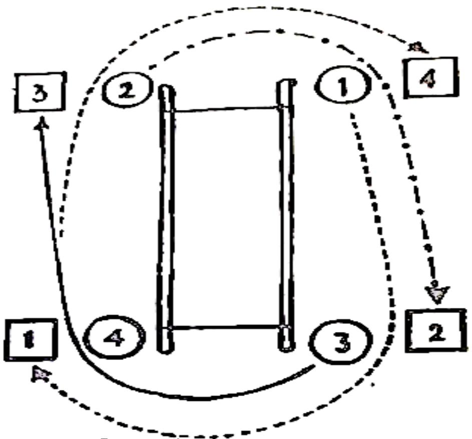
(a) **Advancing -**On the com mand: "Advance". Nos. 1. 2 and 3 will step off with the left foot and No. 4 with the right. The bearers must keep their knees slightly bent and walk with a relaxed gait.

(b) **Retiring-** On the com mand: "Retire", the squad will retire by wheeling and not by turning.

(c) **Lowering a loaded stretcher -** On the command: "Lower Stretcher". Nos. 2 and 4 stoop slowly, gently lower the stretcher to the ground and rise together. If slings are in use Nos. 2 and 4 will remove them after lowering the stretcher, step over the handles to their former positions, and place the loops of the folded slings over the near handles and the ends over the other handles.



(h) **Relieving bearers by changing numbers -**On the command: "Change Numbers". Nos. 1 and 3 will turn about and the whole team will then step off together. Nos. 3 and 2 wheeling round the ends of the stretcher and all moving round two places clockwise. Each bearer I will halt in the position of the bearer whose place he has taken and the new Nos. 1 and 3 turn left about so that all again face the foot of the stretcher.



Changing Bearers

(i) Unloading the stretcher -On the com mand: "Unload Stretcher", the bearers will adopt a similar procedure to that carried out for loading the stretcher. If the casualty is lying on a blanket, the blanket lift should be used; reversing the procedure. Where there is no blanket, after the casualty has been lifted to the bearers' knees. No. 1 will lift the stretcher and carry it three paces beyond the casualty's feet and when the casualty has been lowered to the ground, bearers will march and take up their normal position on the open stretcher.

(j) Closing Stretcher. **-**On the com mand: "Close Stretcher", Nos. 2 and 3. turn inward and close the stretcher by pushing in the poles after traverse bars have been unlocked, folding the canvas on itself and buckling the straps tightly round the stretcher behind the traverse bars.

(k) Returning blankets and stretcher. **-**At the end of the exercise, No. 1 will give the command: No. 3 "Return Blanket". No. 4 "Return Stretcher", Nos. 3 and 4 right turn quick march. The procedure to be followed by Nos. 3 and 4 is similar to that carried out for collecting blankets and stretcher.

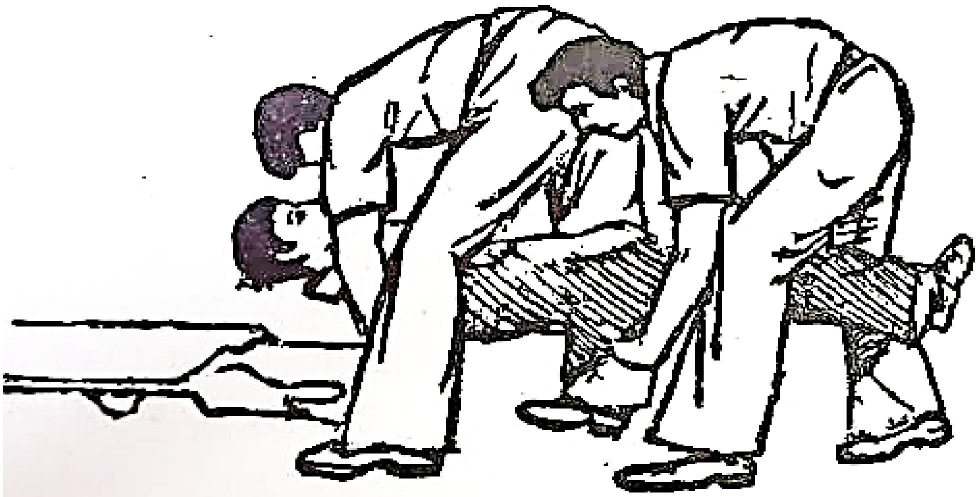
3. **Three bearer drill**

The stretcher will be placed at the casualty's head, in line with his body. No. 1 kneels on the left knee on the injured side opposite the casualty's knees and passes his hands under the casualty's legs. Nos. 2 and 3 kneels on their left knees on opposite sides of the casualty facing each other and passing their hands under his shoulder and hip, lock their finger by the hook grip. On the command: "Lift", the bearers will rise to the erect position and, moving by side paces, carry the casualty head foremost over the foot of the stretcher, the horizontal position of his body being maintained throughout the movement and lower him carefully on the stretcher. When unloading, the casualty will be lifted and carried head foremost over the head of the stretcher.

4. **Two bearer drill**

This drill will be used in mines and narrow cutting where space is limited. The drill will be as follows:

(a) Lifting the casualty. -Both bearers will stand astride the casualty. No. 2 at the head, placing his forearms under the casualty's shoulders; No. 1 about the knees placing his left hand beneath the casualty's thighs and his right below the knees. When both are ready No. 1 will give the command "Lift".



(b) Advancing.-No. 1 will give the order "Advance", and both will step off together with the left foot. taking short even paces and stooping so that the body of the casualty is not far from the ground. They will advance till the casualty is over the stretcher when No. 1 gives the order: "HALT-LOWER".

On the command: "Halt-Lower", the casualty is lowered gently on the stretcher. Both bearers then take up position on the left of the stretcher ready for lifting. No. 2 at the head and No. 1 at the foot.

5. **Rules for carrying a casualty on stretcher** -As a general rule, carry a casualty feet first. The exceptions are:

(a) When carrying a stretcher upstairs.

(b) When going uphill with a casualty whose lower limbs are uninjured.

(c) When going downhill with a casualty whose lower limbs are injured.

(d) When carrying a casualty to the side of foot of a bed.

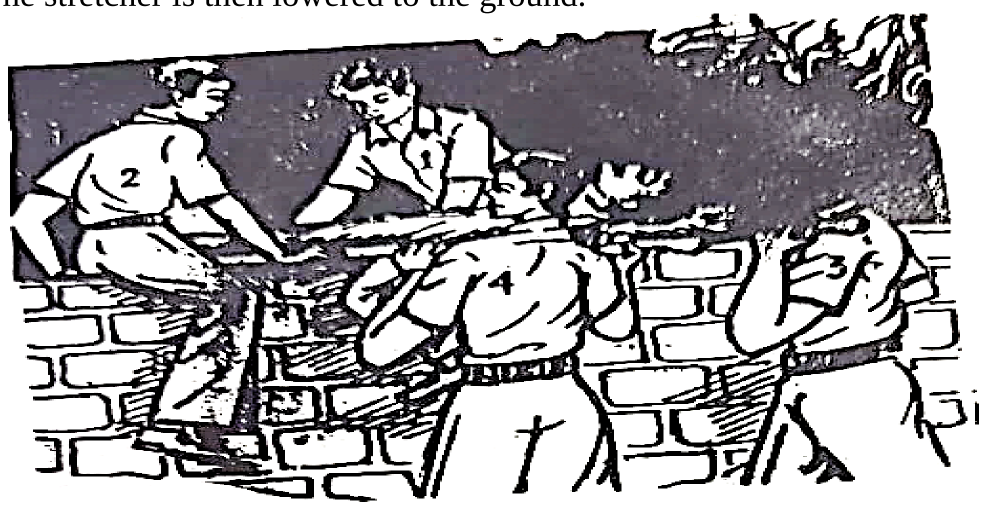
(e) When loading an ambulance.

6. Handling of stretchers in difficult situations.

(a) **Uneven ground -**If possible, the stretcher should be carried by four bearers and kept as nearby level as possible. This can be done and the casualty prevented from falling off by each bearer independently adjusting the height of the stretcher as necessary. Over very uneven ground for short distance the four bearers should face inwards.

(b) **Ditch crossing**. -The stretcher is lowered with its foot one pace from the edge of the ditch. Nos. 1 and 2 bearers then descend. The stretcher is now advanced, Nos. 1 and 2 in the ditch supporting the front and while the other end rests on the edge of the ground above. Nos. 3 and 4 then descend. All the bearers now carry the stretcher to the opposite side and the foot of the stretcher is made to rest on the edge of the ground, while the head is supported by Nos. 3 and 4 in the ditch. Nos. 1 and 2 climb out. The stretcher is lifted forward on the ground above, and rests there while Nos. 3 and 4 climb up.

(c) **Wall crossing -** The stretcher is lowered with the foot about one pace from the wall, the bearers then stand to stretcher. Nos. 2 and 4 on the left, Nos. 1 and 3 on the right. They turn inwards, stoop down. grasp the poles with both hands, and rise slowly lifting the stretcher, holding it level at the full extent of the arms. Then by side paces they advance to the wall, raise the stretcher and lift it on to the wall, so that the front runners are just over the wall. No. 2 then crosses the wall, and takes hold of the front handles; No. 1 then crosses the wall: they grasp the poles, lift the foot of the stretcher, all the bearers then advance and rest the rear end of the stretcher on the wall. The rear runners should be kept on the near side of the wall, otherwise the handles may slip. No. 4 then crosses the wall and takes hold of the left pole, No. 3 then crosses the wall and takes hold of the right pole. The bearers then advance until the stretcher is clear of the wall. The stretcher is then lowered to the ground.



(d**) Movement over debris -**A stretcher should, whenever possible, be carried in the horizontal position. There may be times when this is impossible as the casualty may have to be carried over debris and bearers will have to climb up and down piles of rubble. In such cases 4 or 6 bearers are an advantage. If four bearers are available, one should be at the front end, one at the rear end, and one at each side of the stretcher. When they have to climb over an obstacle or a heap of debris, the bearers at the sides turn inward towards one another and take the full weight of the front end of the stretcher, while the front bearer climbs up on the debris, the front end of the stretcher is then lifted for him to grasp. The stretcher is then advanced, and the bearers at the sides take the weight of the rear end of the stretcher, while the rear bearer climbs on to the debris and grasps the rear end. A similar procedure is adopted when climbing down.

If only two bearers are available, it may be necessary to lay the stretcher down when they reach an obstruction so that they can ascertain the best method of getting over it. The bearer at the front-end climbs on to the debris while the bearer at the rear end passes the front. end of the stretcher up to him to grasp. The rear end bearer then resumes his position and lifts the stretcher to a horizontal position and the bearers cross the obstacle. Care must be taken to see that the stretcher, if laid down, is resting on each "D" with the bed of the stretcher clear of obstruction so that debris will not move under the weight of the casualty or injure him.

(e) **Movement of stretcher in confined space -**In confined spaces, if there is sufficient height and the casualty has been secured to the stretcher, it may be stood on end and, by grasping the sides, can be moved round sharp corners. Where the height is insufficient to permit of this method being used, as in the case of shelters, a compromise between the horizontal and vertical positions is necessary. The casualty should be carried feet first as far as the middle of the right-angled bend, where the front end of the stretcher is placed on the ground and the rear end lifted as high as the roof will permit. The stretcher can then be worked round the bend, one bearer easing the front end and another the rear end. It should not be turned on its side or height will be lost and difficulties increased. At the same time there will be a risk of the casualty banging against the inside of the bend.

(f) **Crossing**

(i) **Crossing over gaps**.-When taking a casualty out of a damaged building it is often necessary to cross a gap in the floor. A ladder may be used as a bridge. Alternatively, two or more joists may be laid across the holes as illustrated below. They should be twice as long as the hole to ensure that they rest on the sound joints of the damaged floor.

(ii) **Gaps in debris -**It is wise to use six bearers as a safety precaution when crossing a pile of debris which contains gaps. Two bearers go across the gap while the remaining bearers turn inwards and, lifting the stretcher, pass the front handles to them across the gap. The two rear bearers support the stretcher as it goes over then relieve the front bearers, who cross the gap and take up their position ready to take over the rear end of the stretcher. The remaining bearers then cross the gap and take up their position at the sides of the stretcher

AMBULANCE LOADING/UNLOADING

7. (a) **Loading**. **-**The stretcher is lowered with its head one pace from the doors of the ambulance. The casualty will be loaded head first. The bearers now stand to the stretcher. On the command: "Load" the bearers turn inwards, stoop, grasp the poles of the stretcher, hands wide apart, palms uppermost, they rise slowly, lifting the stretcher, holding it level at the full extent of the arms. They then take a side pace to the ambulance raising the stretcher evenly to the level of the berth to be loaded. The front bearers place the runners in the grooves, and then assist the rear bearers to slide the stretcher into its place and secure it. If slings have been used, they should be kept with their stretcher. Many ambulances are provided with upper and lower berths. In such cases the sequence of loading is upper right, upper left, lower right, lower left. It should be noted that this might not be practicable if the ambulance to be loaded is of the single rear door type. In such circumstances the following method of loading should be adopted. On the command "Load". No. 4 will take up position inside the ambulance facing the stretcher and No. 2 will take up position opposite No. 3 with No. 1 between the handles facing the ambulance. Nos. 2 and 3 turn inwards and all three bearers lift the stretcher to the required height, move forward and hand the head of the stretcher to No. 4. No. 2 and No. 3 then move backwards to assist No. 1 who will load the appropriate berth with No. 4.

(b) **Unloading**, **-**Two bearers take hold of the handles at the rear and gently withdraw the stretcher. As it is withdrawn, the other two will take hold of the handles at the front, and taking the weight, lower it to the full extent of the arms: then by side paces march clear of the ambulance, lower the stretcher to the ground. To unload an ambulance with a single door Nos. 4 and 1 will enter the ambulance with Nos. 2 and 3 on either side of the door to assist No. 1 to descend. The stretcher is then withdrawn from the ambulance and Nos. 2 and 3 receive the head of the stretcher from No. 4. The stretcher is then carried clear of the ambulance and lowered to the ground.

8. **Transfer of casualty to bed-**The stretcher is lowered at the side of the bed. The bearers take positions as for unloading stretcher, Nos. 2, 3 and 4 being on the side farther from the bed. The casualty is unloaded on the knee of Nos. 2, 3 4, No. 1 will disengage and remove the stretcher (this may be done by pushing it under the bed). He then joins hands with No. 3. All the bearers rise to a standing position, supporting the casualty on their forearms. No. 1 disengages and goes to the patient's head, and supports it. All bearers then step forward and gently place the casualty on the bed. If the bed is narrow and there is room, the stretcher may be placed on the floor with the head close to the foot of the bed. The casualty may then be lifted over the foot and placed on the bed. If the casualty is lying on a blanket and if the bed is narrow and there is room, the blanket lift should be used, the bearers lifting him over the foot of the bed.

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CHAPTER 37

BREATHING APPARTUS

1. **Introduction**

A Rescuer is very often required to enter and work either for fire-fighting or for rescuing into an atmosphere which cannot support life. To enable him to carry on with his normal respiration in such places, he is provided with Breathing Apparatus.

2. **Physiology of Respiration**

Breathing or respiration is a spontaneous action, performed by the human body some 15-30 times every minute. When at rest the body requirements are comparatively low and air is sucked into and out of the lungs by breathing at a rate of 15-18 times per minute. When more energy is exerted either through work or nervous excitement, the breathing rate is increased and may be as much as 30 times a minute or even more.

At rest, about 30 cu. in. (½ litre approx.) air normally inhaled at each breath and about the same quantity is exhaled, this amount is known as Tidal air.

Effects of respiration

Before the student is taken into details, he should understand the effects of respiration, i.e. what takes place during inhalation and exhalation of air.

Inhaled air by volume:

Nitrogen Oxygen	79.04%
Oxygen	20.93%
Carbon-dioxide	0.03%

Exhaled air by volume:

Nitrogen	79.04%
Oxygen	16.96%
Carbon-dioxide	4.00%

That is to say about 4 per cent of Oxygen is absorbed and an equal amount of CO^2 given off.

In heavier work, such as ascending an incline or running, the oxygen consumed may amount to 3 litre per minute, while the volume of air breathed may reach over 100 litres per minute.

3. **Types in use**

Breathing apparatus falls under two broad categories, viz:

(i) **Atmospheric types**: Which either act on filtering air or air being supplied to the wearer by his own or other person's effort e.g., Respirator or Air Filter tow Masks, Equaliser Tube Apparatus Bellows type smoke Helmets, etc. These are not extensively used in the Fire Se vice today due to various limitations

(ii) **Self contained Types**: Here the oxygen or air is kept in compressed form in cylinder and the wearer is independent of the atmospheres working in and also not depending on any second person for help.

Self-contained type is again classified under two heads, viz:

(a) Closed circuit self-contained type in which exhaled air is returned to the breathing bag. regenerated and used again i.e. "The Proto" and "The Salvus" types.

(b) Open circuit self-contained type in which exhaled air is discharged into the atmosphere.

COMPRESSED AIR BREATHING APPARATUS SET CONSTRUCTION

(i) **General Description**

The compressed air breathing apparatus is a self-contained lung-governed open circuit set It has first stage reducer but incorporates a demand regulator which provides for the highest possible work rate; hence no by-pass is required. In keeping with other compressed air sets, its duration depends on the capacity of the cylinder and the amount of work performed by the wearer.

(ii) **Main parts & function of B.A. Set**

(a) **Cylinder:** The body of the cylinder is made of chromium plated marine brass. It has stamped companies trade mark and the cylinder pressure in bar. It is threaded to fit existing cylinder.

Three types of cylinders are available with this set:

(i) 1200 Litre cylinder charged to 132 atmospheres (1980 lbf/in^3) (132 bar).
(ii) 1800 Litre cylinder charged to 200 atmospheres (3000 lbf/in^3) (207 bar).
(iii) 2250 Litre cylinder charged to 200 atmospheres (3000 lbf/in^3) (207 bar).

(b) **Duration**: The approximate duration of the set may be calculated in the following manner:

1200 litre cylinder

$$\text{Approx duration} = \frac{1200 \text{ litres}}{40 \text{ litres/min}} = 10 \text{ minutes - } 20 \text{ minutes}$$

1800 litre cylinder

$$\text{Approx duration} = \frac{1800 \text{ litres}}{40 \text{ litres/min}} = 10 \text{ minutes - } 35 \text{ minutes}$$

2250 litre cylinder

$$\text{Approx duration} = \frac{2250 \text{ litres}}{40 \text{ litres/min}} = 10 \text{ minutes } 46 \text{ minutes}$$

Note:

(i) For the purpose of these calculations, it is assumed that the wearer has an approximate air consumption of 40 litres/min. The standard safety margin of 10 minutes is allowed.

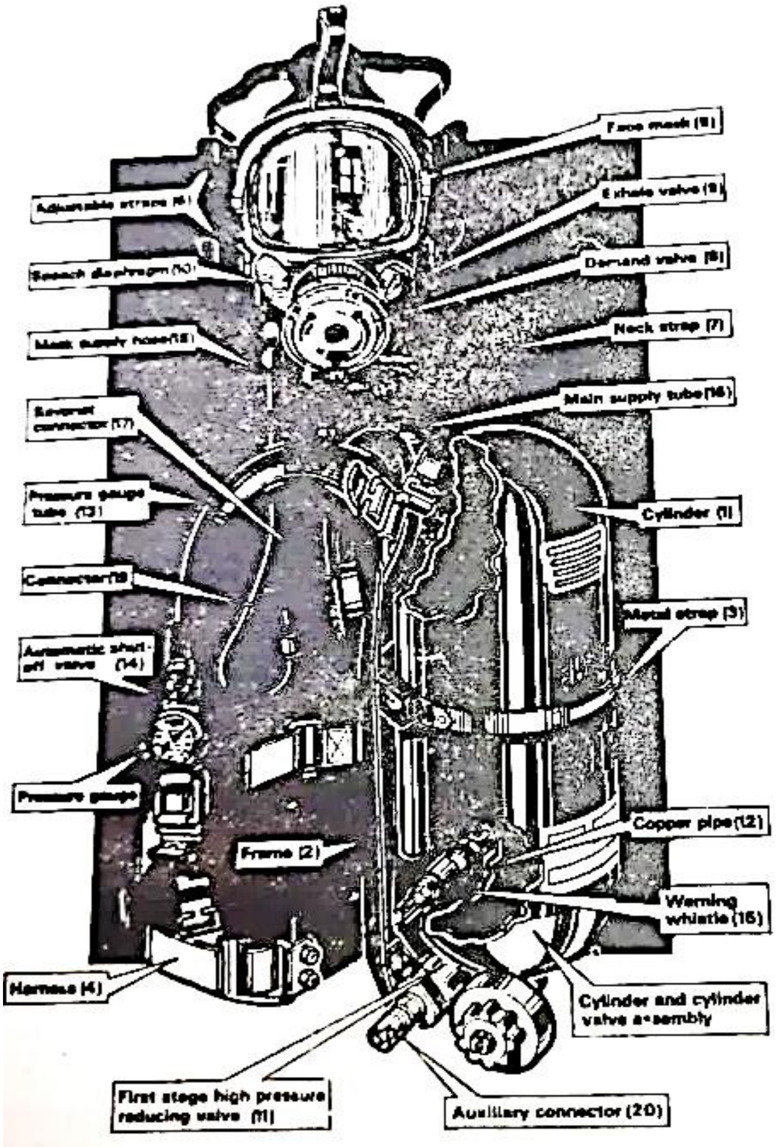
(ii) The duration of the set depends on the amount of work carried out by the wearer and his breathing efficiency. The positive pressure facility has no effect on the duration of the set.

(c) **Carrying Frame and Harness**: An adjustable harness consisting of shoulder straps and body belt secure the set to the wearer. A thermo-setting plastic backplate is shaped to fit on to the wearer's back and is also curved at the bottom to act as a support for the cylinder. The backplate also incorporates two cradles in which the cylinder is securely held by two stain less steel straps and is suitable for use with 1200, 1800 and 2250 litre 175 mm diameter (approx.) cylinders.

(d) **Manifold Assembly**: A manifold assembly is positioned on the backplate; it consists of a nickel-plated copper supply pipe to which is attached a short length of flexible high pressure hose with a hand-operated high-pressure cylinder connector at the lower end, and a manifold at the upper end. Provision is made on the manifold to fix a low cylinder pressure warning whistle.

(e) **Cylinder valve**: The cylinder valve is an integral part of the cylinder and should not normally be removed. It is connected into the neck of the cylinder by a standard taper thread. At right angles to the taper thread on one side is the cylinder valve handwheel which consists of a serrated metal knob and a rubber grip ring. On the other side is the threaded high pressure supply connection. The valve is protected from damage by a rubber buffer.

(f) **High Pressure Flexible Hoses**: Two flexible rubber hoses are connected to the Y manifold on the top of the backplate. The longer of the two passes over the right shoulder to the demand regulator, the other over the left shoulder to the pressure gauge. The hoses are reinforced with terylene and rayon and are secured to the shoulder straps by means of cable ties and/or loops.



(g) **Pressure Gauge**: A pressure gauge gives the wearer a constant reading of cylinder pressure. The gauge is contained in a nickel-plated watertight brass case with a Perspex facepiece. The dial is calibrated from 0-220 atmospheres. An automatic shut-off safety device is built into the gauge inlet which shuts off immediately there is a leak from the gauge. The gauge is secured to the left shoulder strap by a cable tie or loop.

(h) **Warning Whistle:** A low pressure warning whistle attached to the backplate and feed in to the high-pressure manifold, is pre-set to operate when the cylinder pressure drops to a pre-determined level of 45 to 40 atmosphere and automatically warns the wearer that the cylinder pressure is low. Whistle consume up to 2 litres per minute of air.

(i) **Facemask**: Several slightly differing types of facemasks are in current use. The standard face-mask is made of antidermatitic moulded rubber and incorporates an inner (orinasal) mask which is adjustable to suit individual requirements. A bounded air cushion seal round the inside edge of the mask forms a leakproof seal on the face.

The mask is supported on the face by a 'spider' of six rubber adjustable head straps.

The speech transmitter is located on the front of the mask and also incorporates the mush room type expiratory valve. The internally threaded moulded plastic fit ting on the left side of the mask facilitates connection and disconnection of the demand regulator.

(j) **Demand Regulator**: This is a single stage reducer consisting basically of a tilt valve and a diaphragm housed in a suitable casing. The regulator consists of the regulator body, the body cover, a nylon reinforced diaphragm bonded to a central pressure plate, a tilt valve, a tilt valve deflector and a valve body. The tilt valve projects through the deflector into the lower half of the diaphragm case, the head of the tilt valve being held in the closed position, on its seating on the valve body, by the pressure of air from the cylinder.

(k) **Reducer:** The reducer assembly operates at a regulated pressure of 115+ 15 lbs./in^2 (7.8 bar + 1 bar).

(l) **Air-Line Equipment**: This facility is used only by prior arrangement with the Brigade BA officer and involves using the set with an external air supply. This supply is fed to the reducing valve of the set via the instant air socket providing the wearer with a breathable air supply when the main valve on his set is in the OFF position.

Note:

The instant air socket must not on any account be used for air operated tools when a person is using the BA set. The Roberts air frame is provided for the purpose.

TESTING & MAINTENANCE PROCEDURES

4. After roll call or as necessary at other times during each watch, the persons detailed to wear apparatus must carry out the general check of the set to ensure that the apparatus and its ancillary equipment is complete and that it is functioning correctly.

The procedure is as follows:

(a) The demand valve made knob is in the open position.

(b) Check that the cylinder connection is tight.

(c) With the cylinder fully charged, slowly open the cylinder valve fully, there must be no audible leaks.

(d) Note the reading on the pressure gauge. It should be at least 80% of charging pressure.

(e) Close the cylinder valve. The gauge pressure should not fall by more than 10 bar in 1 minute. If this figure is exceeded, test for leaks.

(f) Don the facepiece and adjust har ness.

(g) Put demand valve made knob into the closed position.

(h) Breath normally for 1 minute to check function and moisten expiratory valve. hold your breath and check that there is no flow.

(i) Close the cylinder valve and continue breathing until the air in the set is exhausted; checking that the warning whistle sounds when the gauge needle reaches 45 to 40 atm.

(j) Examine the set clean. Stow the facepiece correctly. Mark the name of the wearer and the cylinder pressure on the set tally. Check BA lamp by operating it.

(k) Check the distress signal unit by operating it so that the key is required to silence it.

(1) Check that the personal line is correctly stowed and attached to the set.

After the general check has been satisfactorily completed, a check of all BA control equipment carried on the appliance should be carried out to ensure that it is available an ready for use.

The result of the tests should be recorded of the test record sheet.

PERIODIC MAINTENANCE TESTING

Test to check the operating efficiency of the demand valve and expiratory valve assembly are correct.

CARE AND MAINTENANCE OF CYLINDERS

Cylinder valves are an integral part of the cylinder and should not be removed. It may. however, sometimes be necessary to renew the valve seating or gland packing: this should be carried out in accordance with the maker's instructions.

Oils and greases must not be allowed to come into contact with the cylinder or valve parts. Outlet threads should be protected with a blank cap when the cylinder is not connected to the apparatus.

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CHAPTER 38

DERRICKS, SHEERS, GYNS, HOLDFASTS AND PICKETS

1. **Object**:

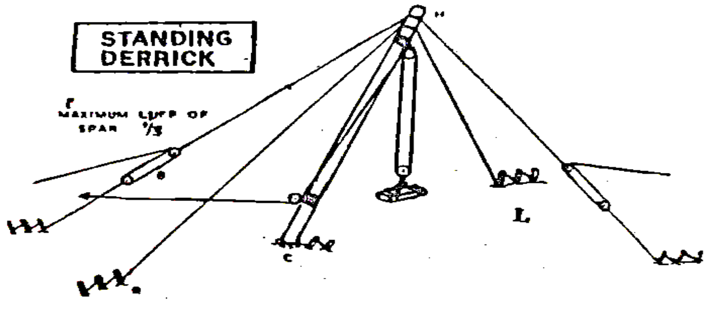
In Rescue Work. Derricks. Sheers and Gyns will be used for lowering. casualties and objects from heights and lifting heavy weights. These are used with tackles for lifting and also for lowering. Each one of them is used in each of apparatus, it is essential to ensure that different way. While selecting the poles for, they are long and strong enough to enable the load to be lifted to the required height after making allowances for the chock-a block and the length of sling and the height of the object being lifted. When selecting the poles for sheers and gyns additional allowance should be made for the slope of the legs. Knowledge of holdfasts and pickets is important, since derricks and sheers are held vertical by means of guys which are tied to holdfasts or pickets.

2. **Standing Derrick**:

A standing derrick is a simple vertical pole with a lifting tackle lashed to its head. The butt i.e., the thick end of the pole is rests on the ground or a sole piece and the pole is held vertically with three or four guys attached to the tip and tied to the holdfast or picket. It is used for raising or lowering objects where the radius of action required is small. The weight can be lifted and moved to the right or left, to the front or rear, but only to a limited distance.

(a) **Layout and Preparation**: Choose a position C for the derrick foot and layout a line FCB to mark the direction of the fore and back guys. Layout a second line RCL at right angles to FCB to mark the side guys (see Fig. 1) Let CH represent the effective length of the spar. Measure distances. CF. CR, CB and CL each equal to 2 CH. provided the ground is flat, F. B. L and R represent the position of the holdfasts. If the ground slopes this must be allowed for so that the slope of the guy may be 1:2.

(b) Lay the derrick in a line from the footing to the fore guy holdfast, with the butt nearly over the footing. Tie a foot-rope to the butt and to a hold fasts on the same side of the footing as the derrick and close to it. Then the guys should be made fast to the tip of the derrick and the holdfasts. Then fix the cross tree or head to the derrick by using square lashing, to support the lifting tackle and to prevent it from binding on the derrick pole. Cross tree should normally be fixed 1% to 2 feet (45 to 60 cm) from the tip of the pole. Pickets or holdfasts should be prepared and kept ready to attach the guys to them during and after erection. Care must be taken to see that pickets or holdfasts prepared are suit. able to withstand the pull coming on to them.



(c) **Selection of Spar**: The length and diameter of a spar depends upon the height from which a weight has to be picked up and the height to which has to be raised. It also depends on the distance from the base at which the weight has to be handled. A simple method to decide the length is as follows:

	Feet	**Inches**	**Metres**
Height of the object (say 3 ft)	3	2	.90
Sling on weight or object (say 2 ft):	2	0	.70
Allowance for chock-a-block	4	0	1.20
Allowance for attachment to spar	1	0	.30
Working clearance	1	0	.30
Effective length	11	0	3.30
ADD			
Height of ambulance or Rescue Truck	3	6	1.05
Spar at tip	2	0	.06
1 foot in ground	1	0	.30
Total length of Spar	17	6	5.25
Say	18	0	5.00

From the Table given above select the spar.

(d) **Raising**: Raise the tip of the derrick as high as possible by hand, supporting after each lift on packing or on a light timber or a ladder. which is moved gradually inwards. Haul in on the back guy and pay out on the fore guy until the derrick is in the required position. The side guys and foot ropes must be adjusted as necessary while the derrick is being raised

(e) **Leaning**: Leaning or luffing are usually necessary in rescue work when stretchers bearing the casualties have to be cleared over a wall or an obstruction. To do this, each guy lines must be controlled under the direct supervision of the leader and no one else. All orders to haul or slacken the guys will be given by the leader and the man responsible for the guys will act on the leader's orders only, as otherwise confusion might arise and lead to accident. The initial luffing should not exceed one-fifth of the effective height of the derrick to allow for stretch in the guy lines when the derrick is first loaded. The maximum permissible luff at any time is one third the effective height of spar

(f) **Walking a derrick**: Derricks can be walked after erecting them in one place. A short spar should be lashed at right angles to the derrick spar and about 2 ft. 6 inches (.75 m) from its base with square lashings. The guys are then slackened off, and the butt of the derrick can be moved by lifting on the short spar at the same time, lowering the butt of the derrick with a hand spike. The butt must be controlled with foot ropes.

(g) **Lowering**: The lowering may be carried out in a similar manner to raising it, except that the process is reversed. Packing must be placed to support the derrick as it comes down. The foot ropes must be taken in as the derrick comes down. When the derrick is not heavy a plank may be used as a lever with one end but ted to the feet of the derrick and the other under the standing part of the guy. The plank should be nearly vertical.

(h) **Guys**: In case 40 ft. 1½ inches (12 m 38.10 mm) lashings are used as guys, join two of them by a double sheet bend and then make a clove hitch in the centre of the joint rope and attach it to the spar. In case 200 ft. 2 in. (60 m. 50.8 mm) rope is being used, make a clove hitch in the centre and then attach it to the top of the spar. Four guys i.e., fore and back, right and left guys, each at right angles to the other, are required.

(i) **Holdfasts**: These are required, one for each guy. The distance between the holdfasts and the foot of the derrick is normally twice the effective height of the derrick. Holdfasts are also required for two-foot ropes.

(j) **Lifting** Tackle and Anti-twisters: This is attached above the cross tree. firmly, by a lashing sling or chain. Anti-twisters should be fixed to the lifting tackle. The fall of the lifting tackle is passed through the leading block, which is attached to the spar above the butt.

(k) **Foot Ropes**: Then attach foot ropes to the foot of the derrick. Foot ropes are necessary during erection and also while the derrick is standing. They may be single or double, spread at 90", according to the condition of site and to the direction of the heel of the derrick. Except for very light weights 3" (76.20 mm) cordage, 3/ 2 tackles should be used. The foot of the derrick must rest on a sole piece or a base plate to ensure that the foot does not sink into the ground.

(1) **Slings and Strops**: Strong lashing 1% inches (38.10 mm) two or fourfold may be used for small derricks. These are required for attaching the runner tackles to the holdfasts, when they are used. They are also used for the object to be raised or lowered. Care should be taken to prevent these from chaffing.

(m) **General Precaution in use of Slings**: The method of slinging any given object must vary according to circumstances, but certain general rules and precautions, as enumerated below, should be observed to ensure safe working:

(i) The size, and therefore the strength of the sling selected, will be governed by the weight of the load.

(ii) The efficient use of a sling is governed between the sling and the edges of the load to prevent the sling coming in contact with sharp edges.

(iii) Timber packing must be inserted bet ween the sling and the edges of the load to prevent the sling coming in contact with sharp edges.

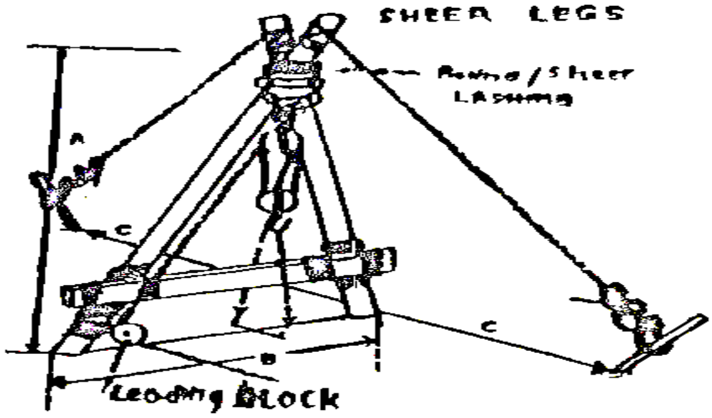
(iv) Hooks must be moused.

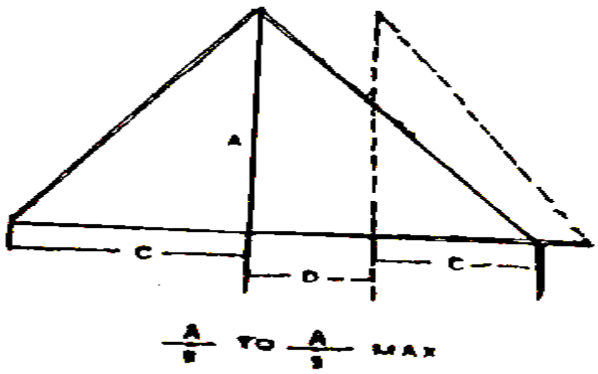
(v) Carelessness in hoisting e.g., shock lifting or snatching must be avoided. (vi) Slings should not be dragged along a floor or the ground, and should never be pulled from under a load, which, when lowered, is resting on the sling.

(n) **Precautions**: Mark the ground proper Use correct method of lashing. Ensure that everyone understands his work. Only the leader gives the orders and there should be no one else controlling the erection of a derrick. Follow the correct sequence in raising and lowering. Ensure that the leaning of the spar is never more than one-third the effective length of the spar.

3. **Sheer:**

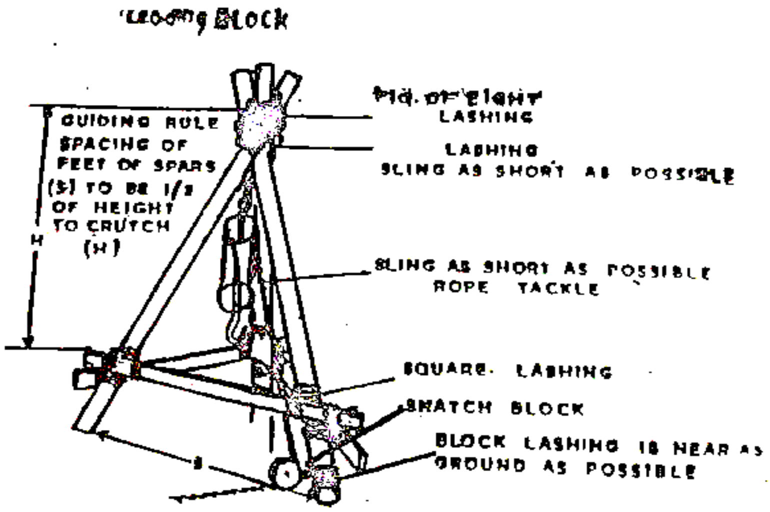
Sheer legs consist of two poles of equal length. Their tops are lashed together. using round lashing. When erected, it looks like an inverted "V" (See fig. 2). They are held steady by a fore and back guy. Sheer can often be employed where the erection of a derrick is impossible. But they can only be used to move the weights in a straight line by swinging the load between the legs, until the sheers are leaning at the limiting slope of 3:1.





(a) **Layout and Preparation:** Lay two spars of equal length with their butts flush together. on the ground and keep the tips resting on a piece of timber, keep a pick helve as a spacing block. Use round lashing on the tips. Open out the legs to one-third the distance between the butt and the lashing and secure them with a ledger and use square lashing. Pass a sling over the spars, to rest on the spars and not the lashing. Hook the lifting tackle into the sling.

(b) **Guys**: The guys are similar to those required for derrick. They should be made fast near the tips of the spars with clove hitches. Use 40 ft. 1½ inches (12 m. 38.10 mm) lashings for small sheers. The fore guy should be fixed to the rear spar and the back guy to the front spar.



(c) **Foot Ropes**: Foot ropes will be required as in the use of derricks.

(d) **Walking Sheers**: Sheers may also be walked as in the case of derricks.

(e) **Raising and Lowering**: Sheers may also be raised and lowered, like the derricks. It should be remembered that usually they are heavy to be raised by hand.

4. **Gyns**: A gyn consists of three spars lashed together at the tips, the butts forming an equilateral triangle, on the ground (See fig. 3). The space required for this is small comparatively and no guys are required. Only a vertical lift is possible.

(a) **Method of Construction**: Layout three spars with their butts flush, and mark the point where the centre of the lashing will come, about 3 ft. from tip of spars. Leave the two outer spars apart and turn the centre spar so that the butt lays in the opposite direction. Ensure that the marks on the tips are in line. Support the tips on block of wood. Keep spacers. Lash them together with gyn lashing. Cross the two other spars until their butts are at a distance equal to half the effective length of spars. Lash the ledger with the spars about one foot from the butts with square lashing. Lay the sling across the lashing at right angles to the spars, with the centre of the sling in the centre of the lashing. Leading block is tied to the centre spar as nearer to the ground as possible and just below the ledger lashing.

(b) **Raising and Lowering**: The head should be lifted as far as possible by hand and the centre spar brought in towards the centre of the ledger already fixed, either by a hand spike lashed across it or by a tackle. When the butts form an equilateral triangle, two more ledgers should be lashed across the butts of the legs. To lower the gyn, reverse the process of rai sing.

(c) **Practical Points:**

(i) The three feet should be on the same level and properly supported. They must be secured from slipping.

(ii) The gyn should be placed with its head over the centre of gravity of the weight to be raised. If the weight has to be swung. the head should be symmetrical about the points of raising and lowering the weights.

(iii) Hauling the load either to flank or taking a swinging lift, is liable to cause the Gyn to capsize. The lower block should not be allowed to come outside the line joining the centre spar and the side spars.

5. **Holdfasts and Pickets**: In rescue work. holdfasts and pickets are used for making fast a line or a guy rope etc. which will be under strain. These are of two types. Those that are found on the site e.g. big trees, gate posts or metal fencing etc. and those which have to be erected e.g. by way of pickets or baulks.

(a) **Precautions**: While using any type of pickets or holdfasts, prevent chaffing of ropes the pickets must be packed, usually by mean: of sacking or sand bags. The timber used a pickets must be strong enough to withstand the strain. The normal size of picket is 3 inches.

inches diameter (76.2 mm-101.6 mm) and 5 ft. (1.50m.) long.

(b) **Pickets:** In normal ground, pickets are suitable as holdfasts since these are quick to erect, and can be used for strains up to 2 tons They may be used as single picket or a com bination of 1 and 1, 2 and 1 or 3. 2 and 1 arrangement. The pickets should be driven into the ground at right angles to the pull. Two thirds of the length should be driven into the ground. The strongest picket should be the nearest to the pull. In the combination of pickets, the lashing connecting the pickets should be at right angles to the pickets and should come from the head of the picket in front to the heel or ground level of the picket at the back. The distance between the pickets should be not less than 3 ft. (90 cm.). Guys should be made fast with a round turn and two half hitches. One man should always be at the picket, when the load is coming on it, to watch and warn against any weakness in the pickets.

(c) **Safe Loads for Pickets**: In ideal conditions, the safe loads that can normally be loaded on to pickets are as follows: Hard wood, pickets 3"-4" dia x 5 ft. (76.20 mm-101.6 mm x 1.50 m).
Single 6-7 cwt (304.80-355.60 kgs):

Combination of	1	to	1	=12-14	cwt (609.60-711.20kgs).
Combination of	2	to	1	= 18-20	cwt (914.10-1016.00 kgs)
Combination of	3	2	to	1=40	cwt (2030 20 kgs)

(d) **Other Types of Holdfasts**

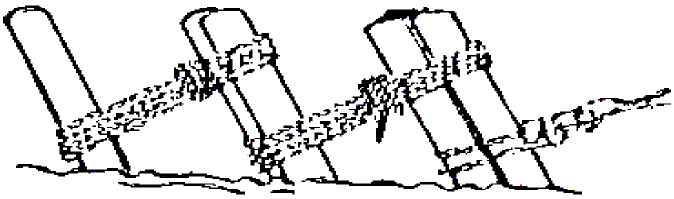
(i) **Buried Holdfasts:**

Buried holdfasts are constructed by burying a baulk of timber or a girder in a trench cut with a front face at 90° to the pull. A connecting trench to take the guy should be cut to accommodate the slope of the guy. The ends of the trench should be filled in and rammed over the baulk but it is advisable to leave the guy fastening visible for inspection.

(ii) **Baulk Holdfasts**:

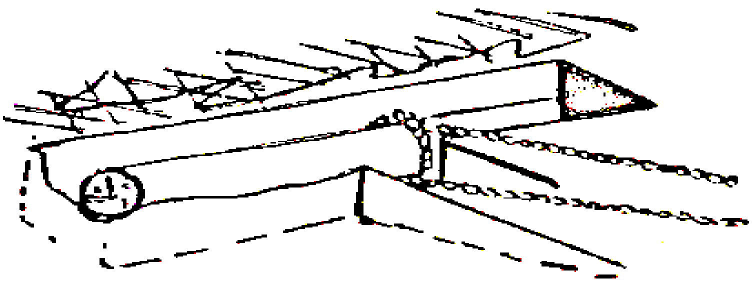
(a) In addition to driven pickets and baulk holdfasts, many improvisations can be made and secure anchorage obtained. Baulks of timber placed across openings in buildings and between strong brick piers and other strong objects may be utilised. Always ensure that the timber used is long enough to give ample bearing on each side of the opening so as to distribute the load adequately. A baulk of timber under the opening of a street man-hole to act as a spreader makes a good improvised holdfast. Here again, the bearings of the timber must be adequate.

(b) Among other holdfasts frequently to be found the site suitable for use as anchorages are lamp standards or posts. Reinforced concrete or steel standards used as lighting or cable bearers are strong and reliable and make good anchorages. A pole is equally suitable and forms a good round bearing for a fibre rope.



1 2 1 PICKET HOLDFAST

BAULK HOLDFAST



BURIED ANCHORAGE

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CHAPTER 39

SETTING UP A FIRE HUT, FIRE CONTROL IN A CLOSE ROOM AND SMOKE CHAMBER

1. **Object**:

When a building catches fire, nor mal conditions are greatly upset, breathing becomes difficult, visibility is reduced and movement, restricted to a great extent. When the fire is inside a closed room and it is necessary to enter the same for fighting the fire or effecting a rescue, it is worse still. Any hasty action on the part of a fire fighter or rescuer may result in injury to the operator and the fire may also get out of control. Everybody connected with the CD Fire Fighting Services should therefore know the different points to be observed in controlling a fire in a closed room or in effecting a rescue from therein.

2. **Reconnaissance**:

A thorough rapid reconnaissance is a vital preliminary to attack the fire. Time so spent is near wasted. In making this reconnaissance, the leader will ascertain the location, type of fire, its likely fire spread. He will assess if there is any special risk or danger involved & will think of a suitable method to attack the fire. When the fire is extinguished, all debris must be cooled with water and final reconnaissance made to ensure that there are no hot spots which might flare up after the fire fighters have left. This first recon naissance may show that the fires are too large for the capacity of the appliances available, if so, additional help should be summoned and the available appliances used to keep the fire under control, by preventing it from spreading. pending the arrival of reinforcement.

3. **Methods of entry:**

Behaviour of the fire will greatly vary according to the construction of the room, access of air inside the room, the combustible materials present etc. The method. to be adopted in entering the room also varies in each case. There are, however, certain guiding priorities which should be followed in different situations:

(i) When the fire is suspected in a closed room and the door opens outwards. heated gas, smoke inside the room, may be awaiting release. Therefore, if the door is opened suddenly & without taking cautions, the hot gas and smoke gushing out, may knock out the operator. Therefore, when opening the door, the operator should place his one (normally right) foot firmly against the closed door, stoop low and then gently open the door. In doing so his foot is pre venting the door to be flung out suddenly, and whatever gas or heat comes out, is passing above his head.

(ii) When the door opens inwards in this case the outrush of hot gases will be lesser and chances of getting knocked out is also reduced. However, if the door is opened fully at once the heated gas and smoke will come out, overwhelming the operator. The safe method therefore, is to open it slowly.

4. **Other points to note before entering**

(i) **Cutting off supplies**: For a building on fire, it is always advisable to cut off supplies of electricity, gas etc. as unless this is done, these may present additional hazard.

(ii) **Portable Extinguishers**: Before entering the room on fire, it should be ensured that adequate first-aid firefighting equipment is available to tackle the fire. These may be in the form of water or sand buckets or chemical extinguishers etc.

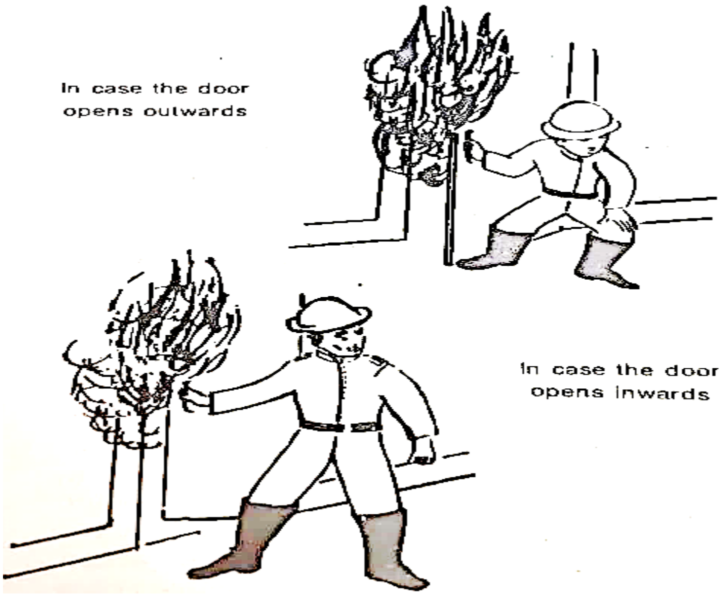
5. **Smoke**: Quite a small fire can produce a large volume of smoke. Unless the smoke is very thick it is not normally a danger to life, provided the trapped persons can get away from it without delay. It can, however, produce feelings of panic, which must be avoided. A wet cloth or handkerchief placed over the mouth and nose will give some measure of protection against the discomfort in breathing, checking a large number of harmful particles from entering the lungs. It does not, of course, avoid the ill effects of lack of oxygen, monoxide to which pro longed breathing of smoke may give rise.

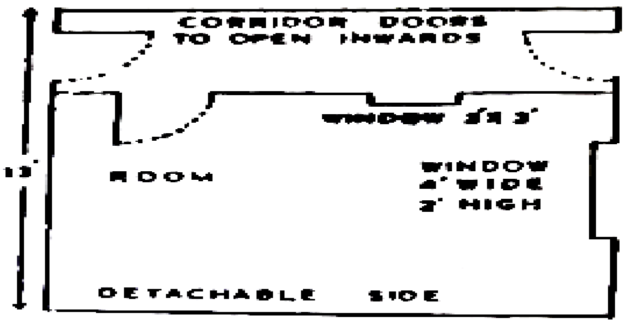
(i) **No entry**: The room is to be entered in a crawling position as this position will allow the rescuer to avoid the smoke. The door behind him must be closed as this will prevent further ingress of fresh air containing oxygen which will be useful to open the door as otherwise the fire inside may overwhelm him. He should keep his head and face well down as this will enable him to breath fresh air and see things clearly. As soon as the fire is discovered it should be attacked at the heart with the fire extinguishers or stirrup pump. While controlling the fire it is to be seen that no unnecessary damage is caused either by the use of excessive water or fire extinguishers.

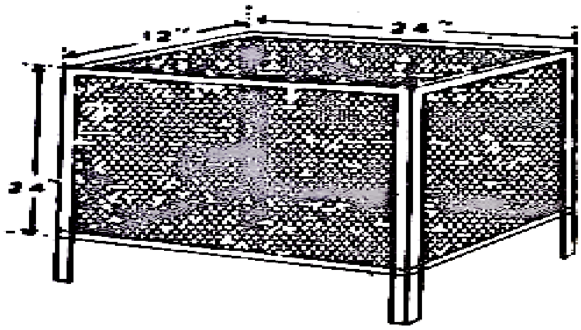
(ii) **Searching a building**: When possible, it is advisable to work in pairs while entering a smoke-filled room or building. This gives confidence and makes it possible for one to assist the other. People trapped by fire or smoke particularly children, often take refuge under beds or in cupboards in which they hide to escape the smoke and flames. Searching though swift should be thorough. Every room should be investigated and no possible hiding place. however unlikely, should be overlooked.

(iii) **Searching a room**: Searching a smoke-filled room is not an easy task and it is unlikely to be successful unless carried out with a definite plan. Once inside the room a complete round should be made, keeping close to the wall, feeling under and on the beds, and opening and feeling inside cup-board, wardrobes and other articles of furniture. Finally, the room should be crossed diagonally to make sure that no one is lying inside in the centre (see fig.). It

OPENING A DOOR OF A ROOM ON FIRE

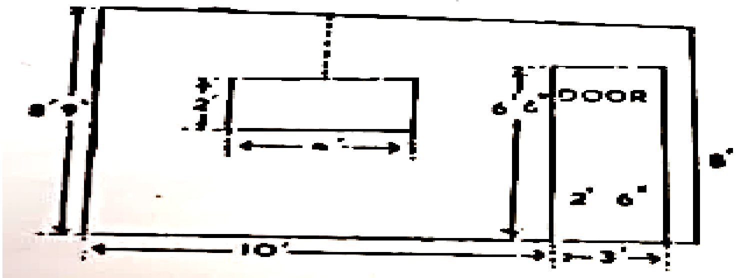






FIRE BASKET

Side Elevation



Frame work of 1 ¼ “ x ¼ “ angle iron sides & bottom of expanded metal

should always be remembered that floors immediately above the fire may have been weakened sufficiently to become dangerous and care should be taken while searching the centre of the room. Whether or not the windows should be opened to obtain fresh air depends on the circumstances. Only when it is known that the fire is in a distant part of the building and is being tackled or the atmosphere is cool, it is safe to open the windows.

6. **Some firefighting hints**

(i) Attack the fire as quickly as possible.

(ii) Always attack the heart of the fire rather than the flames. mere spectacular looking

(iii) All combustible materials near the fire should be removed or cooled from time to time by spraying water to check the spread of the fire.

(iv) If the fire is spread over the floor start at the end nearest to you.

(v) When the fire is out, cool down all debris and make a final survey to ensure that there are no hot embers or hot spots which might flare up afterwards.

(vi) In case of electrical fires, switch off the main first. Do not attack electrical fires unless you are sure that the circuit is dead.

(vii) Do not use water on fire involving petrol oil etc. Smother it with earth or sand.

(viii) if your clothes catch fire, lie down Immediately cover your face with your palms and roll yourself on the ground. Never run.

(ix) If somebody else's clothes catch fire, cover him with a blanket or knock him down and roll him on the ground. Do not put water on him.

(x) Exclude air by keeping doors and windows closed when possible.

(xi) In a building damaged by fire or blast. keep near the walls, where ceiling and stairs are strongest.

(xii) Attack fires at the closest possible range.

(xiii) Take advantage of whatever cover is available and fight the fire from behind a door or any large piece of furniture, provided he can still direct his jet straight into the heart of the fire from the protected position.

(xiv) Remember that phosphorus will reignite when dry.

(xv) Do not enter a burning building or room, except to save life, without firefighting appliances.

(xvi) Before leaving, be sure that all fires are out.

7. **Details of demonstrations**.

(i) **Fire-fighting demonstration**:

Smoke chamber drill and control of fire in a hut are two outstanding demonstrations which besides being instructional also hold the interest of the public. It properly staged these demonstrations have considerable propaganda. value. The demonstrations also familiarise the trainees with the type of conditions they are likely to encounter & therefore give them confidence in tackling fires.

(ii) **Fire Hut**:

A fire hut is required for two purposes namely (a) demonstrations such as smoke chamber drill and (b) practical training in Firefighting. For demonstration the hut should be con structed in such a way that its one side or end can be easily detached so that as many people as possible are able to see it. For practical training in the fire-fighting the hut should be completely closed, as it is important that the trainees should have experience of heat and smoke in a room on fire. Suitable dimensions of fire hut are 12 ft x 10 ft x 8 ft with a corridor measuring approximately 3 ft wide through which the trainees will have to go in order to reach the room in which the fire is burning: It can be made of creosoted timber framing with any sheet or corrugated iron sheet nailed on the inside. No external sheeting to the framing will be required. A door and wired glass window should be fitted to the hut. A hole should be bored in the floor to drain muddy water away (for diagram and specifications of fire hut, see fig.)

(iii) **Fire Baskets:** In order to create a realis tic yet controlled fire and smoke effect two baskets will be needed. A fire basket is made of expanded metal 1ft x 2ft x 2ft supported on an angle iron frame with 6" legs.

(iv) **Furniture**: It is recommended that some old unserviceable furniture should be used for decorating fire huts, or furniture may be improvised by using old wooden cases properly covered with some old pieces of cloth. As for bed, an old iron cot may be provided on which some improvised bedding consisting of grass and an old bed-sheet can be spread. pillow may be similarly improvised of a gunny bag stuffed with grass.

(v) **Material for fires in fire huts**: To get a good fire/smoke effect, waste materials such as rags, old jute bags, discarded straw/palm mats, waste paper, cotton waste, wood shaving, grass, unserviceable wooden cases etc. should be used.

(vi) **Protection for Instructor**: As Instructors have to go frequently in the fire hut to give confidence to the trainees and to guide them, it is necessary that they should take additional precautions to protect their eyes and lungs from constant exposure to smoke, heat and toxic gases. This protection can easily be secured by putting on a wet cloth over the face and using goggles, during training. Besides, the practical training in fire hut should be so staged that the instructors do not have to go in the hunt for more than 4 or 5 times on any single day. Additional help may be sought from other Instructors when necessary.

(vii) **Protection for trainees:** When the Instructor does not accompany the trainees in the fire hut, a rope should be attached to trainee's waist so that the trainee can give it a pull and at the same time put on a wet cloth or handkerchief and get protection from heat fumes. A first aid box should be kept handy for treating burns and minor cuts. All fuel and flammable articles should be kept away from the fire hut preferably in an independent room/enclosure.

8**. Smoke Chamber**:

The purpose of smoke chamber is to simulate conditions likely to be encountered by the fire-fighters while actually working in a smoke-filled building, and practice the different techniques of fire-fighting under such conditions.

9. **Method of working**:

Much will depend on the particular type of building, materials, intensity of fire etc. However, certain guiding principle common to all such fires, can be laid down. These are:

(i) **Breathing**: In a smoke-filled building, breathing is rather difficult. If, however, some hazardous poisonous articles are involved, then inadvertent inhalation of poisonous fumes may cause a fatality. For that purpose, the following precautions should be taken:

(a) Do not enter a room without proper air breathing apparatus, if poisonous gases are known or suspected. Remember that wet face and wet clothes do not afford any protection against such gases.

(b) Always work in pairs in thick smoke, as this not only gives confidence, but also makes it possible for one man to assist the other in an emergency.

(ii) Smoke also reduces visibility, and the only course left open may be to work by touch. In such circumstances great caution is necessary.

(iii) In such circumstances, men must not walk, but shuffle, i.e., slide their feet forward and weight of the body should be kept poised on the rear foot until the advancing foot has tested that it is safe to move forwards.

(iv) In ordinary smoke i.e., non-poisonous smoke the air will always collect near the floor as heated smoke tends to rise higher. It is, therefore, desirable to advance on all fours i.e., crawling in such circumstances.

(v) As one crawls forwards, he should raise the free hand in his front, lightly clinched, with the back uppermost, to feel for obstruction. In an affected building, electric installation may often be seriously dislocated so that live electric wires may be hanging at odd places. In such cases, there is risk of electrocution, unless the fire-fighter is extremely careful.

(vi) When getting down the stairs, in a smoke filled and dark building it is better to proceed backwards down stairs. This has the advantage that the stairs can be grasped with hand, thereby preventing a fall in case of a slip.

(vii) One should not remain in smoke longer than what he can endure. If work is of a longer duration, it should be carried on a relay system, each pair being inside for 5 to 10 minutes at a time.

(viii) Possibility of getting lost in a smoky building should always be borne in mind. While entering therefore, a mental note should be made of any feature which may assist in retracing the route to safety. A very simple way is to tie one end of a long 1½" line, to his waist and the other end tied to some secure objects outside the building.

(ix) When entering a dark and smoky building. always try to keep near the wall. This is safe.

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CHAPTER 40

RESPIRATORY SYSTEM

(Anatomy and physiology of respiration, suffocation, types, causes and treatment, artificial respiration)

1. **Object**:

Respiration and circulation are the two vital processes essential for continuation of life. The respiratory process may get interfered with in a number of ways, accidently due to any of the natural calamities such as floods, fires, earthquakes etc. Fortunately, the heart (representing the circulatory system) continues to beat for a few minutes after, the respiration has stopped accidently and if, during these very precious minutes, the cause of interference to respiration is removed and the natural process of respiration is initiated, the victim can be brought back to life. The rescuers and the first-aiders must, therefore, have a thorough knowledge of the subject to enable them to take quick and correct action when faced with cases of suffocation i.e. interference with the normal process of breathing.

2**. Anatomy and Physiology of respiration:**

The respiratory process is partly under our conscious control and partly an involuntary effort. Thus, we are able to alter the depth and rate of breathing at our own will, for some length of time. During sleep and when not consciously attentive to it, the breathing pro cess carries on normally and as per demands of the body. The process is controlled by "Respiratory Centre" located in the brain. The back ground of all causes of suffocation and that of various methods of artificial respiration will be understood clearly if the processes of inspiration and expiration are analysed.

(i) **Inspiration, Inhalation or breathing in:** During this phase of breathing the following things happen and cause increase in size of the chest-cage.

(a) The diaphragm (a muscular-fibrous dome shaped partition that separates the contents of the chest from those of abdomen) is pushed downwards.

(b) The front ends of the ribs along with the sternum (chest bone) move for wards and upwards.

(c) The above processes are helped further if.

(d) The arms are held away from the trunk in a forward and upward direction.

(e) The vertebral column (back bone) is bent backwards.

(ii) **Expiration, exhalation or breathing out**: During this process the reverse actions as those noted in inspiration take place.

(a) The diaphragm is pushed up.

(b) The ribs with the sternum drop down or return to original position (Expiration is helped further, if).

(c) The arms are placed on the sides or crossed immediately in front of the abdomen.

(d) The backbone is bent forwards.

3. **Common causes of suffocation in disasters**:

(i) **Drowning**: In drowning, which is responsible for a considerable death due to floods, there is blocking of air passages due to water. In some cases, there may be spasm of the epiglottis.

(ii) **Mechanical interference of breathing**: In earthquakes, and floods, per sons get buried under the debris of the Houses in such a manner that it becomes impossible for them to use the muscles of chest and or abdomen effectively enough to permit adequate oxygenation of the blood.

(iii) **Electric shock:** Short-circuiting of electric wires may follow house collapses and lead to electric shock. The powerful electric current causes temporary paralysis of the respiratory centre leading to stop page of respiration.

(iv) **Toxic gases**: Toxic gases enter the breathing system in cases of victims trapped in houses on fire and sometimes even the rescuers themselves may get suffocated by such gases.

4. **Signs and symptoms of suffocation**:

(i) Gasping for breath, restless and may pull at his clothes etc.

(ii) Coughing and spluttering or whistling noise.

(iii) Eyes are blood shot and staring.

(iv) Veins in the neck stand out.

(v) Face is livid, with finger nails and lips bluish.

5. **First aid measures:**

(i) The first thing to do is to remove the cause of suffocation.

(ii) Commence artificial respiration, immediately, ensuring that:

(a) The air passages are clear. It must be remembered here that in all unconscious persons and even in natural deep sleep, the tongue tends to fall back causing some interference in process of breathing, especially if the person is lying on his back.

(b) All tight clothing around the neck, chest and abdomen is loosened at once.

(iii) Take steps while the artificial respiration is on, to conserve the general strength of the victim, by removing clothing if it is wet and protecting him from effects of weather.

6. **Choice of method of artificial respiration**:

There are a large number of methods of artificial respiration and out of these, the following 5 methods may be found useful. Each method has its advantages and disadvantages.

(i) **Holger-Nielson's method**: This method is now recommended by most official bodies all over the world, since 1955 onwards as it is easy to learn, it causes greatest amount of exchange of air in the lungs and is not fatiguing to the operator. It, cannot however, be used effectively if the patient's arms or shoulders are seriously injured. Under such circumstances Schaefer's method may be found convenient.

(ii) **Silvester's Method**: If the victim has such injuries that he cannot be turned face down, the above methods cannot be utilised and rescuers recourse may have to be taken to Silvester's method. The disadvantage of this method which is 100 years old lies in the fact that due to the face up position the tongue tends to fall back and another person is required to hold the tongue forwards throughout the operation of artificial respiration.

(iii) **Eve's Method:** This method is useful under certain circumstances but its dis advantage lies in the fact that it takes some time to rig up the necessary equip ment before artificial respiration can be started. It is useful.

(a) when there are internal injuries to the chest and abdomen and no direct pressure can be applied to those parts.

(b) when a drowned person is being brought ashore by the rescuers, the victim can be held face d downwards by two rescuers, walking back through shallow waters to the bank and the method employed enroute, thus saving valuable minutes.

(iv) **Sitting Method**: Useful in cases where a drowned person is rescued into a small boat or when an electricity worker gets a shock while on the top of a pole.

(v) Schaefer's Method: This method is least fatiguing to the operator, but there is no positive active movement employed to encourage inspiration or inhalation.

7. **Holger Nielson's Method**:

(i) Place the patient face downwards with head resting on hands kept one on the top of the others. The head should be turned to one side.

(ii) Check mouth and nose for foreign materials and bring the tongue forwards by giving firm blows between the shoulders with the flat of the hand.

(iii) Kneel on one or both knees, facing the victim, close enough to be comfortable when your hands are placed on the patient's back in such a way that they lie just half-way down the shoulder blades. The tips of thumbs should be touching each other while the fingers should be pointing downwards and outwards.

(iv) Compression Phase: Rock forwards until the arms are quite vertical, so that the weight of the upper part of the operator's body exerts slow, steady pressure through the hands directly down wards on the patients back. To achieve this, the elbows must be kept straight. Keep this position for two seconds only.

(v) Expansion Phase: Rock backwards slowly, without giving a jerk. As you come back, slide your hands down the victim's arm to the elbow. Lift the elbows upwards applying just enough force to feel the tension of the patient's arms, shoulder and back muscles. The elbows are held up for two seconds, and then gently lowered to the ground. completing the Expansion Phase and one full respiratory cycle.

(vi) Repeat the movements starting from pressure on the back etc. The whole cycle should take about six seconds and this is ensured by counting aloud 1-2-3 while compression is being applied, change when hands are being slide down the elbows and 1-2-3 again, when the elbows are held pulled up and change, again during transition from expansion to compression phase. Thus, counting 1-2-3 change 1-2-3 change, completes the cycle in six seconds and ensure correct action simultaneously.

(vii) In weaker victims or in children, the pressure to be applied should be reduced and this can be achieved by pressing the shoulder blades with tips of figures only.

8**. Schaefer's Method:**

(i) Place the victim on a flat surface in face down position with one arm extended with the other bent. The head should be on one-side and resting on the bent arm.

(ii) The operator should then place himself astride or kneel on one side, at the level of buttocks, facing the patient's head.

(iii) He then places his hands one on each side flat over the lower part of the back over the lower ribs with the little finger resting on the lowest ribs.

(iv) With the arms straight and moving at the knee, gradually bring the weight of your body forwards on the victim so as to produce firm pressure. This forces the air (and water, if any) out of the lungs initiating the expiration or exhalation phase.

(v) Keeping the hands where they are release the pressure and return back to original position.

(vi) One complete cycle should take about five seconds. This is ensured by counting 21-22 while exerting pressure and 23-24-25 while resting back.

9. **Silvester's Method:**

(i) Place victim on the back and the remove false teeth, etc. from his mouth.

(ii) Hold his tongue forward by holding it in a piece of bandage. This is done by an assistant kneeling at the waist level of the casualty facing towards.

(iii) Place a rolled-up blanket or some such material under patient's shoulder. This straightens up the windpipe.

(iv) Kneel just above the patient's head and hold both his arms near the wrists.

(v) Draw the arms outward and upward gently and steadily and hold them as far as they will go above the head for two. seconds.

(vi) Bring the arms down until the elbows press against the sides of the chest. Fore-arm crossed. Hold this for two seconds.

(vii) The cycle is then repeated at the rate of 10 to 12 times per minute.

10. **Eve's Method**:

In this method, the victim is placed face downwards on a stretcher (proper or an improvised one) and fastened to the same by wrists and ankles. The stretcher is then rocked sharply through 45 degrees to a head-down position and then to feet-down position. The head-down position, which initiates expiration, should take longer i.e. 3 ½ second while the feet down position. 2 ½ seconds.

11. **Sitting Method**:

In this method one of the rescuers holds the victim in a sitting position in his front, facing in same direction as himself and alternately bends his body forwards and backwards initiating exhalation and inhalation respectively.

12. **Mouth to mouth artificial respiration:**

This method is recommended especially in case of infants and young children.

(i) Clear the air passage i.e. the mouth and throat of the casualty of water, mud. food etc.

(ii) Tilt its head to straighten up the air passage.

(iii) Hold the jaw in jutting out position.

(iv) Pinch the nostrils to prevent air, leakage unless the victim is an infant or young child.

(v) Blow into mouth (and nose, if victim is a small child) until the chest is seen to get inflated.

(vi) Listen to the casualty's breathing out as you wait and take in breath.

(vii) The Frequency per minute should be 10 to 12 times for adults and 18 to 20 times for young children or infants.

13. **Cardio Pulmonary (C.P.R.):**

In the Course of giving artificial. Resuscitation respiration by any of the above methods, it is often likely that instead of the breathing being restored to normalcy, circulation itself may stop and may be indicated by absence of the neck pulse. First Aider must be alert enough to start cardio pulmonary Resuscitation immediately in such an instance in the following manner:

(i) Give a hard-hitting blow with a closed first on the midpoint of the breast bone.

(ii) Feel the neck pulse, it may have started beating again if not:

(ii) Airway clearance

(iv) Four quick blows of mouth-to-mouth respiration.

(v) External heart compressions with the heel of the hand in use pressing the mid-point of the breast bone and the heel of the other hand pressing the former simultaneously. These com pressions should be sharp and jerky pressing the chest by 5-6 CMS., each time and twice every second. Give 15 such compressions.

(vi) Feel the neck pulse. If it is absent. (vii) Mouth to mouth respiration twice.

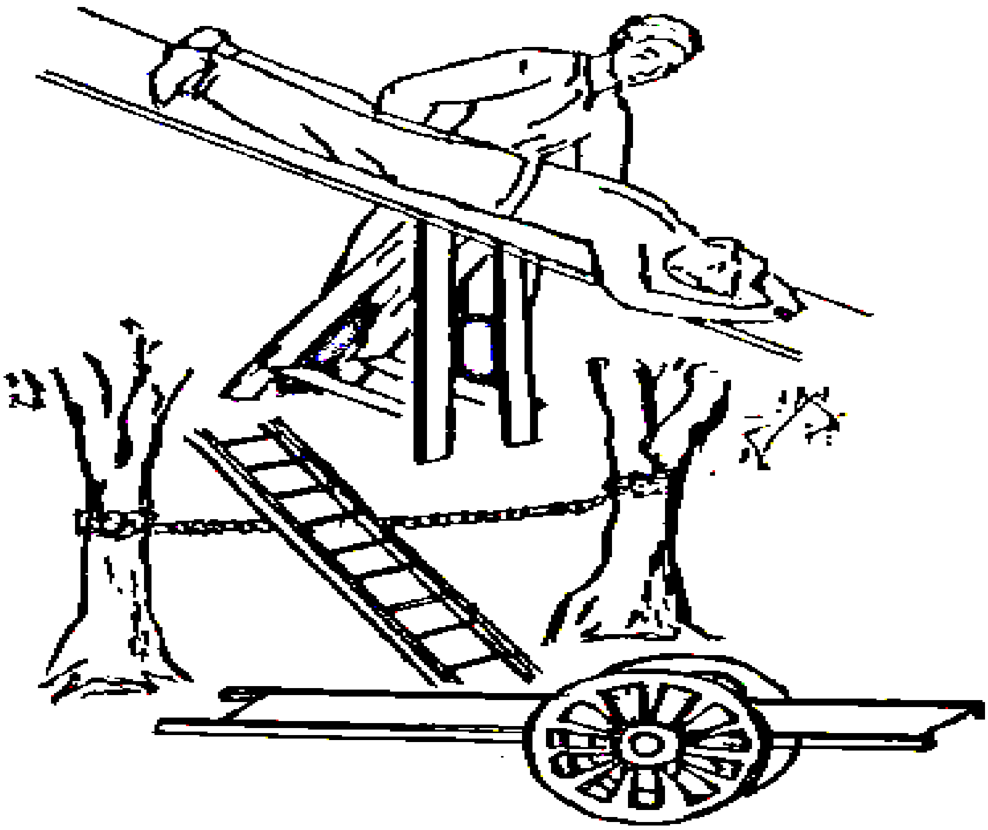
(viii) External heart compressions 15 times.

(ix) Feel the neck pulse and until it returns carry on with step (vii) and (viii) alternately.

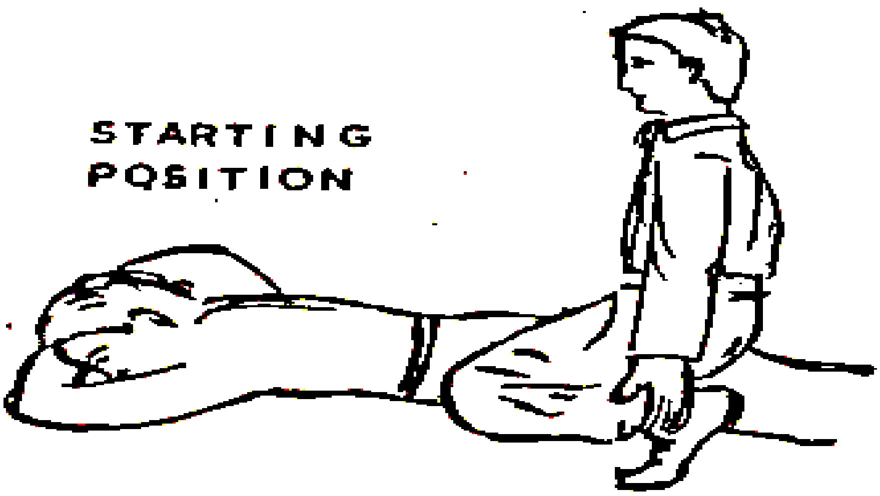
(x) After it returns, resort to any one of the above methods of artificial respiration until the same is restored to normalcy.

14. **Additional measures in cases of drowning:**

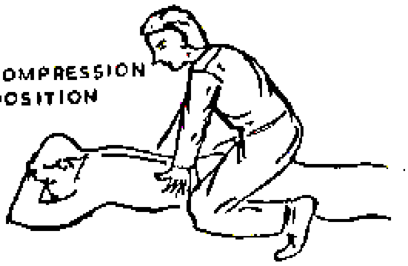
No time should be wasted in trying to remove water from the respiratory passages. All that is needed to be done is this.

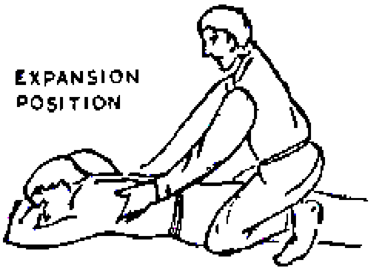


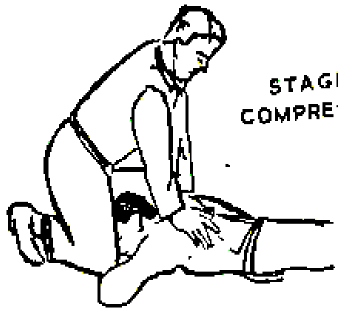
SCHAFER'S METHOD OF ARTIFICIAL RESPIRATION

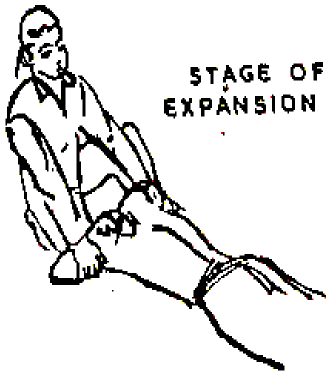


HOLGER NIELSEN METHOD OF ARTIFICIAL RESPIRATION

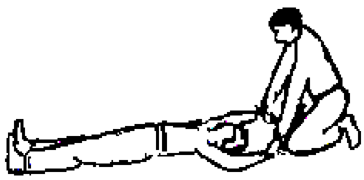






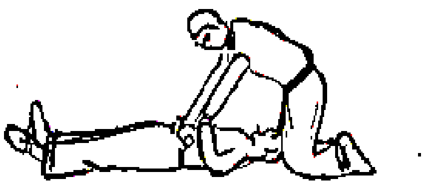


SILVESTER'S METHOD OF ARTIFICIAL RESPIRATION



EXPANSION PHASE

NOTE—FOR SAKE OF CLARITY OF THE SKETCH THE ASSISTANT HOLDING THE TONGUE HAS BEEN OMITTED



COMPRESSION PHASE

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CHAPTER 41

BURNS AND SCALDS

(Their causes, effect & treatment)

1. **Object**:

It is cruel truth that many lives are lost due to incorrect first-aid, in cases of burns, than due to delayed first-aid. The apparent simplicity of the injury has, in the past led to its dangers being under rated. With the recent experiments carried out in all aspect of burns, there has been radical change in the treatment and in the first-aid of burns. But it is difficult to shake-off older and popular belief suddenly as therefore, in the modern first-aid of burns there are more "don'ts " than "do's". It is, therefore, absolutely essential that first-aid par ties, fire-fighting parties and all others concerned with emergency relief work become thoroughly familiar with the modern method of first-aid of burns.

2. **Causes and effects of burns**:

(i) **Causes of burns**: These may be summarised thus:

(a) Dry heat such as fire, hot or molten metal, flash or ignited petrol etc.
(b) Electricity or lightning.
(c) Corrosive chemicals e.g., strong acids or alkalis.

(ii) **Causes of scalds:**

(a) Boiling water.
(b) Steam.
(c) Boiling oil e.g., used in cooking.
(d) Hot tar etc.

(iii) **Effects of burns:**

(a) Shock due to reduction in circulatory blood volume as explained in para 3 below.

(b) Sepsis, due to the fact that burn is a type of wound having a very large open surface.

(c) Scarring follows upon the sepsis and may lead to disfigurement, disability and economic loss.

(d) Death. If due to shock it usually takes place within 48 hours and if due to toxaemia, usually after one week.

3. **How burns cause severe shock**:

That the majority of deaths in burns are caused by shock due to reduction in circulatory volume, has been realised only recently. This recognition has changed the first-aid. hospital treatment radically. The mechanism of shock in cases of burns is explained thus:

(i) When the skin is burnt smaller blood vessels and the capillaries of the skin dilate in calibre and their walls become permeable i.e., leaky. Through these walls, the fluid part of the blood. called plasma escapes. It carries with it some salts, glucose and proteins etc. This plasma is of pale-yellow colour and is lost in three different ways.

(a) Out on the surface of burns.

(b) Between the skin layers giving rise to blisters.

(c) Diffuse in the deeper layers of skin, giving rise to swelling of the limb etc.

(ii) This loss of plasma results in thickening of blood as well as in reduction of total circulatory blood volume of the body. (The red cells of the blood are only partly lost). The cause of shock, therefore, is this reduction in blood volume and the prevention of shock. therefore, is possible if the volume is made up by replacing the fluids. The ideal fluid to replace plasma would be plasma itself but in its absence other fluids such as sugar solution and water containing some common salt and Bicarbonate of soda also serve the purpose in an emergency. This, "fluid replacement therapy" is the basis of the modern method of first-aid as well as, hospital treatment for burns.

(iii) Response to first-aid and allotment of priorities: Although the depth of burns will depend upon the degree of heat and length of exposure, the more important factor concerning the survival chances is the area of exposure. This is so because the loss of plasma and the extent of pain. factors which lead to shock, increase proportionately with the surface area of the human body. It has been found by experience that burns involving more than 20% surface in adults and 15% surface in children require vigorous and urgent hospital treatment such as plasma or blood transfusion. As the percentage of body surface involved increases the case becomes more and more serious, until with more than 70% of body surface involved the cases become topless usually ending fatally. The first aider must therefore, allot higher priority for evacuation to hospital for all cases having burns affecting 20% to 70% of their body surfaces. To help first-aider to calculate roughly but quickly, the per centage of body surface involved. a diagram of "rule of 9" is given.

4. **First Aid of Burns:**

(i) Cover immediately the burnt surface with a clean or sterile dry sheet of cloth or towel extending well beyond the edges of burns and bandage lightly. This will reduce surface infection to a minimum.

(ii) **Give fluids, by mouth in sips or by teaspoons:**

(a) Anti-shock solution, made by adding one teaspoonful of bicarbonate of soda, two teaspoonfuls of common salt to 4 pints of water. Up to a pint can be given in one hour.

(b) After the above has been given or in the absence of above. give hot, sweet tea.

(c) In absence of both, even plain water given in sips will do. You may add some sugar or gur to it.

(d) But do not give any fluid by mouth if the casualty is unconscious.

(iii) Immobilize the burnt limb to a splint. This gives rest to the part and reduces pain and loss of plasma.

(iv) Raise the burnt and splinted limb. The gravity effect will further help in reducing loss of plasma from the burnt surface.

(v) At a later stage and if available, arrange for injection of Diazepam and Tetanus toxoid or another anti-biotic drug.

(vi) At a later stage and if available, arrange for injection of Diazepam and Tetanus toxoid or other anti-biotic drugs.

(vii) Ointments, greases, powders etc, should not be used in the emergency treatment of burns.

(viii) No attempt should be made to clean up the burnt surface. Fresh burns are relatively sterile and any attempt at cleaning by first-aider may lead to more dirt being added to it.

(ix) No attempt should, similarly be made to open the blisters. The procedure causes pain and may add to the infection and is above all unnecessary.

(x) Clothes sticking to the burnt area should not be pulled away but cut around the burn with a pair of scissors.

5. **First Aid of Special Types of Burns:**

(i) (a) **Chemical Burns**: If corrosive chemical comes in contact with the skin, first dab away (not wipe) the chemical and then wash out with plenty of water. Apply suitable antidote and cover with a sterile dressing and treat as for an ordinary burn. If the chemical is an acid, a mild alkali such as powdered soda-bicarb is the antidote and if the chemical is an alkali, boric acid powder or vinegar is the antidote. If the burns are caused by phosphorus, cover the burns with moist dressing after thoroughly washing away the phosphorus. Keep the dressing wet until suitable medical help is available. On no account should oils, greasy dressing or tannic acid jelly, triple dye or brilliant green be used in phosphorus burns until every trace of phosphorus has disappeared from the tissue.

(b) **Chemical Burn of the Eye**: If an accidently lime, cement or battery acid splashes into the eye, it should be washed immediately with copious water. Make the patient lie down and pour clean water into the inner corner of the eye in a continuous stream, letting it run over the eye ball and out through the other corner. Milk is ideal for eye wash when alkalies like lime, caustic soda etc. are splashed into the eye. Then put some castor of drops into the eye and cover it with a sterile dressing pad. The patient should be sent to a doctor for further treatment.

(ii) **Burns of the Face**: Burns of the face need quick treatment.

(a) Take a triangular bandage or a place of clean cloth and cut site for eyes and mouth.

(b) Smear a me Vaseline around eyes and mouth.

(c) Apply the bandage dry and the ends off at the back of the head.

(d) The patient should be sent at once to the hospital.

(iii) **Electric contact Burns**:

These are usually painless and deep. They appear shallow and unimportant but take long time to heal. First aid treatment for these burns will be same as for burns in general. In most of these cases, the first problem could be resuscitation from asphyxia caused by electrocuting. Artificial respiration should be applied immediately.

DO'S AND DONT'S IN BURNS

(a) Do cover immediately the burnt surface with a clean piece of sheet or towel and bandage it.

(b) Do give fluids by mouth. Any fluid will do but preferably give anti-shock solution or sweet tea.

(c) Do immobilize the limb with a well-padded splint

(d) Do raise the limb to diminish oozing of plasma.

(e) Do keep the casualty warm, without making him sweat

(f) Do treat burns over 20% body surface as very urgent cases.

DONT'S

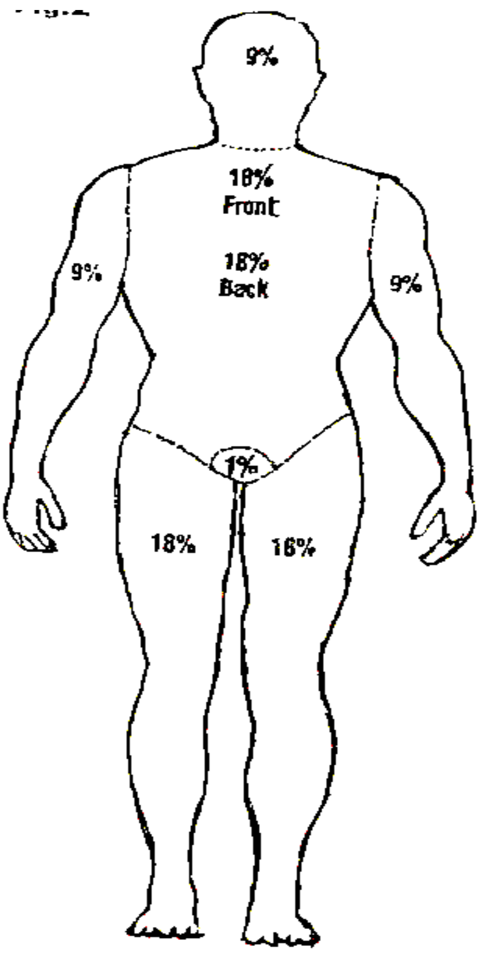
(a) Don't pull cloth sticking to burnt area but cut it around.

(b) Don't open blisters. This is not only painful and may add to infection but is an absolutely unnecessary procedure.

(c) Don't attempt to clean the burnt area. All fresh burns are usually relatively germ free.

(d) Don't apply greasy ointments or powders. The doctor at the hospital will have to waste time in removing it.

METHOD OF CALCULATING BODY SURFACE RULE OF NINE



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CHAPTER 42

ELEMENTS OF BANDAGING

(Use of Triangular and Roller Bandages)

1. **Introduction**:

It is an amazing fact that a piece of cloth such as a bandage. properly utilised can save a life in emergencies such as severe bleeding from limbs or snakebites. The proper utilisation of these pieces of cloth called bandages, however, needs some training mostly practical. It is, therefore, essential that the volunteers of first-aid parties as well as other services learn all about these bandages.

2. Uses of Bandages: Bandages are used for various purposes. These can be summarised thus:

(i) to control bleeding.

(ii) to control swelling as due to contused injuries.

(iii) to keep an injured limb at rest and support its weight e.g., by a sling.

(iv) to secure a limb to a splint e.g., in cases of fractures. burns or lacerated wounds.

(v) to hold dressings in place.

(vi) to give support and rest to a joint which is sprained.

(vii) to protect wounded parts of the body from exposure.

3. **Types of bandages**:

There are many types of bandages in use but the most common types, especially useful in large scale emergency work are the triangular and the roller ones.

(a**) The triangular bandages**:

(i) **Peculiarities of the triangular bandage**:

(a) It is easy to apply.

(b) It holds temporary dressings better compared to roller bandage.

(c) It can be used for almost every purpose for which a bandage is needed.

(d) It can be improvised out of any suit able material.

(ii) **Parts of a triangular bandage (See sketches):** The bandage has an apex or point, a base or longest side and two sides of equal length (100 cms) and two ends. It can be used as open or unfolded, broad-based or narrow folded. Each form is suitable for application for different purposes.

(iii**) Rules for applying triangular bandage:**

(a) The bandage must be reasonably clean and correctly folded as per the requirement e.g., narrow, broad etc.

(b) The injured part or limb must not be disturbed or moved to any great extent for purposes of bandaging.

(c) Once the bandage is fixed its position should not be changed by pulling or pushing it.

(iv) **Triangular bandage as a sling (See sketches):**

The large arm sling: This is applied in the following manner:

(a) Stand in front of the patient.

(b) Apply the open triangular bandage to the front of the chest, with apex towards the injured arm.

(c) Place the upper end of the bandage over the other shoulder with the other end hanging down towards the ground.

(d) Carry the upper end round the back of the neck and forward over the shoulder of the injured side.

(e) Then bend the injured arm carefully at the elbow and place the forearm across the chest with the hand pointed towards opposite shoulder.

(f) Lower end of the bandage can now be brought over the forearm and tied to the upper end, in front of the shoulder on the injured side just below the collar bone.

(g) The apex is then folded towards the elbow and fixed with a safety pin.

The small arm siling: This is applied in a way similar to above but in this case the bandage is used in its broad fold and no safety pin is used anywhere.

(v) **Other uses of open triangular band age:**

(a) **On the head**: This is used to keep a dressing in place on the scalp or forehead, particularly when the dressing is large or there are several wounds.

(b) **For hand or feet**: This bandage is particularly useful when the injury is extensive and the dressing is of considerable size as in a case of extensive burns.

(c) **For chest or back**: This bandage is used to hold dressing on burns or wounds of the chest or back. Place the point of bandage over the shoulder on the injured side, carry the bandage down over the chest or back so that the middle of the base is directly, below the shoulder. Roll or fold the base as far up as you desire. Carry the ends around the body and tie them directly below the shoulder with a square knot. This leaves one long and one short end. Carry the long end up to the shoulder and tie to the point.

(d) **For shoulder or hip or face**: The open triangular bandage can also be used for holding dressing over shoulder or hips. Further, in case of burns of the face, the triangular bandage can be used to cover the entire face, after cutting two holes for eyes.

(vi) **Triangular bandages as a broad fold**: This can be used for various purposes, such as tying the splints and over dressings on the following parts of the body:

(a) Head and ear.

(b) Neck

(c) Arm, forearm, thigh or leg.

(d) Cheek or ear.

(e) Elbow or knee.

(vii) **Triangular bandage as a narrow fold**:

As "Narrow fold" is made by folding the broad fold to half its breadth, it increases in thickness proportionately and also becomes quite strong for these reasons, it can be most conveniently used for following purposes:

(a) Keeping dressings in place over small areas over the limbs.

(b) Applying pressure to wounds for purpose of stopping bleeding.

(c) For holding the standard wooden or improvised splints in place.

(d) For padding splints at places where they are likely to cause pressure.

(b) **The roller bandage:**

(1) **Material used**:

(a) Cotton.

(b) Unbleached calico.

(c) Gauze

(d) Flannel

(e) Muslin.

(f) Adhesive plaster.

(ii) **Parts of a bandage:**

(a) Head or roller part.

(b) Tail or "free end"

(iii) Varieties of bandaging procedures:

(a) Simple spiral for wrist and ankle.

(b) Reversed spiral for fleshy parts.

(c) Figure of eight for joints.

(d) Spica for hip, shoulder and thumb.

(iv) Width and lengths of Roller Bandage commonly used.

Parts to be bandaged	Width in Inches/Cms.	Length In yards/ Metres
Finger	1/ 2.5	2/ 1.8
Arm	2-2 ½ (5-6)	4-6 /(3.5-5.25)
Leg	3-3 ½ (7-8)	6-8 (5.25-7.0)
Body (Trunk)	4-6/(10-15)	8/7
Head	2-2 ½ /(5-6)	6/5.25

(v) **Rules for bandaging with a roller bandage:**

(a) Bandage limbs from below upwards and from within outwards over their fronts and in position in which they are to remain.

(b) The bandage should be first securely fixed by couple of turns round the limbs.

(c) Each turn should over-lap 2/3rd the ending turn, margins to be kept parallels.

(d) Bandage the chest from below upwards and abdomen from above downwards.

(e) Bandage evenly and firmly but not, with such pressure as to interfere with the circulation. Do not cover tips of fingers or toes, as their appearance helps to judge state of circulation in the limb.

(f) The joints are not to be bent after bandaging. Therefore, bandage the knee in straight or slightly bent position and elbow at right angles.

(g) The end must be secured with a safety pin or with a stitch. The latter method is especially useful in case of children.

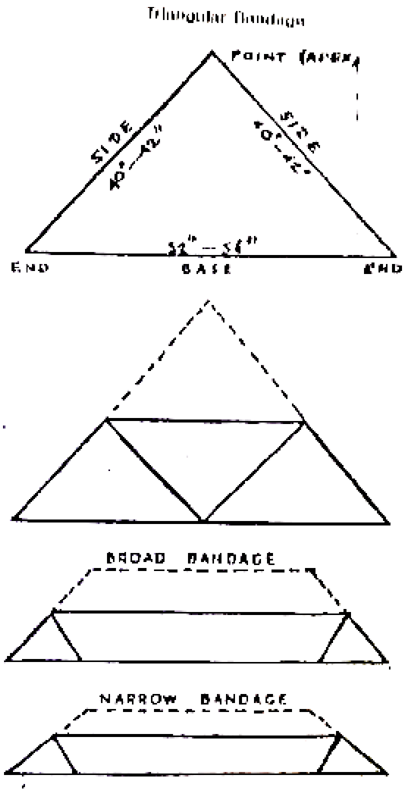
Table showing the kinds of Roller Bandage to be applied to different parts:

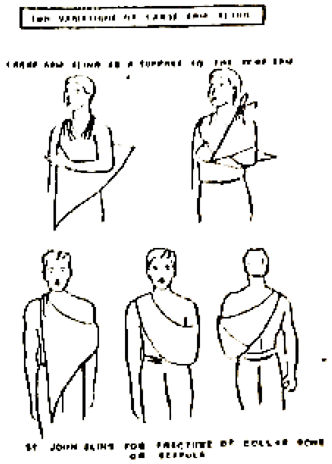
Sr. No.	Parts to be bandaged	Kind of Bandage	Object of Bandage
1.	Head	Capelin	To retain dressings. To exert pressure on a pad placed over a bleeding wound.
2.	Chest	Spiral	To give support, exert pressure. dressings. or retain dressing.
3.	Breast	Spiral	To give support.
4.	Abdomen	Spiral	To give support, exert pressure, or retain dressings.
5.	Thumb	Spica	For sprain of the thumb. or to arrest haemorrhage from the part
6.	Fingers	Spiral known as the continuous finger bandage.	To retain dressings. especially in case of burns or scalds.
7.	Hand	Figure of 8	To retain dressings, fix splints etc.
8.	Wrist	Spiral	do
9.	Fore-arm	Reverse Spiral	do
10.	Elbow: (a) To cover the point	Divergent Spica	To keep the forearm bent, as in fracture or in injuries about the elbow joint.
	(b) To leave the point uncovered.	Figure of 8	To retain dressings or to exert pressure.
11.	Upper Arm: (a) For the Spiral lower part.	Spiral	To retain dressings, fix splints etc.
	(b) For the upper part Spiral	Reverse Spiral	-do-
12.	Shoulder	Spica	To retain dressings or to exert pressure.
13.	Great Toe	Figure of 8	For sprains or haemorrhage from the part
14.	Foot	Figure of 8 followed by the spiral & the Reverse Spiral	To retain dressing or exert pressure or fix splints.
15.	Heel: (a) To cover the point.	Divergent Spica	To retain dressing or exert pressure or fix splints.
	(b) To leave the point uncovered.	Figure of 8	-do-
16.	Ankle	Spiral	-do-

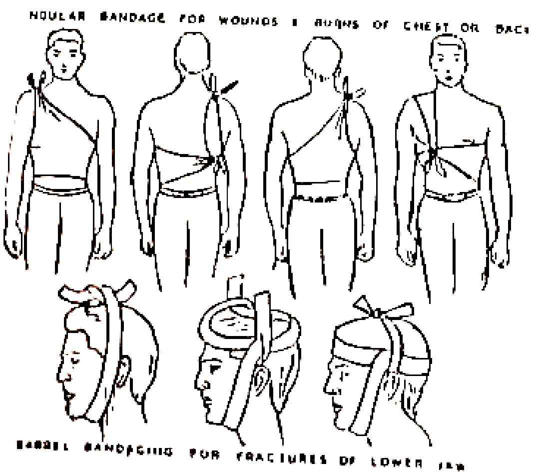
17.	Leg	Reverse Spiral	-do-
18.	Knee:		
	(a) To cover it.	Divergent Spica	To give support to the joint.
	(b) To leave the point uncovered	Figure of 8	To retain dressings.
19.	Thigh	Reverse Spiral	To retain dressings. or to exert pressure.
20.	Groin	Spica	To retain dressings. or to exert pressure.

BANDAGES ARE USED FOR FOLLOWING PURPOSES

1. To keep an injured part at rest and to support its weight e.g. by means of a sling.
2. To secure a limb to a splint, to the trunk. or to its fellow.
3. To control bleeding or swelling by making and maintaining firm pressure.
4. To keep dressings in place.
5. To protect wounded parts from exposure.


Triangular Bandage
POINT (APEX)
SIDE
40"–42"
SIDE
40"–42"
52"–56"
END
BASE
END
BROAD BANDAGE
NARROW BANDAGE


ST JOHN SLING FOR FRACTURE OF COLLAR BONE OR SCAPULA


NODULAR BANDAGE FOR WOUNDS & BURNS OF CHEST OR BACK
BARREL BANDAGING FOR FRACTURES OF LOWER JAW

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CHAPTER 43

CO-ORDINATION WITH OTHER CIVIL DEFENCE SERVICES

The Fire Fighting Service being an essential and important service of Civil Defence, it is imperative that the activities of this service should be well co-ordinated with that of the other Civil Defence Services. Taking into con sideration that the Fire Fighting Service of Civil Defence is divided into two groups viz. (a) House Fire Party, and (b) Auxiliary Fire Service. the co-ordination of the above two has specific areas of responsibility and hence needs to be clarified.

House Fire Party-The House Fire Party is an extension of the Warden Service and in view of the fact that the Warden Service is the most integrated service amongst all the other ser vices and has a major role in fulfilment of Civil Defence aims and objectives. The House Fire Party also gets linked with the other services through the Warden Service.

Auxiliary Fire Service. As regards the Auxiliary Fire Service the role play of this service is firstly linking up of this service with that of the Fire Services of the city since the basic aim of this service is to act as an auxiliary to the Fire Services. As a part of Fire Service. their co-ordination with Wardens. Communication. First Aid through the Incident Control Officer at the scene of incident is of major importance in fulfilment of Civil Defence aims and objectives. The work output of this service will indirectly have a bearing on the output of services like Rescue, Salvage and Welfare. The Auxiliary Fire Service being manned by the Home Guards opens up the role for co-ordination between the Home Guards and the Training Service of Civil Defence without which efficient Fire Fighting operations by the Home Guards personnel will be not possible. smooth functioning is that of Civil Defence since it happens to be one of the 12 Services of Civil Defence Organisation.

Training Courses (Fire Fighting Service) As in case of all Civil Defence Volunteers, the volunteers of Fire Service also have to undergo a basic Civil Defence Course at local level (town) to get the necessary exposure to Civil Defence.

Such volunteers who have undergone such courses are selected to undergo the Basic Fire Fighting Course of 30 periods of 45 minutes each at the local level. Selected volunteers out of these are sent to State Central Training Institutes (C.T.I.) to undergo a 84 periods Advanced Course of 45 minutes each

Few of the volunteers belonging to Fire Fighting Service are selected by the State Directorates and sent to National Civil Defence College, Nagpur to undergo 30 days course of 8 periods a day to become proficient members of the Auxiliary Fire Service.

The interaction of Fire Fighting Service with that of First Aid and Ambulance at the scene of incident has a direct bearing on the Civil Defence operations and morale of the citizens of that area. Hence, co-ordinated activity within these three services is of paramount importance.

The Auxiliary Fire Service even though manned by the Home Guards and works under the Fire Services, the co-ordination to ensure.

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CHAPTER 44

LEADERSHIP

1. Who is an Officer?

An Officer is basically a person in charge of a group of subordinates or in other words a per son who directed the work of others.

2. What makes an Officer successful?

(a) Sound knowledge of work.

(b) Sound knowledge of responsibility.

(c) Skill in leading his team.

(d) Skill in improving methods.

(e) Skill in instructing.

(f) Cooperativeness and a knock to get along with others.

3. What is expected of an Officer?

(i) **As an Organiser:** He must plan and organise his work efficiently with a view to obtain the required results, giving due con sideration to the safety and welfare of his subordinates. He must, therefore be familiar with the principles and methods of Man Management and should know how to analyse jobs and pre plan his line of action.

(ii) **As a Mobile Experts**: He must make sure that the work is done, advice his subordinates and correct their mistakes. To do this effectively, he must possess a thorough knowledge of his own work.

(iii) **As a Leader:** He must give orders. guidance and instructions clearly and precisely. He must promote team work in his own section and see that working relations are good. He must possess a keen sense of responsibility. He must to able to understand and lead his subordinates, which calls not only for innate ability, but also for the development of such ability to suitable training.

(iv) **As an instructor**: He must train his sub ordinates do the job. He must consequently know and apply the fundamental principles of training.

4. **Duties of an Officers**

There is a great deal for Officers to learn concerning the care and management of their men. There are several things that any Home Guard dislikes intensely, and a little though and the gaining of knowledge and experience will prove that the reasons for those dislikes are well founded. In avoidance of such causes for dissatisfaction is a contended Unit created.

Several common faults found in Officers are a grievous sign of inexperience and a cause of much annoyance to the men, since it is desired that Officers should become very good officers as soon as possible, they should guard against the following items. Neglect of the first four will cause them to become very unpopular, since it would be evidence of a serious lack of thoroughness and common sense. The last item is only what every Officer Commanding has the right to expect.

The care of men under all circumstances whether they are temporarily or permanently under your care, is your first and last consideration. Any dereliction in that regard will cause justifiable annoyance and unrest.

"I am not quite certain whether this man comes under (b) or (g) and I think I ought to have advice about him. I do not want it to be thought that I have him marked. Who can give me the most reasonable advice in the circumstances? My own Sergeant? The C.S.M.? The Coy. Commander or the Second-in Command? Am I fully justified in having a quiet talk with an old Home Guard"?

"I am parading this man (g) whether my O.C. likes it or not, and I want him properly dealt with. He has had three warning over the same offence (or similar ones) and if he is not dealt with, the platoon discipline will suffer".

These are the lines that any and every officer must work on. Try to aim the whole time for paragraphs 37 to 40 of the "Personal Points for All Leaders" and you will not be far wrong. provided you possess the basic qualities of a good officer. If you have not these qualities you cannot blame your O.C. for asking that he be relieved of you.

5. **Man Master ship**

The worst fault of an officer is to embark on any form of training unless he has studied beforehand exactly what he intends to do, and the lessons he intends to teach. In attention, slackness, weariness of mind and body are usually not the result of overwork on the part of the men, but may be treacle to lack of foresight, imagination, energy or common sense in those in commend.

Good officers can keep men fully employed and interested in instructional work for four and a half hours a day at the maximum and they can do this only by working over eight hours a day themselves.

An Officer who cannot instruct his men by reason of his laziness or lack of interest cannot be expected to achieve any efficiency in his Unit. The following are some of the qualities that contribute to the making of a good officer:

(i)Loyalty

(ii) Honour

(iii) Truthfulness

(iv) Patience and Perseverance

(v) Tact

(vi) Firmness

(vii) Justice

(viii) Intelligence

(ix) Judgement

(x) Job knowledge

(xi) Self control

(xii) Sense of humour

(xiii) Zeal

(xiv) Power of Command

(xv) Initiative

(xvi) Sense of discipline

(xvii) Courage-both moral and physical

(xviii) Sense of duty.

(xix) Self-confidence.

Rules are hard to lay down, for so much depends on the character of the individual Officer, on the individual men and on the many changing conditions, from dead clam to howling gale.

When you look over the notes on "Man Management" and the "Personal Points for all Leaders" you will realise that:

(a) A platoon Commander who is always parading his men to his Company Comman der gets it in the neck for sheltering behind Regulations and having no power of com mand, and

(b) A Platoon Commander who seldom parades his men to the Coy, Comdr., but who has an obviously inefficient platoon, also gets it in the neck for having no power of Command.

An Officer Commanding must possess the basic qualities of a Court Judge. It is a part of a junior officers training to endeavour to reach that standard. Not only must be he neither unjust nor weak, but he must develop common sense and knowledge of psychology. Experience with Home Guards will show that a sense of humour is essential.

Therefore, any Platoon Commander always keeping in mind that his men are neither universal trainees nor regular soldiers, but of a totally different type of voluntary force, should watch for the main cases as under. Each case will need different handling. For examples:

(a) The innocent who fouls a by law.

(b) The pseudo innocent who is obviously bluffing.

(c) The good man restless under control whom punishment will embitter.

(d) The jester who needs a quiet hint on over-stopping the mark to the border of insubordination.

(e) The bumptious or over confident man who requires bringing up with a round turn.

(f) Those who can be classed as the ignorant. the dope, the lazy, the scapegoat, the accidental misbehave to. for whom the full punishment allowed by regulations would be obviously unfair.

g) Those who may safely be classed as shyster, liar, slacker or general trouble maker, for whom full punishment is an obvious necessity. The true trouble shooter usually falls in this category.

(h) The natural coward, usually a bully out of the line and a grovelling menace in it. He is rare, but you will meet such cases and should know how to deal with them.

Learn generally to appreciate circumstances such as these:

(i) "If I let (b) off with a caution, what effect will it have on the platoon". in Certain cases, it may be advisable to explain an act of clemency to your unit with a final injunction "Heaven help the next."

"If I let (b) off, shall I get him know I was being bluffed? shall I let him know by direct or indirect methods? Shall I keep quiet and wait till he appears next time?"

(ii) Do not cause inconvenience to your men unnecessarily. Think ahead and be clear in all your own plans and decisions. Good planning is the essence of success in any field.

(iii) Do not keep your men in the sun or exposed to sun and rain when they can easily be in shade or shelter.

(iv) Do not leave men too long at "Kandhe Shastra" (Slope), at "Savadhan" (Attention), or at the stand at ease. No matter what duty you are on, make a clear distinction between "Vishram" (stand at ease) and "Aaram Se" (Stand easy). Also do not overstrain the men whilst conducting Drills, know their physical capacity and do not drive them beyond their limits.

(v) Do not slack up at any time in keeping your men keyed upto their drill. These things will soon become automatic if you keep quietly at them. Realise that it saves hours of parade ground work. Do not however make the fatal mistake of nagging continuously at your men, or you will find lying back in the traces.

Over Punctuality

Being on parade a long way ahead of time is definitely not a sign of keenness and emphatically does not impress seniors or juniors. To any Home Guard it is just as bad a fault as unpunctuality. It is a sign of bad training when men have their such needed leisure time actually wasted.

Selfishness

You may not mean to be selfish, but nothing creates dissension more quickly in a unit than act of "putting one across" another Unit. It is foolish, for the sake of momentary win, to create a feud that will last for months. Help rather than hinder each other it will pay in the long run.

Legitimate grievances are easily adjusted within the Area or within the Zone. Many differences can very simply be settled by the toss of coin.

This does not mean, however, that you should not set out to make your unit the most efficient, keen, healthy rivalry is the finest incentive.

If all officers and N.C.O's play fair to each other one of the biggest obstacles to Unit contentment and one of the greatest enemies of efficiency, is conquered. Anyone who does not play the game must be classified as a misfit.

Punishments

All Officers must learn the extent of their various powers according to the "Home Guards Act" and other regulations. They must essentially also learn "what powers they do not possess".

The prevalence of offences in Zone or Unit is emphatically not a sign of efficiency. It affects the junior officers to an even greater degree than it does to the Officer Commanding, since they are in closer touch with the men.

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