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JOINTING CHAMBERS FOR UNDERGROUND ROUTES

CONTENTS

INTRODUCTION

Before describing in detail some of the various types of jointing chambers it is worth considering why jointing chambers exist at all, as a knowledge of this, and of the factors to be born in mind when designing a jointing chamber, gives one a better appreciation of why they exist in the form that they do. Fundamentally, jointing chambers are necessary because joints have to be made in underground cables. These joints are made for a number of reasons some of which are:-

(i) The maximum length of cable that can be wound onto a cable drum of reasonable size is usually much less than the length of the cable route.

(ii) The longer the length of cable to be drawn into a duct the more difficult it becomes to rod the duct and draw the cable in.

(iii) Large cables have to be divided into two or more smaller cables in the distribution of pairs from the exchange to the subscribers and in the provision of spurs in junction routes.

(iv) In loaded cables loading coils have to be inserted at intervals along the cable.

As joints in an underground cable are necessary, provision must be made in the underground route to accommodate them. Facilities must also be provided for the associated operations of drawing in the cables, making the joints, maintaining the joints throughout the life of the cable, and so on. These requirements can be met by the provision of jointing chambers.

An underground cable route may consist of anything from a single cable buried directly in the ground to a large number of cables in multiway ducts or even in a cable tunnel and hence the facilities required of a jointing chamber vary from jointing point to jointing point. It would be unnecessary, uneconomic and impracticable to always provide a jointing chamber suitable for the largest routes on a smaller route where something simpler would do and therefore a number of different types of standard jointing chambers have been designed. These jointing chambers satisfy the needs of the majority of jointing points and may be divided into three groups, couplings, joint boxes and manholes.

COUPLINGS are the simplest and cheapest form of jointing chamber. They are used on singleway duct routes where they form an openable enlargement of the duct and are sometimes used to protect the joints of cables buried directly in the ground. Couplings are completely buried in the ground and therefore are only used under grass verges and cheap paving where the cost of reinstatement is low. If it is anticipated that access to the joint will be required fairly often or if the joint is under expensive paving then some other type of jointing chamber must be used.

JOINT BOXES are larger than couplings and are used on one, two, three or four-way duct routes. Some joint boxes have a simple cover and are completely buried while others have covers that are flush with the surface of the footway or carriageway. The two type are called buried joint boxes and surface entry joint boxes respectively. Buried joint boxes are only used in grass verges and under cheap paving and then only when it is anticipated that the box will not have to be opened frequently.

MANHOLES are provided when none of the joint boxes provide adequate facilities. They are much larger than joint boxes, the jointer working inside the manhole in contrast with a joint box where he would work sitting on the edge. Manholes are in effect an underground room beneath the footway or carriageway and are usually built in reinforced concrete although sometimes it is more convenient to build the walls of brick.

JOINTING CHAMBER DESIGN

As the function of a jointing chamber is to provide facilities for making, accommodating and maintaining joints in underground cables, their design is governed by the need to provide these facilities, by practical considerations and by economics. These factors are interdependent and in deciding the shape and size of a manhole or the materials from which it is to be constructed all three factors must be taken into account. This section, by discussing size, shape, jointing chamber fittings, and so on, shows how the design is influenced by the three main considerations.

Before proceeding with these design details however, one generalization on the economics of jointing chambers can be made. Generally the cost of a jointing chamber is considered over its expected life. Savings in initial costs are only justified if it is anticipated that they will not be outweighed by increased maintenance costs during the life of the chamber.

SIZE

For several reasons small jointing chambers are cheaper than large ones; they require less materials, the size of the hole to be excavated is smaller, if the chambers are very small they can be prefabricated or assembled from prefabricated parts, and so on. In deciding on the size of a jointing chamber therefore it is often a case of finding the minimum size that will provide all the required facilities. A rough guide is given by the number of duct ways in the route but the size depends on the number and type of cables entering the chamber rather than the duct ways.

The cables effect the size of the chamber in the following ways:-

(i) The greater the number of cables entering the chamber the larger the chamber must be.

(ii) The larger the cables the greater the amount of space they and their joints occupy.

(iii) The larger the cables the greater the space required for jointing and maintaining them.

(iv) The larger the cables the less acutely the cables can be bent in drawing the cables in and in leading them from the duct to their jointing and final positions. The minimum radius to which a cable may be bent also depends on the type of cable. For example, coaxial cables can be bent less acutely than paper cored multipair cables of the same size.

In addition to these cable requirements, space must also be provided for the jointer and for loading coil cases if they are required.

SHAPE

The best shape for a jointing chamber from a point of strength and economy of materials is spherical but this shape is very unsuitable for accommodating joints and is also difficult to construct. The next best shape is tubular but this shape is also difficult to construct on site and is therefore only used on some types of couplings. A jointing chamber with straight, vertical walls and a flat roof and floor is comparatively easy to construct however and the straight walls are very suitable places for accommodating the cables and joints. Most jointing

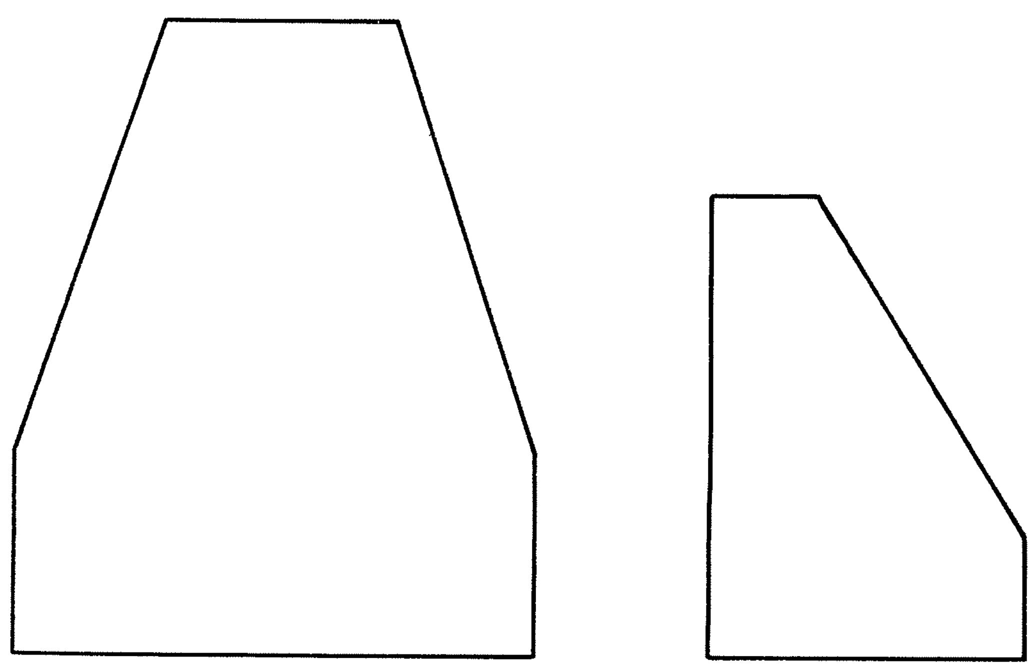

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Fig. 1

chambers are made in this form therefore. They are generally rectangular in plan but sometimes, when there are duct routes entering a manhole at right angles to one another, one or two of the corners are cut off to form a manhole that is roughly triangular in plan as shown in Fig. 1. This reduces the size of the roof and consequently the loads imposed on the roof and walls, and also reduces the size of the hole to be excavated yet still allows the cables to be lead in large radius curves from duct entry to duct entry.

ENTRY

In order to work on the cables in jointing chambers access to them must be provided. This is obtained in different ways for couplings, joint boxes and manholes.

Couplings are first uncovered by digging and then the top half is removed to expose the cable.

Joint boxes have covers which form the whole or nearby the whole of the roof of the chamber and on the removal of these, access to the cable is obtained. The covers of buried joint boxes must first be uncovered by digging.

Manholes have smaller covers than joint boxes. The jointer gains access to the cables by removing the cover and climbing down into the manhole via the entrance shaft.

JOINTING CHAMBER FITTINGS

Various fittings are provided in jointing chambers the commonest being, cable brackets and bearers, sumps, anchor irons, steps and ladders. Cable brackets and bearers are described in greater detail later in the pamphlet and only the need for them and the other fittings together with a brief description is given here.

Cable brackets and bearers

Underground cables in general and joints in them in particular must not be left unsupported. The joints in couplings can be left lying on the bottom of the coupling, but in joint boxes and manholes the cables are less liable to damage, and are easier to work on, if they are supported on brackets protruding from the walls. Sometimes the brackets are fitted to standards instead of the walls but this is avoided when possible.

Sumps

Joint boxes and manholes are relatively water tight but water often enters the ducts and drains into the jointing chambers. This water has to be removed before work on the cables can commence and to assist in this a sump is often fitted. The sump is a hole in the floor 9 inches square and 1 foot deep covered by a protective grating. A slope is given to the floor so that the water in the jointing chamber drains into the sump. The jointing chamber can then be drained by removing the sump grating, inserting a pump inlet into the sump hole and pumping the water out. Without the use of a sump the last inch or two of water would be very difficult to remove. For small joint boxes a difference in level in the floor of 1 in. gradually sloping from one end to the other, is arranged to replace the sump in larger boxes.

Anchor irons

When cables are drawn into ducts the pull on the rope at the drawing in end should be in line with the duct. Normally the winch is considerably higher than the duct mouth however and snatch blocks are used to change the direction of the rope. Anchor irons, which are rings embedded in the concrete floor of the jointing chamber, are provided for the attachment of these snatch blocks.

Manhole steps and ladders

To enable the jointer to enter a manhole steps are fitted in the entrance shaft. If the entrance is close to one wall these steps are continued to the floor but usually the entrance is near the centre of the manhole roof and a ladder has to be provided. A manhole step may also be fitted in the larger joint boxes.

FORCES ACTING ON JOINTING CHAMBERS

In designing joint boxes and manholes, consideration has to be given to the forces to which the structure will be subjected in order that the structure will be capable of withstanding them. These forces are discussed in detail in E.P. Draft Series LINES 2/3 and only an elementary treatment will be given in this pamphlet.

The forces acting on jointing chambers can be divided into two classes, dead loads and live loads.

Dead loads consist of the weights of the roof and walls themselves, the covers, the shaft if provided, the filling between the roof and the paving, the paving itself, the cables, the cable brackets and bearers, and loading coil cases. They also include the horizontal forces due to earth pressure and transmitted loads from the foundations of adjacent buildings.

Live loads consist of the loads imposed by traffic passing over or near the chamber and forces imposed during cabling operations.

The effect of these forces on the roof will be different to their effects on the walls and floor and it is better to consider the roof, end walls, side walls and floor seperately.

The Roof

The dead loads on the roof of a carriageway manhole at a normal depth below the surface are much smaller than the live loads and may for practical purposes be ignored.

The live loads can be divided into two types; those transmitted through the road structure and soil, and those transmitted directly through the manhole cover and frame. The former are distributed over a larger area of the roof than the area over which the load is distributed at the surface. The manner in which the area increases depends on a great many factors such as the moduli of elasticity of the roof and the materials covering it, the density of the soil, and so on. For practical purposes it is usual to assume that the stress spreads out at an angle of 45 degrees to the horizontal. Thus if a load was applied to an area three inches square on a road surface twelve inches above the roof of a manhole, it would be assumed to act on an area (3 + 12 + 12) inches square at the roof level.

The loads applied to the cover and frame however are only distributed over the area of the frame and are therefore applied as concentrated loads to the roof. To relieve the roof of this concentrated load, two reinforced concrete beams are usually cast into the roof to support the shaft and cover.

End Walls

The end walls are subjected to the following forces;

(a) The compressive force due to the weight of the roof and the forces transmitted by it.

(b) Distributed forces due to the earth pressure and traffic loads transmitted by the soil.

(c) Concentrated forces due to loads imposed on the anchor irons when cabling is in progress.

(b) and (c) produce bending stresses in the walls in the same direction but (c) is often in excess of (b).

Side Walls

The side walls are subject to the same loads as the end walls except for the loads due to the anchor irons. In place of these loads however, there are loads due to the weight of the cables and their brackets but these loads are relatively small compared with the other loads.

Floor

The floor has to support the weight of the walls and any vertical components of forces transmitted through them. These forces are concentrated around the edge of the floor and produce large shearing forces. The forces are distributed by the floor and resisted by the reaction of the soil on which it is laid.

TYPICAL COUPLINGS, JOINTING CHAMBERS AND FITTINGS

COUPLINGS

Couplings are usually made of cast iron or reinforced concrete. A selection of cast iron couplings is illustrated in Fig. 2. The types shown should be used with steel and cast iron ducts only.

Coupling (a) has a well in the lower half to accommodate cable joints. This enables rodding operations to be carried out without disturbing existing joints. The well has two holes on one side which provide outlets for subscribers' distribution cables if required, otherwise they are closed with steel plugs. Coupling (b) is a through coupling which is available in two sizes, the smaller for 3 and $4\frac{1}{4}$ inch ducts and the larger for 4 inch ducts. Coupling (c) is a branch coupling with a branch outlet for 3 or $3\frac{1}{4}$ inch ducts.

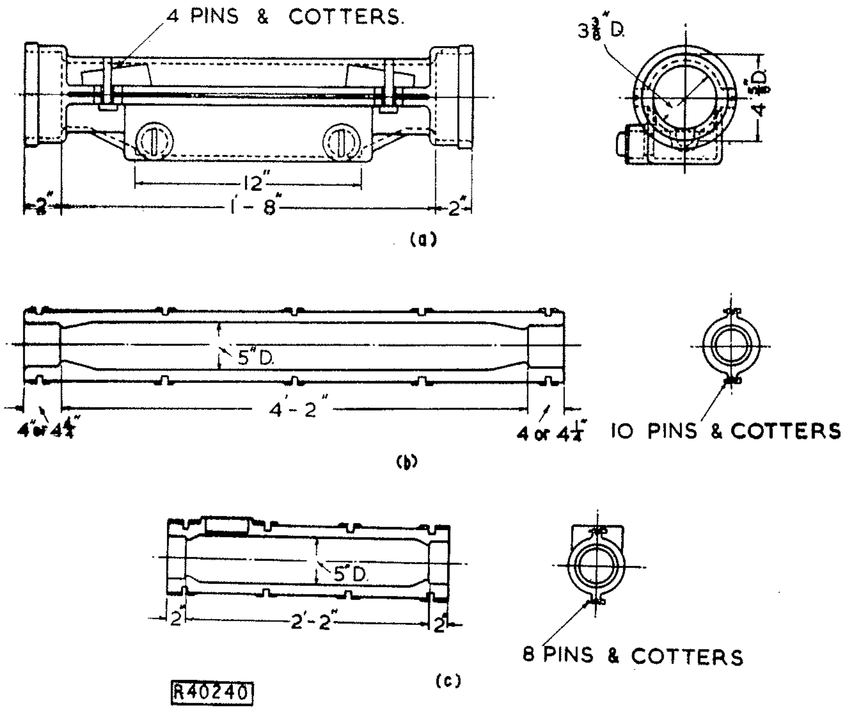

Fig. 2

Concrete couplings are used on self-aligning and asbestos-cement duct routes. The steel reinforcement in each half of each coupling is extended at each end to form handles. Two typical couplings are illustrated in Fig. 3.

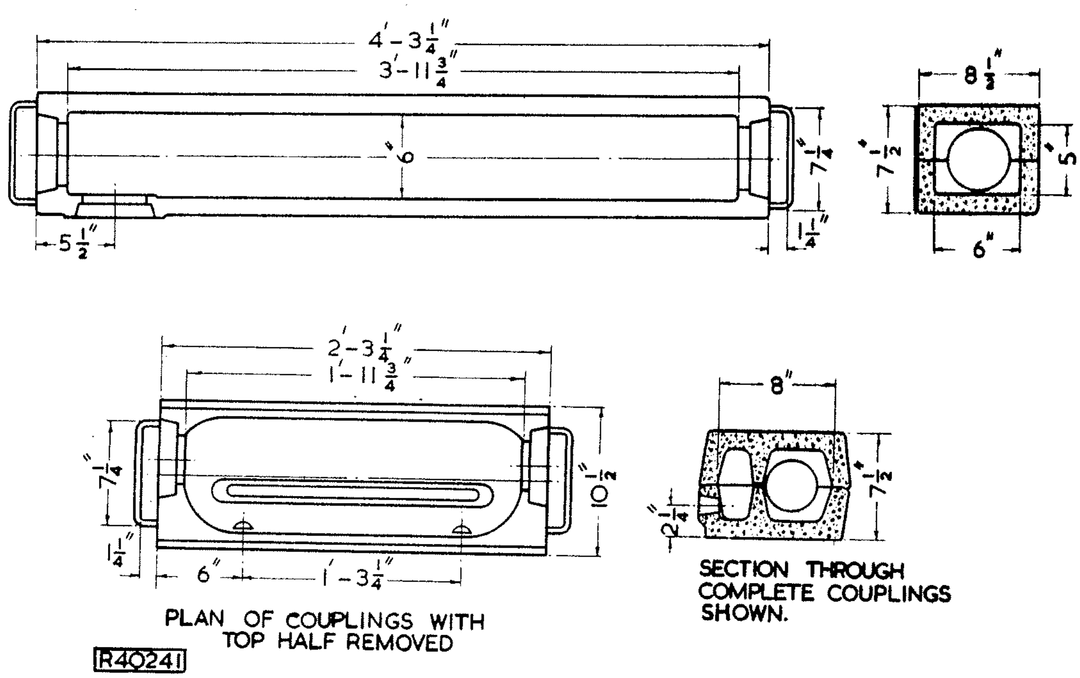

Fig. 3

Coupling (a) has a branch outlet to accommodate both types of duct up to $3\frac{5}{8}$ inch nominal bore, a similar type of coupling is available with an overall length of approximately 2 ft. 6 inches and a further branch coupling, approximately 4 ft. 6 inches long, has a branch outlet designed to accommodate 4 inch nominal bore ducts. Coupling (b) has a recess to accommodate joints and two small holes in one side of the lower half for distribution cables

All couplings should be laid on a firm, level bed of soil and the duct route should be laid to provide a spigot at either end of the coupling. In dry situations a duct with a good stanford lining may be left dry in the coupling socket, otherwise the spigot end should be coated with rubber bitumen emulsion compound and wrapped with pipe yarn. This ensures a fit that will exclude dirt from the interior of the coupling. In wet situations the lower halves of the coupling sockets and the lower portions of the duct spigots are coated with the rubber bitumen compound and the ducts are pressed home. Plastic sealing cement is rolled into pencil form and placed on the upper portion of the duct spigots and, where a concrete coupling is used, on the mating surface of the lower half of the coupling. The upper half of the coupling is then installed to form a watertight joint.

Unused branch outlets in concrete couplings should be sealed with the plug illustrated in Fig. 4.

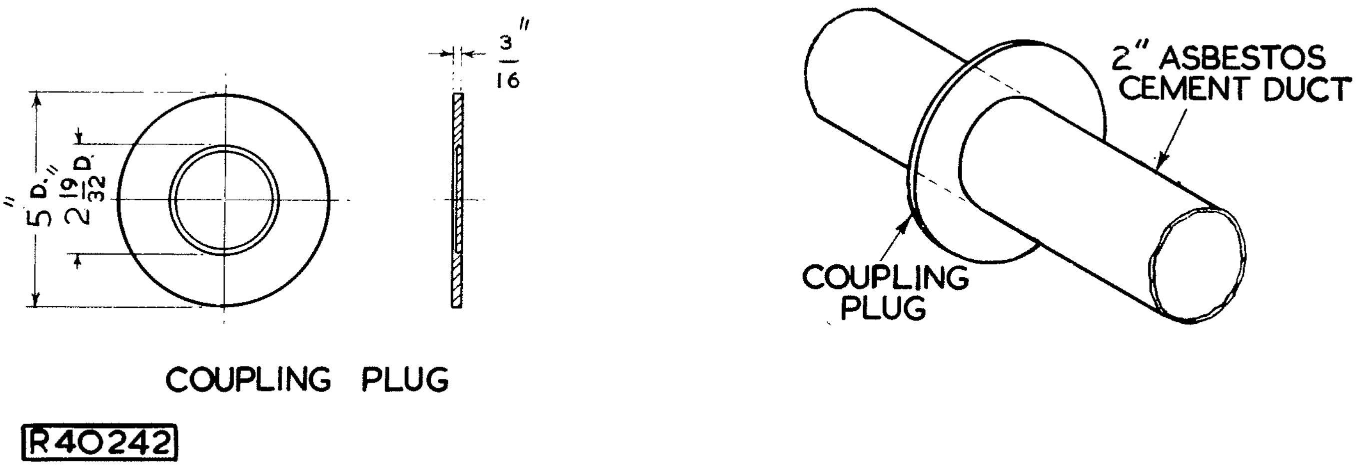

Fig. 4

This plug, with the centre disk removed, is also used to provide a sealed joint in concrete coupling on 2 inch asbestos cement duct routes. Fig. 4 illustrate the plug used in this manner. Unused branch outlets in cast-iron couplings may be closed with a cork or wood plug.

BURIED JOINT BOXES

Two sizes of buried joint boxes are in general use providing jointing chamber facilities for two and three-way duct routes respectively. Details of the construction of a buried joint box are given in Fig. 5, this illustrates the larger of the two boxes. All dimensions, excepting the height, apply to both boxes. The smaller box has an internal height of 11 inches. The boxes are installed to give a minimum depth of 1 foot 6 inches from ground level to the upper surface of the roof, the concrete base and ends being cast in situ. When this concrete has set the two sides and four slabs forming the roof, which are pre-cast in reinforced concrete, are fitted. The sides of the box are marked with a "T" on the surface nearest the tensile reinforcement, these surfaces form the inner walls of the box. The roof slabs are fitted with iron loops to form handles for lifting purposes.

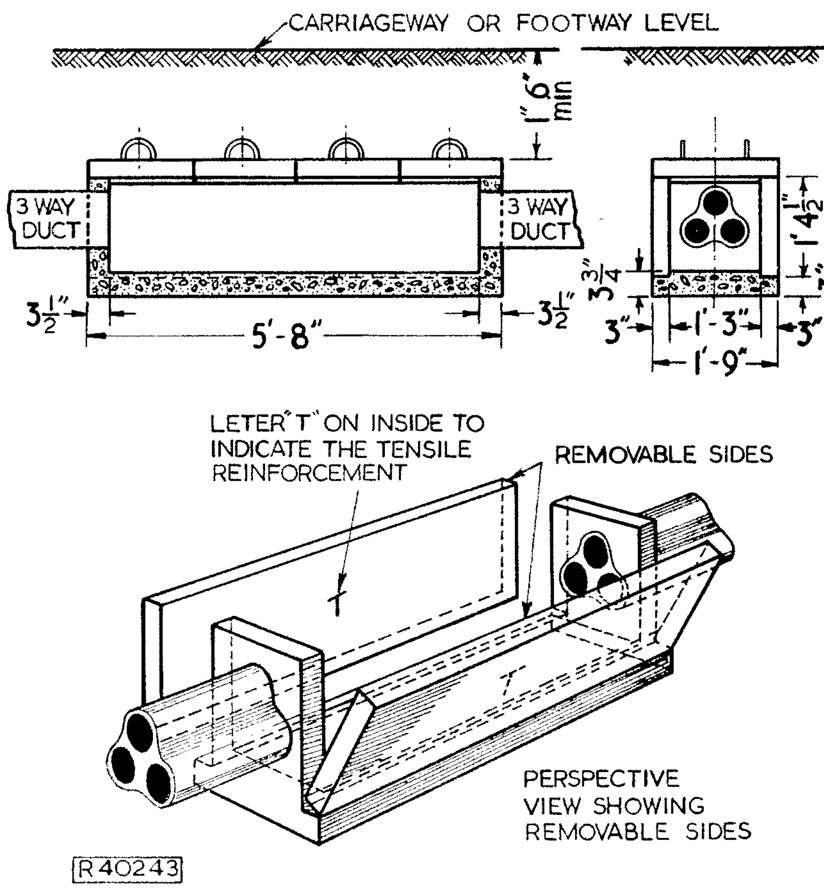

Fig. 5

JOINT MARKERS AND MARKING POSTS

The position of buried couplings and joint boxes are indicated by means of joint markers or marking posts. The markers and post used are illustrated in Fig. 6, and the numbers used by the B.P.O. to identify the individual items are given.

Markers No. 1 and No. 3 are fitted in carriageways and footways respectively. They should be attached to the coupling or joint box by means of a length of galvanized iron wire. Marking posts are used where a surface marker may become an obstruction due to the wear of the surrounding pavement, or where it may be covered by subsequently added layers of macadam etc. The marking post should be placed against a boundary wall so that it is in line with the position of the buried jointing point, and the horizontal distance from the jointing point should be marked in feet by means of figures attached to the post. Marker No. 4 is suitable for attachment to fences or walls and may be used to indicate the position of a subscribers leading-in pipe.

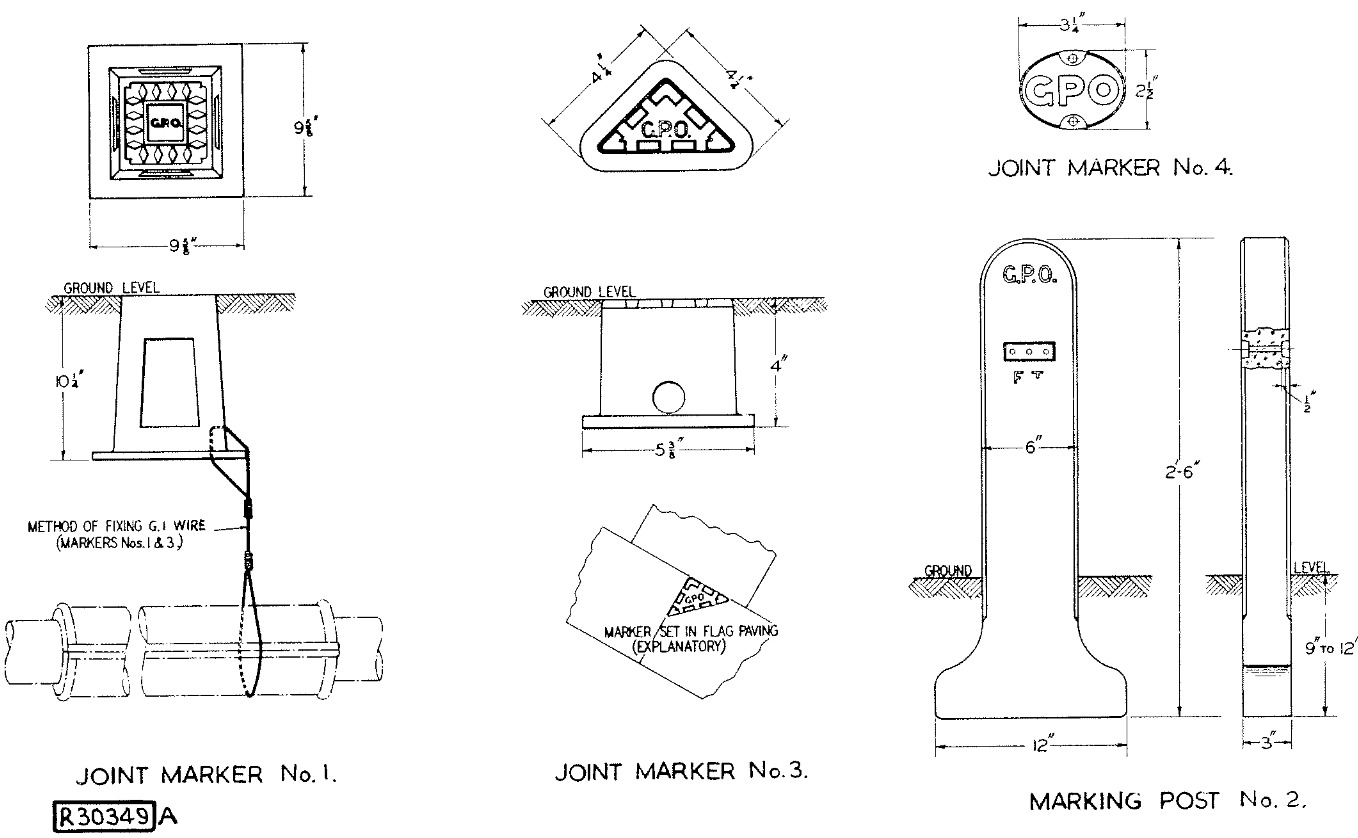

Fig. 6

SURFACE JOINT BOXES

Surface joint boxes provide jointing facilities for duct routes comprising one to four-ways. They may be constructed in footways or carriageways. Reinforced concrete, unreinforced concrete or bricks are used in their construction, reinforced concrete is normally used in the larger joint boxes but, for the smaller joint boxes and in situations where it is difficult to erect shuttering, brickwork may be used for the walls. The type and construction of joint boxes may be identified by certain code letters. The various code letters and their interpretations are given below.

J – Joint box
F – Footway
C – Carriageway
B – Brickwork
U – Unreinforced concrete
R – Reinforced concrete

Thus JBF would indicate a footway joint box built in brick.

The major difference between footway and carriageway joint boxes is the type of entrance cover assembly fitted. Footway boxes are not subjected to the heavy traffic loads experienced by carriageway boxes, and therefore footway cover assemblies need not be so substantially constructed. The footway entrance assemblies are termed channels and covers, they are made of cast iron or pressed steel and a concrete slab is cast in the cover. The entrances to carriageway boxes are closed by frames and covers of unit construction. These may be provided to fit entrances requiring from one to three standard size covers. The frames and covers are cast iron and the pockets in the top of each cover are filled with ashphalt.

Footway Joint Boxes

Fig. 7 illustrates a small footway joint box suitable for medium sized cable joints on distribution cables.

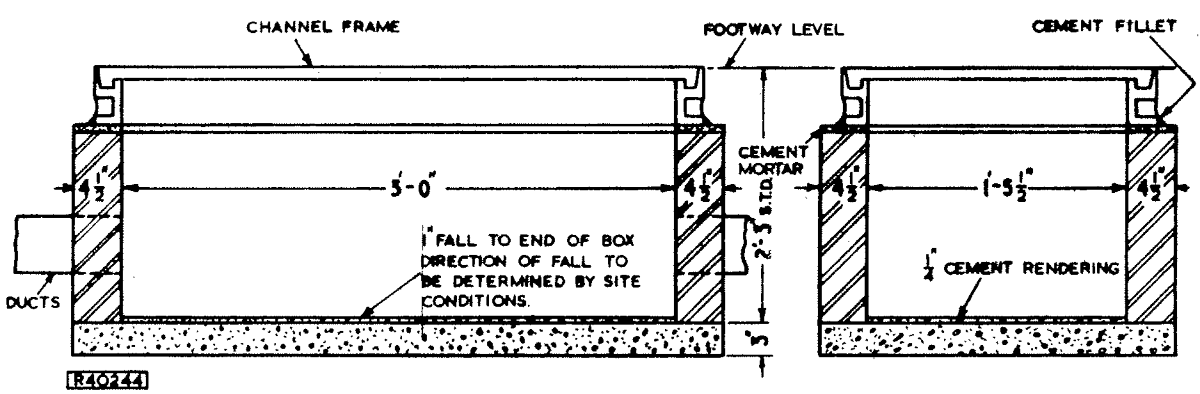

Fig. 7

A similar box with reduced dimensions is used for small joints, and distribution boxes – of the same pattern – designed for very small joints have also been installed. The distribution box is now only installed in special circumstances as it is generally considered to be an uneconomic construction. These boxes are generally constructed in $4\frac{1}{2}$ inch brickwork.

A "double junction" box with a small reinforced concrete roof is illustrated in Fig. 8. This box is generally constructed in $3\frac{1}{2}$ inch reinforced concrete and may be used for several auxiliary or main joints.

Joint box brackets or cable bearers are provided in these boxes as required, to support the cables.

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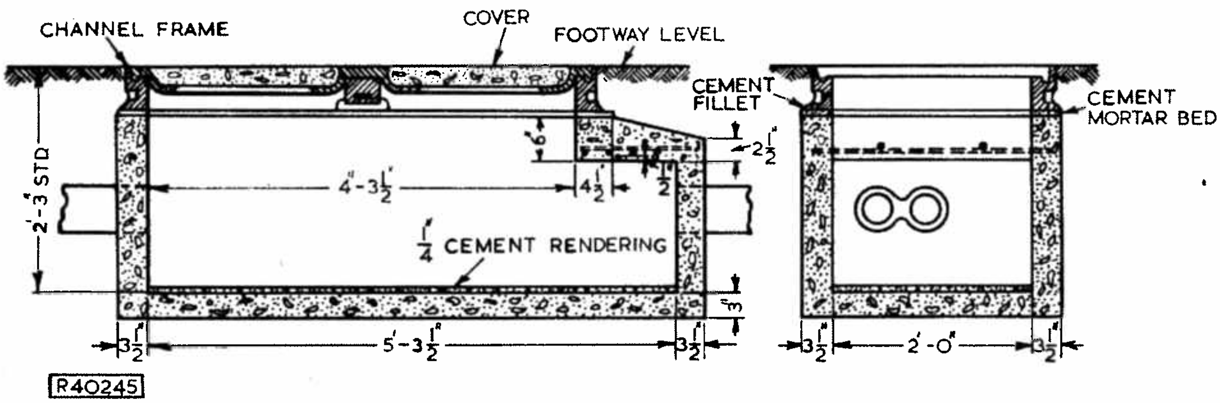


Fig. 8

Larger joint boxes may be constructed in the footway when it is necessary to provide greater working space for large joints. Three standard boxes are available to meet these requirements, ranging from 5 ft. $3\frac{1}{2}$ inches to 7 ft. 6 inches internal length. The intermediate sized box in this range is illustrated in Fig. 9.

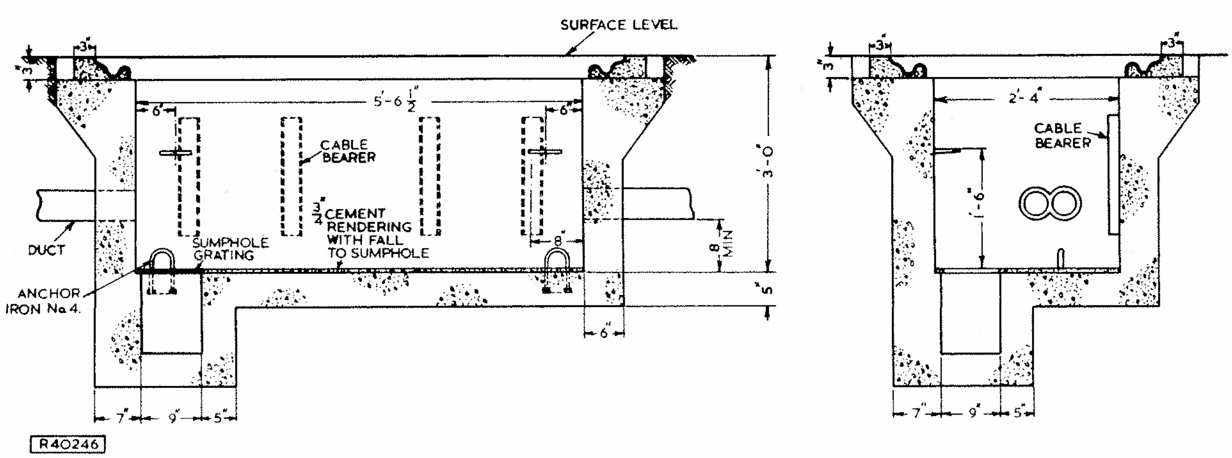


Fig. 9

These boxes may be constructed in 6 inch reinforced concrete, 9 inch brickwork or 12 inch unreinforced concrete. Each box is provided with a sumphole, covered with a grating, anchor irons, manhole steps and cable bearers.

CARRIAGEWAY JOINT BOXES

The three larger footway boxes may be constructed in the carriageway, suitable modifications being made to enable carriageway frames and covers to be fitted.

The carriageway joint box illustrated in Fig. 10 is similar in size and construction to the largest of the footway boxes; but, to enable the box to be fitted with unit type covers, the entrance is reduced and the roof supported by two reinforced concrete beams.

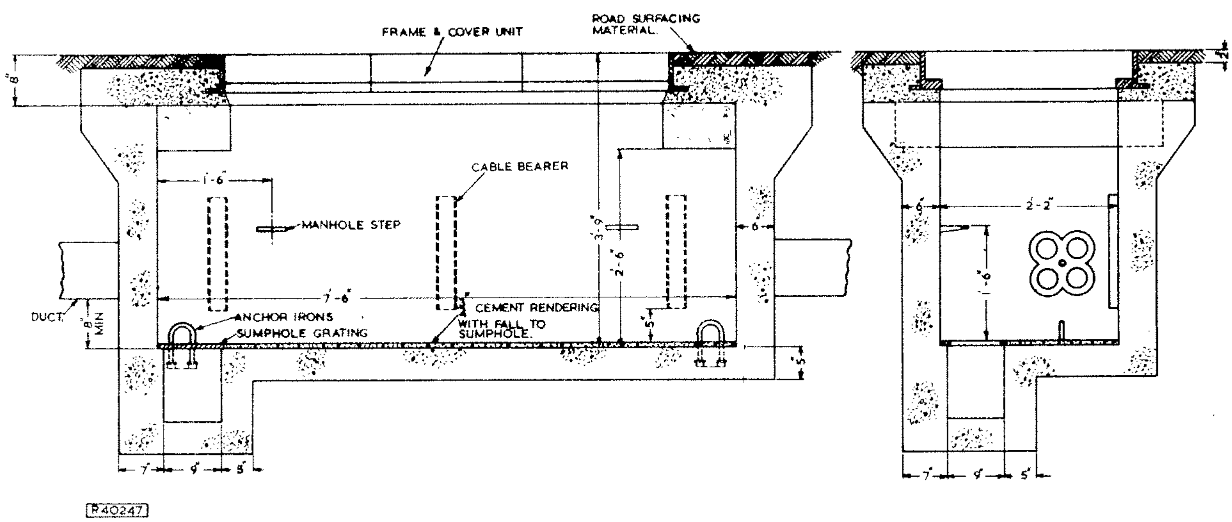


Fig. 10

MANHOLES

Manholes are provided in the footway or carriageway where joint boxes do not provide adequate jointing facilities. Normally manholes are constructed in reinforced concrete but brickwork construction may be used where obstructions prevent the erection of shuttering.

Standard rectangular manholes vary in size from 6 ft. by 3 ft. 6 inches by 5 ft. high to 13 ft. 6 inches by 5 ft. 6 inches by 7 ft. high. Two intermediate sizes have internal heights varying from 5 ft. 6 inches to 7 ft. 6 inches. The internal height of these manholes is dependent on the number of duct ways which have to be accommodated. A standard rectangular manhole is illustrated in Fig. 11. It is equipped with cable bearers, anchor irons in the walls and floor and, as the entrance is to one side of the manhole, steps are fitted in the wall. In the larger manholes, where the entrance is placed centrally in the roof, steel ladders of suitable length are provided.

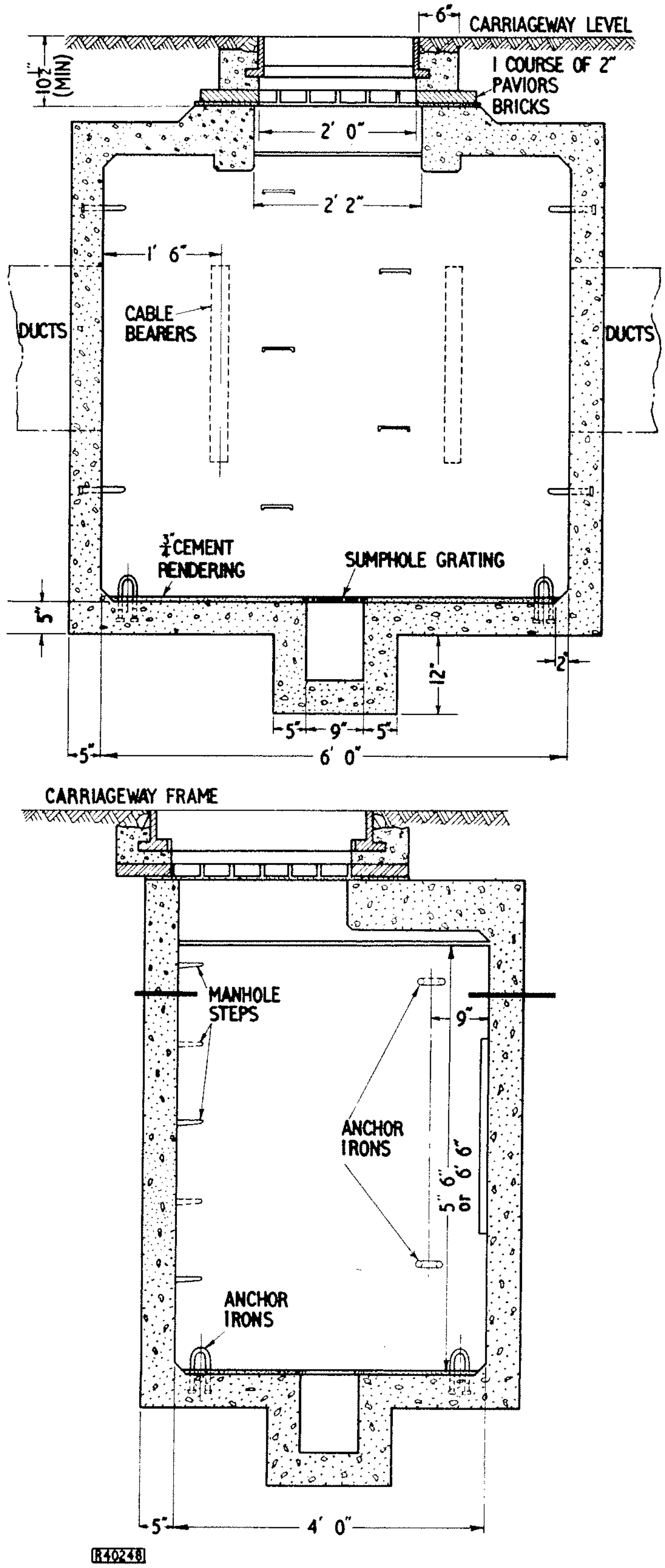
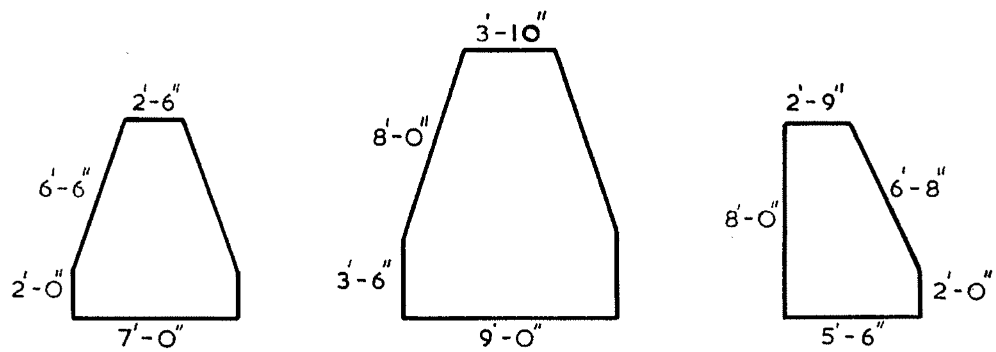

6"
CARRIAGEWAY LEVEL
10½" (MIN)
1 COURSE OF 2" PAVIORS BRICKS
2' 0"
2' 2"
1' 6"
CABLE BEARERS
DUCTS
DUCTS
¾" CEMENT RENDERING
SUMPHOLE GRATING
5"
12"
2"
5"
9"
5"
5"
6' 0"
CARRIAGEWAY FRAME
MANHOLE STEPS
9"
ANCHOR IRONS
5' 6" or 6' 6"
ANCHOR IRONS
5"
4' 0"
R40248

Fig. 11

Shaft entrances are provided where obstacles, such as water and gas pipes and sewers, prevent the manhole being constructed at normal depth. It is general practice in towns, when manholes are constructed in the footway, to allow about 18 inches between the top of the manhole roof and the surface of the pavement. The provision of a shaft under these circumstances allows other undertakers small plant to pass across the roof of the manhole.

Standard triangular manholes may be installed where a change in the direction of a duct route is necessary; they provide adequate facilities, under these circumstances, and require less excavation than a rectangular manhole of suitable size. The outline plans of the triangular manholes used are illustrated in Fig. 12.



OUTLINE PLANS OF STANDARD TRIANGULAR MANHOLES

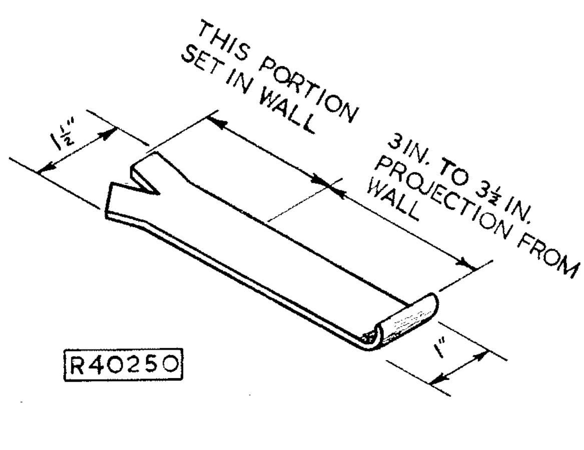
R40249

Fig. 12

CABLE BEARERS AND BRACKETS

To prevent damage to cable sheaths and conductors, cables and joints in joint boxes and manholes must be adequately supported.

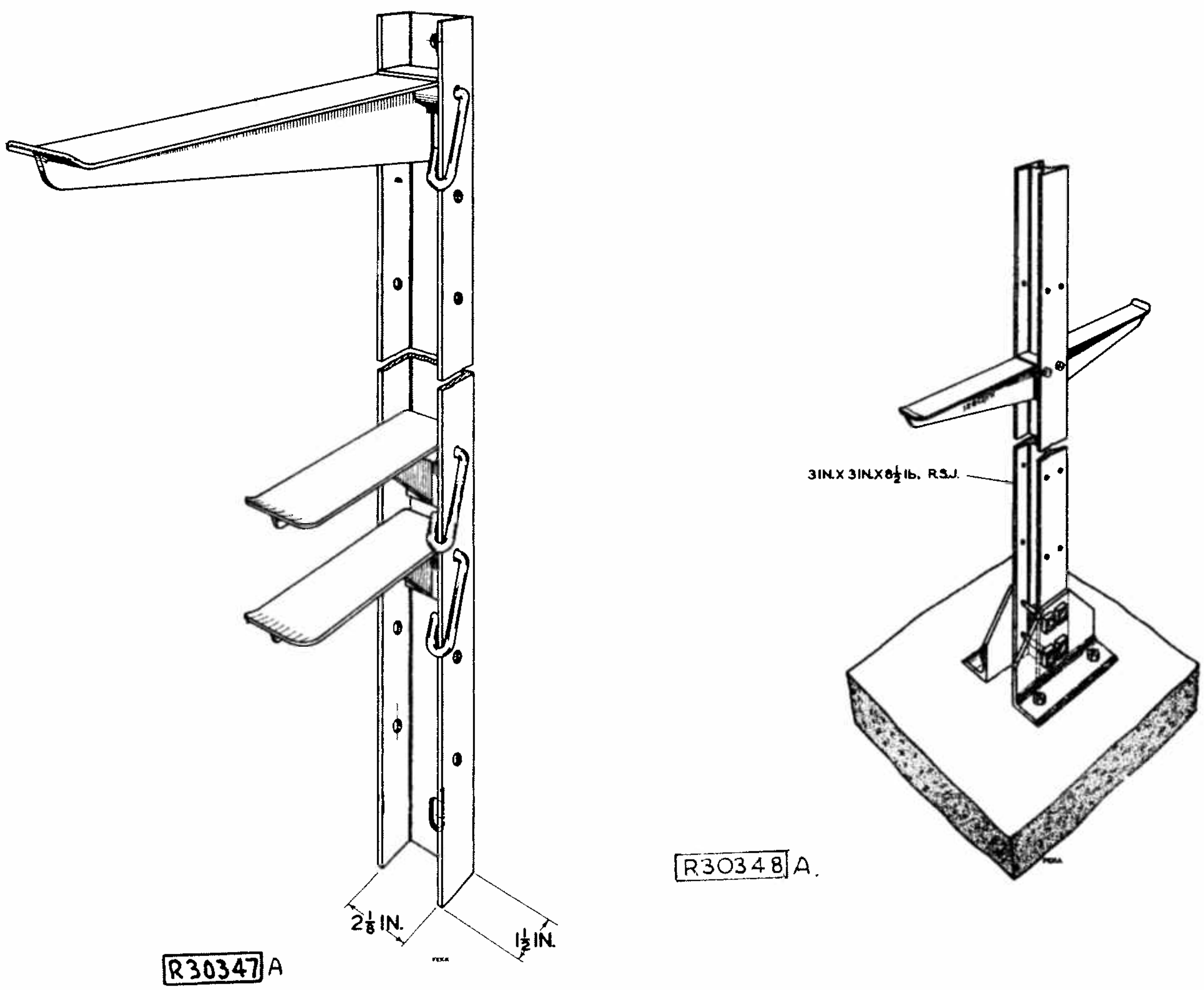
A bracket suitable for supporting small cable joints in the smaller types of joint box is illustrated in Fig. 13. The bracket is built into the joint box wall so that it projects for 3 to $3\frac{1}{2}$ inches, thus providing horizontal support for cables and joints.



R40250

Fig. 13

For larger joints more substantial cable brackets are used and these are supported by cable bearers. The bearers are fixed to the jointing chamber walls or, in exceptional circumstances, to the floor by means of Lewis bolts. They are known respectively as wall type and standard type. The wall type bearers are of light pressed-steel channel section and the standard type are cut from rolled steel joist. Cable brackets of grey cast iron are available in effective lengths ranging from 3 inches to 24 inches. The brackets fit both types of bearer. The size of bracket chosen will depend upon the number and diameter of cables to be supported, as a general rule it is desirable not to place more than two medium or large signal cables on any bracket in a jointing chamber. The brackets are fixed to the wall-type bearers by means of locking pins and the standard type bearers by means of nuts and bolts. Wall-type and standard-type bearers with brackets in position are illustrated in Figs. 14(a) and 14(b) respectively.



(a) (b)

Fig. 14

Expansion Bolts

Expansion bolts may be used for the fixing of cable bearers etc. in finished concrete, brickwork or materials of a similar nature. The complete assembly, illustrated in Fig. 15, consists of a galvanized iron nut and bolt with a special lead plug and a cast or malleable iron wedge.

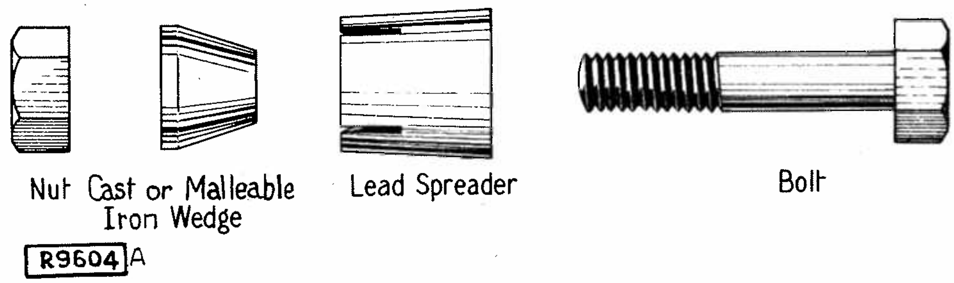
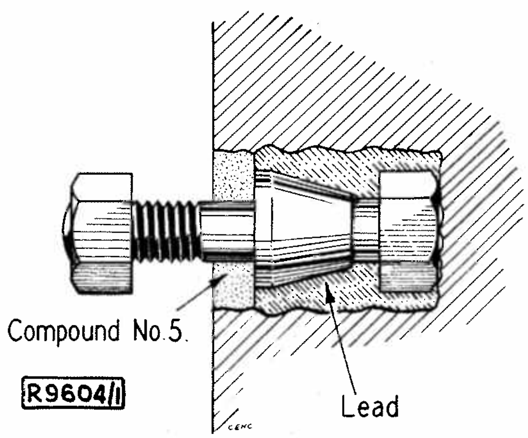


Fig. 15



To fix the bolt, a cylindrical hole is made to the required depth. The bolt is placed head first in the hole and the lead plug and steel wedge passed over it. The wedge is then driven home, with the aid of a short length of pipe, until the hole is tightly packed with lead. The remaining cavity is filled with a little compound or cement. The bolt, fixed in position, is illustrated in Fig. 16.

Fig. 16

MANHOLE AND JOINT BOX COVERS

The covers of manholes and surface entry joint boxes fit in frames or channels in such a manner that both the frame and the cover are flush with the surface of the footway or carriageway. A jointing chamber cover should fulfil, as far as possible, the following requirements.

(1) Capable of carrying the loads likely to be imposed on it with a reasonable factor of safety.

(2) Be easy to remove by the minimum number of men without the use of bulky or cumbersome equipment.

(3) Have a long useful life.

(4) Have a non-skid surface.

(5) Be easy to install.

Some of these requirements conflict and in designing a jointing chamber cover a compromise has to be made. For example, increasing the strength tends to increase the weight of a cover and hence makes the cover more difficult to remove. The best compromise for a cover fitted in a carriageway carrying fast moving traffic will not be the best compromise for a cover fitted in a footway and the types of covers fitted in footways are therefore different from those fitted in carriageways.

CARRIAGEWAY COVERS

Early frames and covers for telephone and telegraph purposes were adaptations of types already in use for access to drainage systems. The covers were of two basic types:-

(i) A cast iron "tray" divided into compartments which were filled with some hard wearing material such as wood blocks or concrete.

(ii) A cast iron upper plate, which formed the wearing surface, having an arrangement of supporting ribs below it.

The cover rested in a massive frame of inverted "tee" section. The load bearing surfaces consisted of "chipping blocks" of relatively small cross sectional area, the levels of which could be modified by the manufacturer to prevent the cover "rocking" when new.

A section through a wood filled cover and frame is shown in Fig. 17. This type, whilst exceedingly heavy, was easy to install due to the rigidity of the massive frame casting. The cover ususally developed "rock" soon after installation due to unequal wear of the chipping blocks. Another disadvantage of this type of cover was the necessity of lifting the heavy cover vertically for some 6 inches to gain access to the chamber. The cover shown in Fig. 17 is a circular type. Oval covers were also used and these had the further disadvantage that they were liable to fall through the frame aperture and damage the cables.

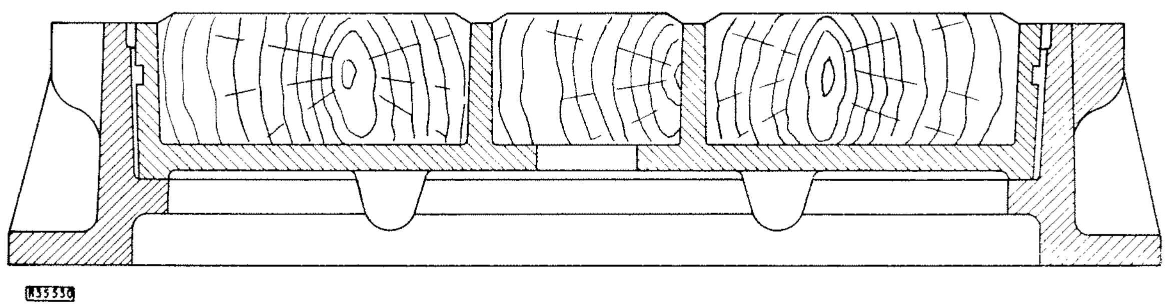


Fig. 17

The oval type of cover was superseded by a rectangular cover and frame on which the seating surfaces were serated in an endeavour to increase the area of contact between the cover and the frame and thereby reduce the rate of wear. In practice the increase in life was not realized due to slight casting inaccuracies causing small area contact surfaces which rapidly wore causing rock to develop. Its installation and handling characteristics were similar to the circular manhole cover. A section through this type of frame and cover is shown in Fig. 18, the left-hand half of the section is through the centre of the frame and cover and the right-hand half through the serated bearing surfaces.

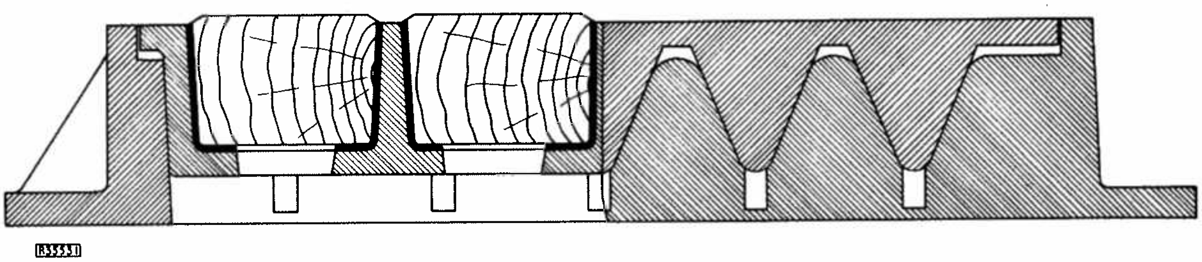


Fig. 18

Slide Out and Multi-Cover Type

The earlier types of frames and covers were all superseded by slide out types of cover. Manholes were fitted with a square frame and cover and joint boxes with either a single rectangular frame and cover or frames taking either three or four rectangular covers. The frames were hollow and were filled on site, as were the covers, with concrete. Figs. 19 and 20 show the single rectangular type and the four cover type before being filled.

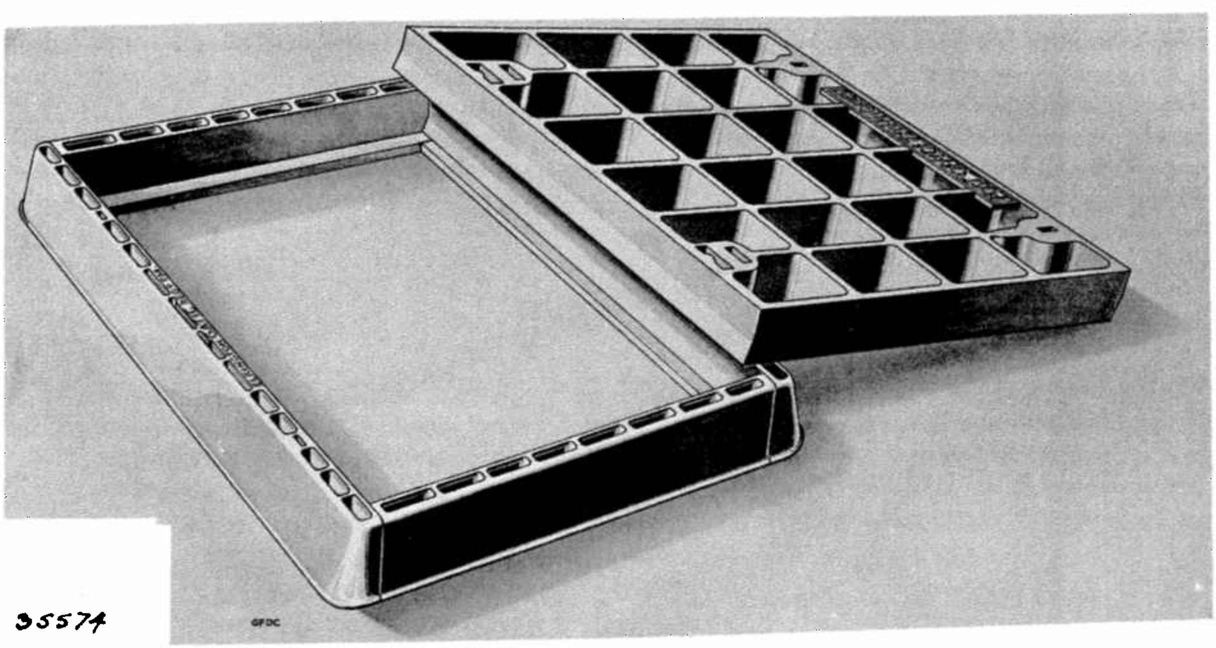


Fig. 19

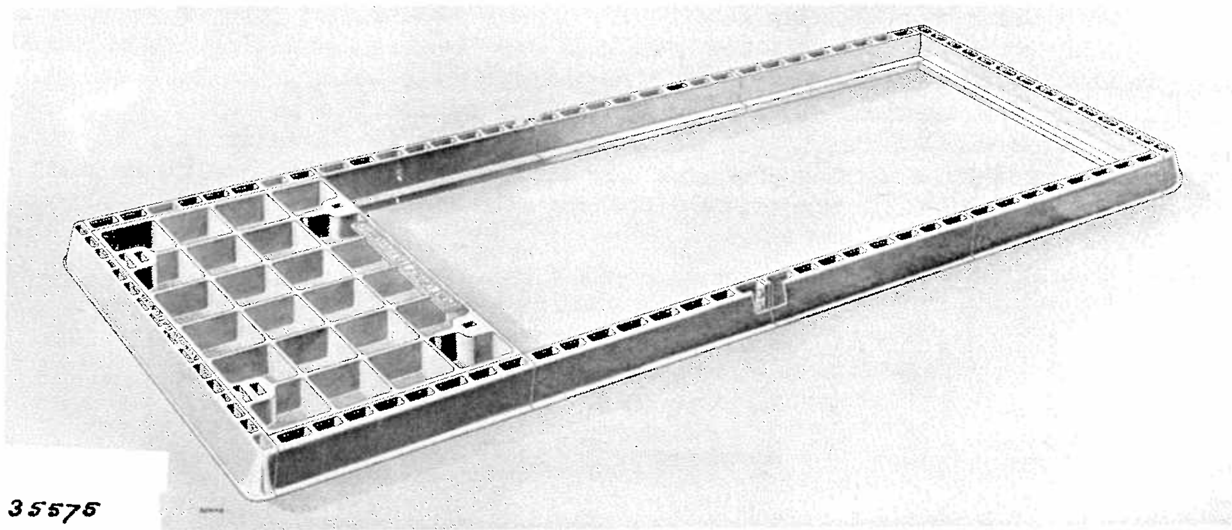


Fig. 20

A section through a single cover and frame is shown in Fig. 21.

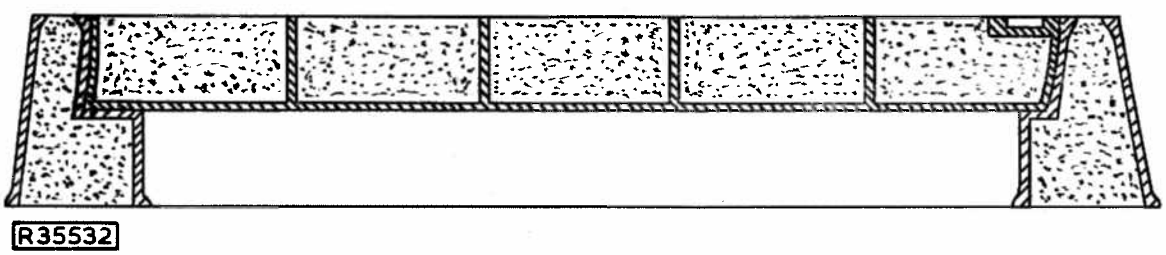


Fig. 21

The seating areas of these covers and frames are fully machined and the covers are individually matched to their frames or sections of the frame. This was done to provide a large area of contact and hence reduce the rate of wear. The lack of rigidity of the frame however made their installation to the standard of accuracy required to take full advantage of the large seating areas, extremely difficult under field conditions. As a result "rock" developed early in the life of the unit and the lightness of the frame sections proved inadequate to withstand the consequent hammering.

The removal of the covers is extremely easy, it being only necessary to lift one edge of the cover and then to slide it off. The method of doing this is illustrated in Fig. 22 which also shows the key used for lifting the cover.

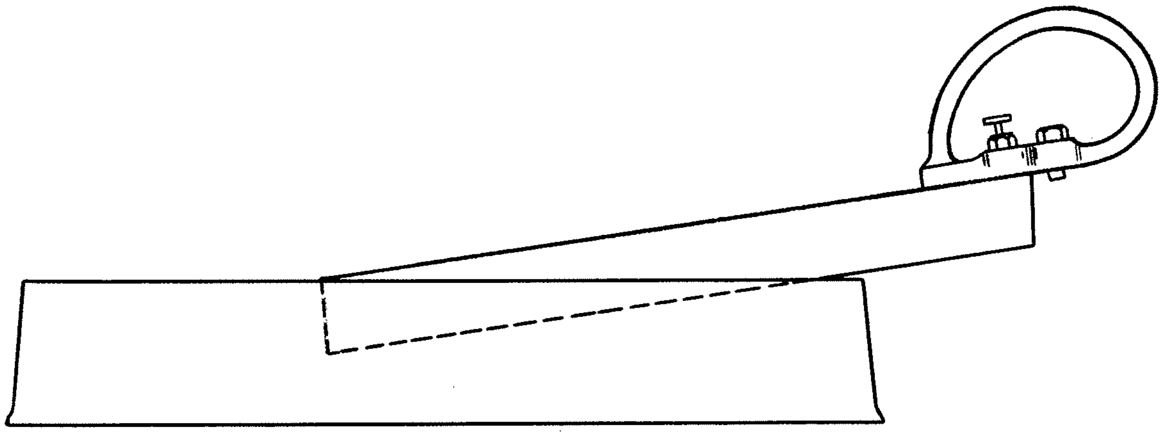


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Fig. 22

Unit Type

To overcome the disadvantages of the earlier types of carriageway cover a new type of cover was designed after an investigation had been carried out into the reasons for the short life of the earlier types. The new covers are in three units; A, B and C.

The A unit is a single cover and frame for use on carriageway manholes.

The B unit is an end unit comprising one cover and three sided frame. Two B units are fitted together to form a two cover entry.

The C unit is a centre unit and can be inserted between two B units to form a three cover entry.

The bearing surfaces of the covers and frames are machined to a standard of accuracy that permits full interchangeability of the parts. The covers are supported along two sides only and no bearing surfaces are provided on the end sections of the frame. During transport and installation the covers are bolted to the frame by four bolts which are subsequently removed. This prevents the frames and covers from warping before they are installed and ensures an intimate contact along the whole of the bearing surfaces.

The frame is made of substantial, inverted "T" and "L" shaped, cast iron sections which are bolted together.

The covers are also cast iron castings and comprise, five supporting beams, a filling supporting plate, filling retaining ribs, two semi-circular ribs on which the cover slides out supported by two webs at right angles to the beams, and two

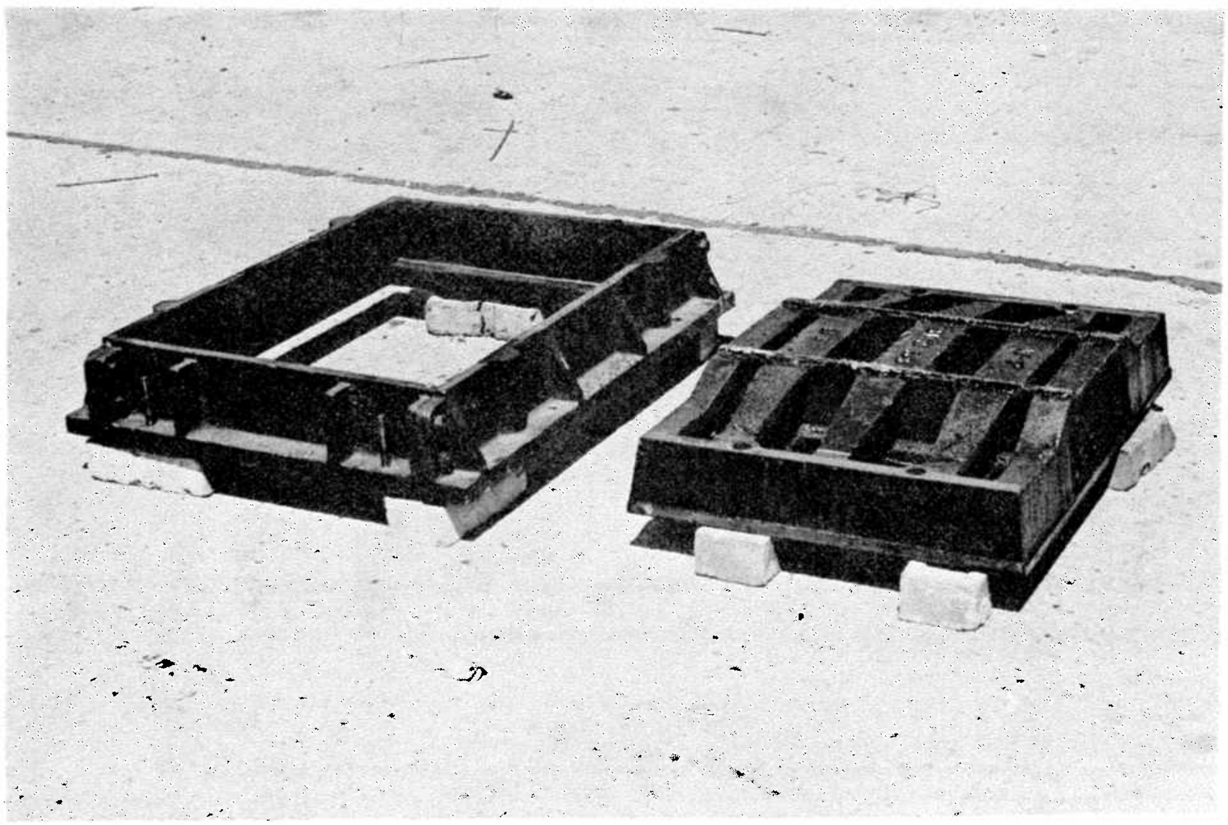

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Fig. 23 (a)

R35534

Fig. 23 (b)

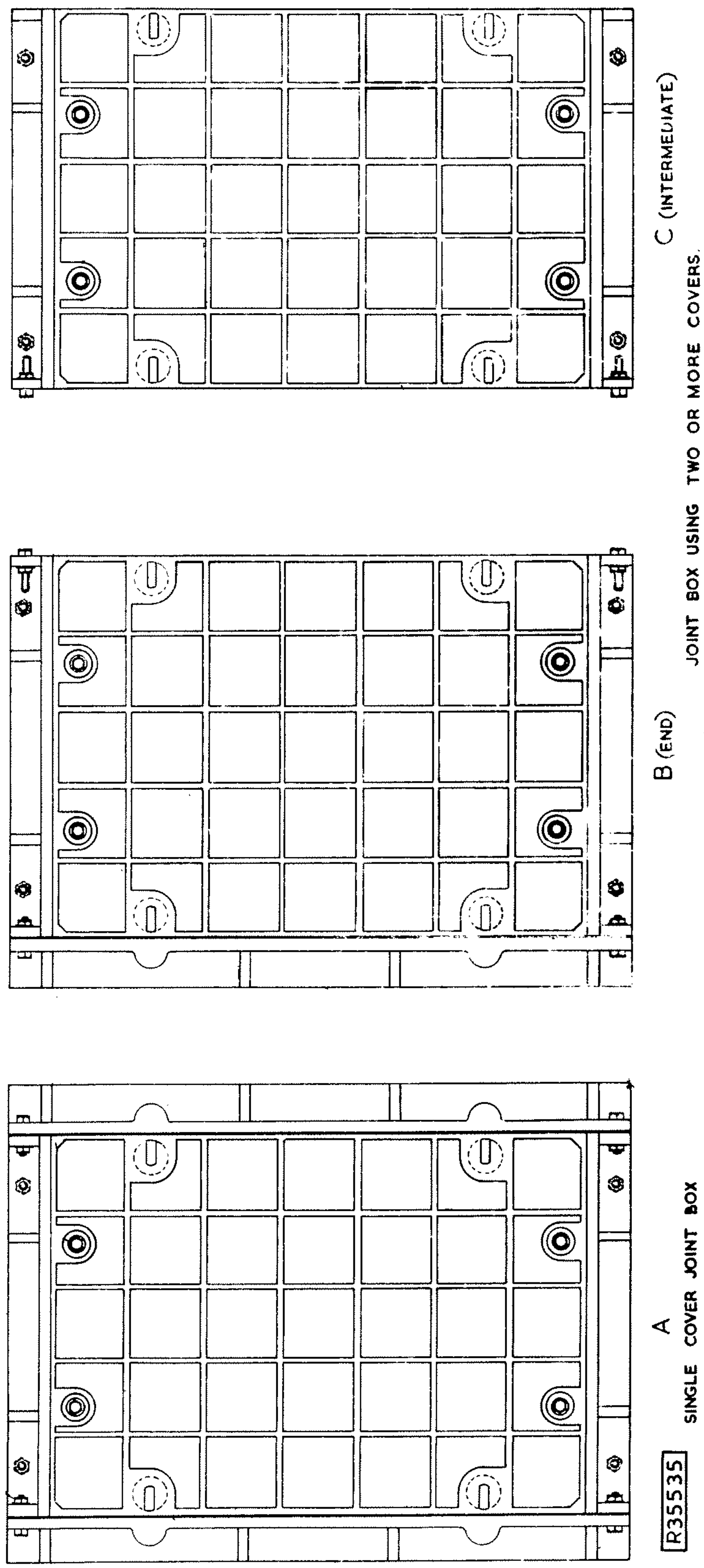
C (INTERMEDIATE)
JOINT BOX USING TWO OR MORE COVERS.
B (END)
A
SINGLE COVER JOINT BOX
R35535

Fig. 24

cover seatings which are machined to provide the bearing surfaces. The filling is of high grade flooring asphalt containing 25% of ground granite and is inserted by the manufacturer. The slide out facility of the earlier multicover type is retained and the same key is used for their removal. It is necessary to lift the edge of the cover $5\frac{1}{2}$ inches, 1 inch higher than the earlier type.

An A unit frame and the underside of its cover are shown in Fig. 23 (a) and a carriageway joint box fitted with two B units in Fig. 23 (b).

The three units are shown in Fig. 24.

FOOTWAY COVERS

Footway joint box and manhole covers have to withstand much lighter loads than the carriageway types. Hence a cheaper and lighter type of framework and cover can be fitted. To distinguish between frames and covers used for carriageway and footway it is usual to refer to a frame for a carriageway cover and a channel for a footway cover. The channels are usually of cast iron and the sides and ends are cast in one piece. When cross beams are required for multicover types they are fitted after the channels are installed. The covers are cast iron trays filled with concrete and a flange round the edge of the cover fits into the channel of the frame.

Joint boxes have frames with rectangular openings and rectangular covers for the smaller boxes and rectangular openings with two square covers for the larger sizes. The square covers are supported along all four edges by the insertion of a beam across the width of the opening.

Manholes have a frame with a square opening and one square cover.

A typical footway joint box cover is illustrated in Fig. 25. The dimensions are those of the larger of the two common sizes of rectangular cover.

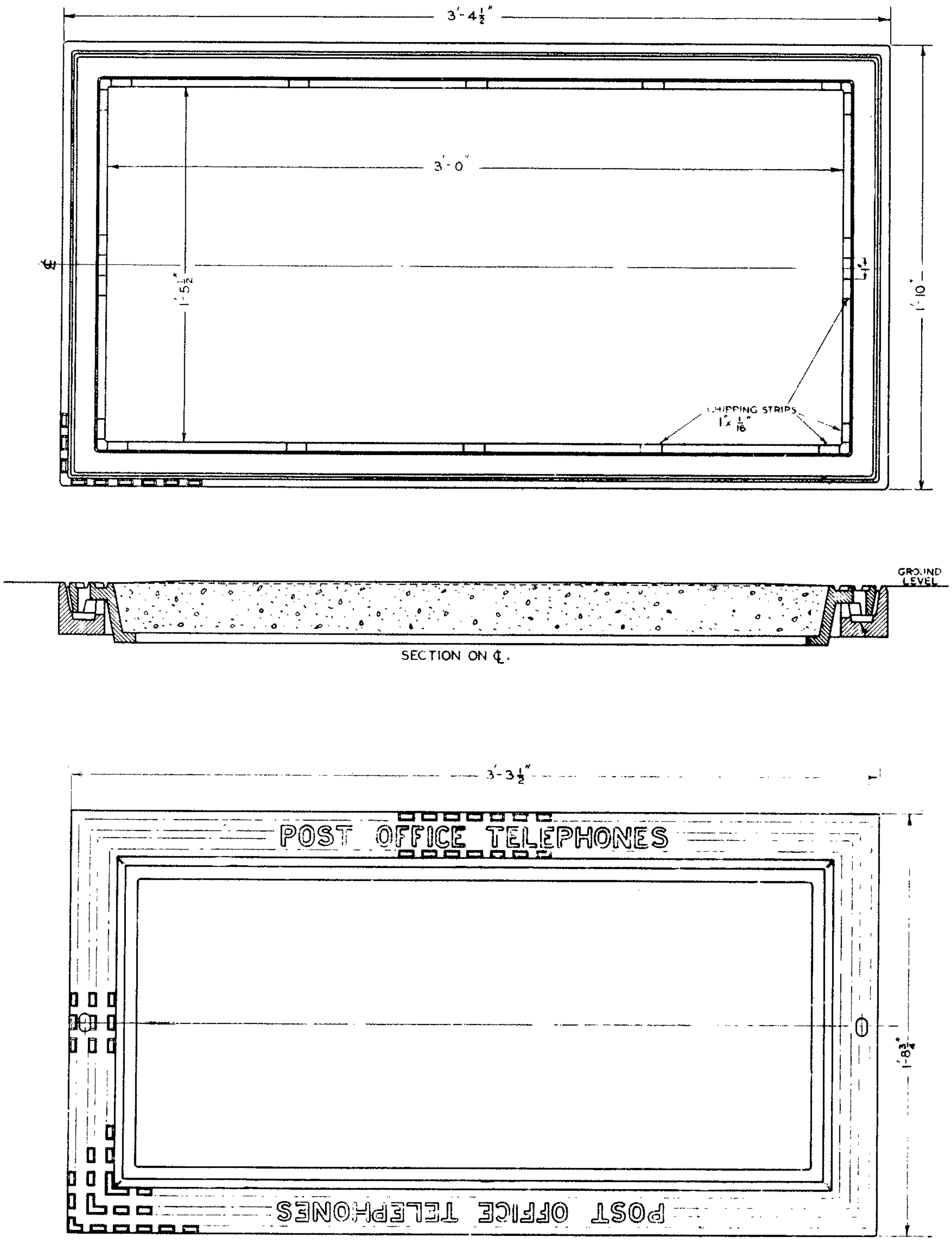

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Fig. 25

CONSTRUCTING A MANHOLE IN REINFORCED CONCRETE

Whilst the construction of any manhole presents an individual problem, according to the prevailing local conditions, most concrete manholes are constructed along the following general lines.

A hole of the required dimensions is excavated and, if necessary, the sides are supported with poling boards held in place by horizontal walings. The bottom of the excavation is levelled and any soft spots are dug out, these are filled with hardcore and consolidated to form a solid foundation for the manhole. A hole 1 ft. 7 in. square and 12 in. deep is dug in the foundation for the sumphole.

Two light wooden templates, slotted to receive reinforcing bars, are placed in position, the lower template is supported on four wooden pegs placed at the corners and is positioned about 1 ft. above the foundations, the upper template is wedged 1 ft. below roof level. Shuttering for the sumphole is set up and the floor is covered with a layer of concrete $1\frac{1}{2}$ in. thick. The L-shaped reinforcing bars forming the end-wall-to-floor and side-wall-to-floor ties are placed in this concrete so that the horizontal members are just covered. The vertical members are placed in the outside slots of the lower template so that, when the walls are erected, they will be covered by $\frac{3}{4}$ in. of concrete. (Fig. 26).

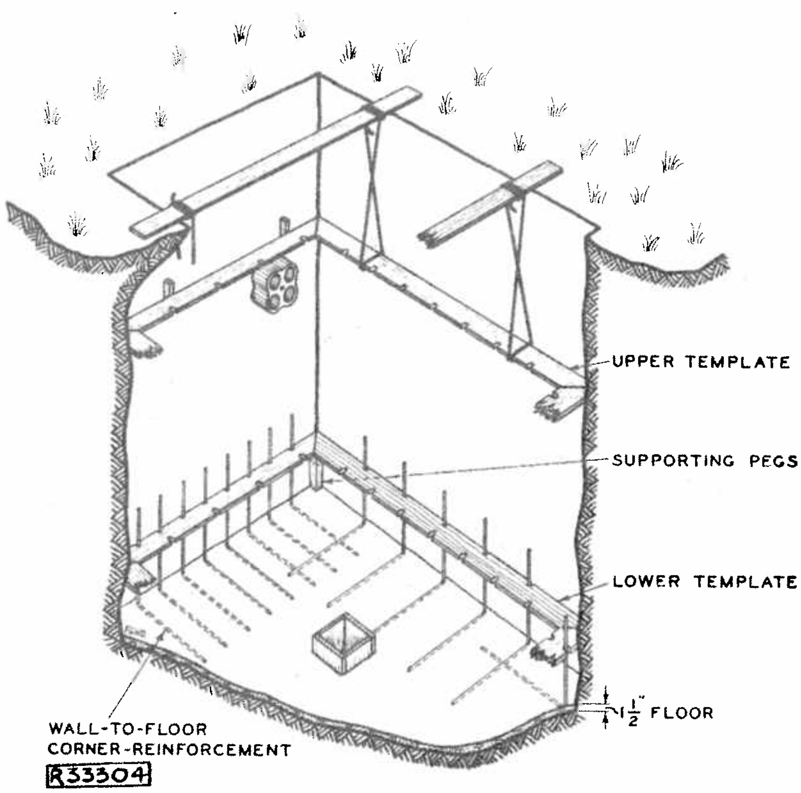

Fig. 26

Additional concrete is placed as soon as possible to bring the whole of the floor up to the required thickness and anchor irons are set in the floor where necessary. The main reinforcing bars are placed in position with the horizontal members $\frac{3}{4}$ in. below the surface of the concrete and the vertical members passing through the inside slots of the templates so that, when the walls are erected, they will be covered with $\frac{3}{4}$ in. of concrete. This stage of the work is illustrated in Fig. 27.

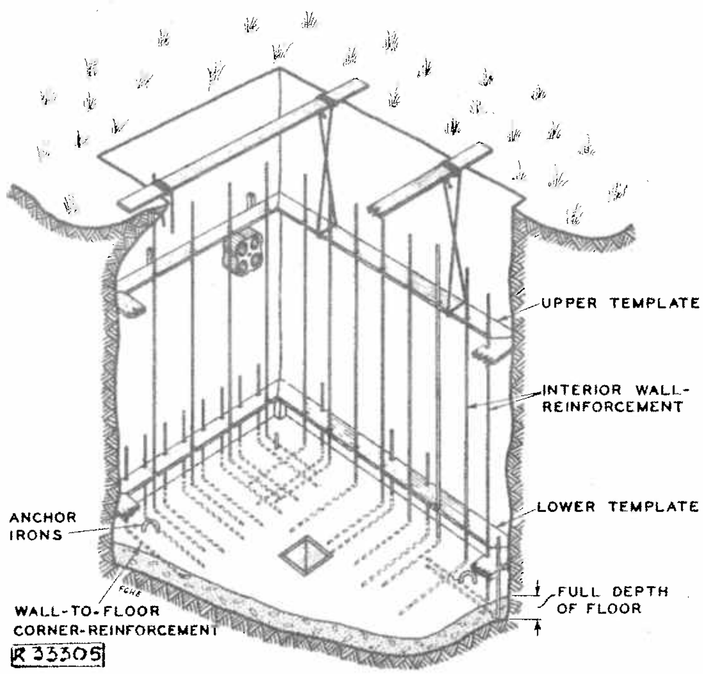

Fig. 27

When the floor has been laid for at least 12 hours the erection of the walls may be commenced. The main framework of the shuttering is first fixed in position, this consists of stout wooden members, cut to size and chambered at their outer angles to form the webbed joint in the corners of the manhole. The first set of shuttering boards are placed horizontally around the four sides of the framework and the portion of the floor upon which the walls will be placed is cleaned and rendered with $\frac{1}{4}$ in. of cement mortar. The space formed by the shuttering boards and the framework is then immediately filled with concrete which is well tamped. The next set of shuttering boards is placed horizontally round the sides of the framework and the concrete placed in the space provided. The walls are built up in this way until the required height is reached. As the erection of the walls proceeds the wooden templates can be recovered and the horizontal reinforcement and side-to-end-wall corner reinforcement placed in position at the requisite spacings, wall anchor irons, steps and Lewis bolts for the cable bearers are also placed in position. The shuttering having being suitably cut at the required positions.

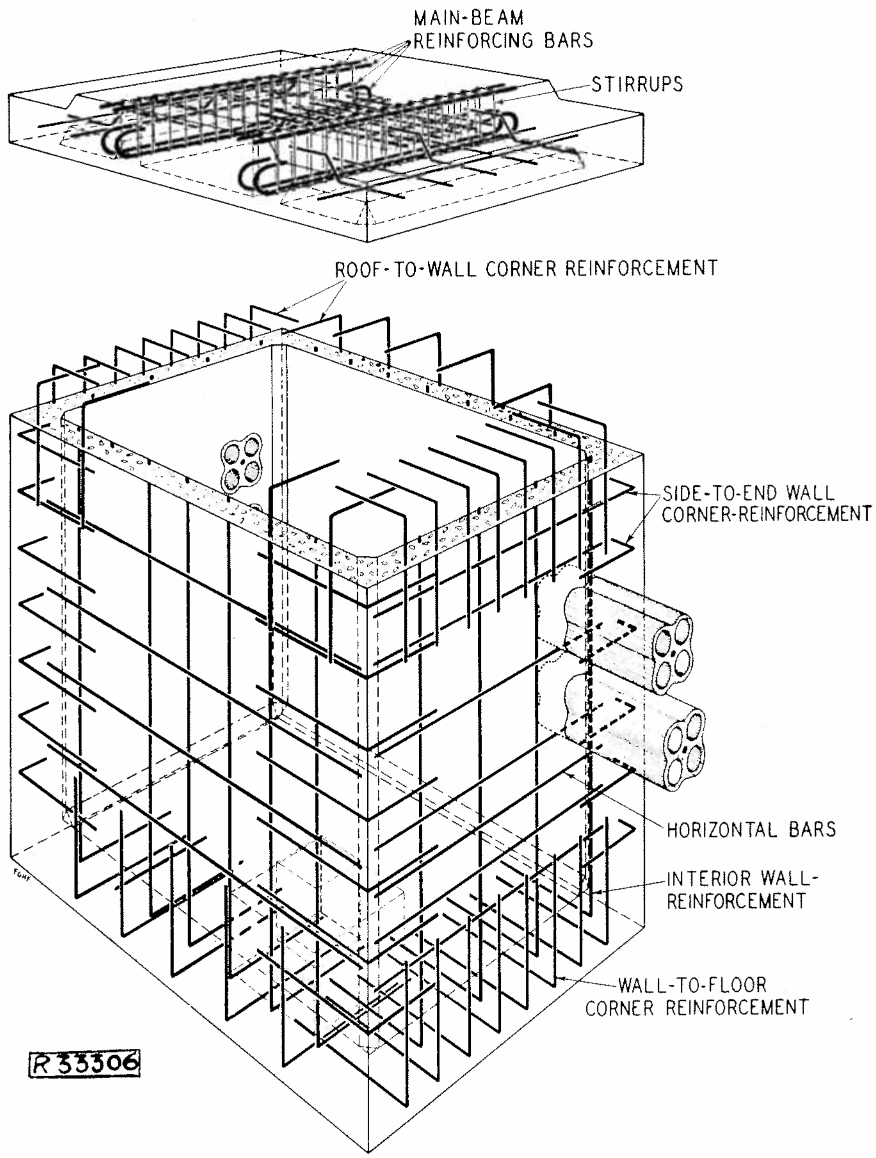
MAIN-BEAM
REINFORCING BARS
STIRRUPS
ROOF-TO-WALL CORNER REINFORCEMENT
SIDE-TO-END WALL
CORNER-REINFORCEMENT
HORIZONTAL BARS
INTERIOR WALL-
REINFORCEMENT
WALL-TO-FLOOR
CORNER REINFORCEMENT
R 33306

Fig. 28

The erection of the walls should be completed in one operation, if this is not possible and there is a break of more than two hours the top surface of the unfinished wall should be rendered with a $\frac{1}{4}$ in. thickness of neat cement just before the recommencement of concreting.

When the walls have reached the required height the shuttering for the roof is set up, the boards being arranged to form recesses at the position of the roof beams. A 1 in. thickness of concrete is then laid over the roof area, including the recesses for the beams. The beam reinforcement, which has been previously assembled is placed in the recesses, the main reinforcing bars being set to obtain 1 in. cover. The remainder of the roof reinforcement is then laid with the rods just visible above the surface of the concrete. The bent bars are supported by a single-wired fixing where they enter the beam reinforcement. Concrete is then added to the required thickness, covering the main reinforcement and the roof-to-wall corner reinforcement. The upper face of the beams is spade finished, and the roof given a slight slope to the sides to avoid accumulation of water on the roof. The complete manhole is shown in Fig. 28.

After the specified time allowed for the concrete to harden has elapsed, the shuttering should be struck and the floor rendered with cement mortar $\frac{3}{4}$ in. thick and given a slight fall towards the sumphole from the sides.

Traffic may be allowed to pass over the manhole 7 days after the completion of the roof if Portland cement has been used in the construction, or 24 hours after the completion of the roof if high-alumina cement has been used in the construction.

CONSTRUCTING A MANHOLE IN BRICK

Normally manholes are constructed in reinforced concrete but when the erection of shuttering is impracticable because of obstructions or existing duct routes manholes may be constructed in brick.

The floor is made of Portland cement in a similar manner to that described for the reinforced concrete manhole. Reinforcing bars are not fitted however and templates are not required.

The walls are then built in brick 9 inches or 14 inches thick in English bond depending on the size of the manhole. The bricks are laid in cement mortar and flush pointed. Fig. 29 illustrates English bond brickwork. The space between the back of the wall and the face of the excavation is back filled as the brickwork progresses.

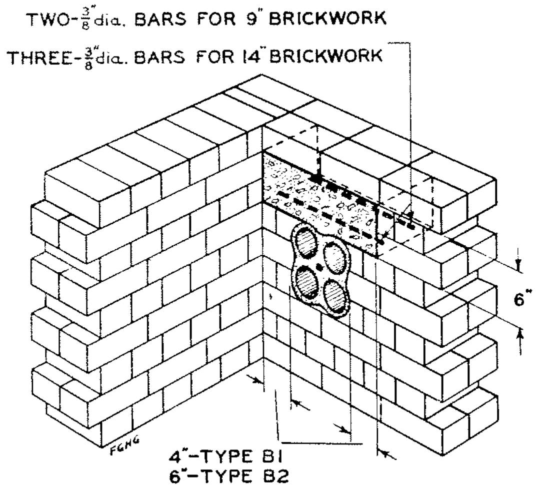

FIG. 5. CONCRETE LINTEL

35576

Fig. 29

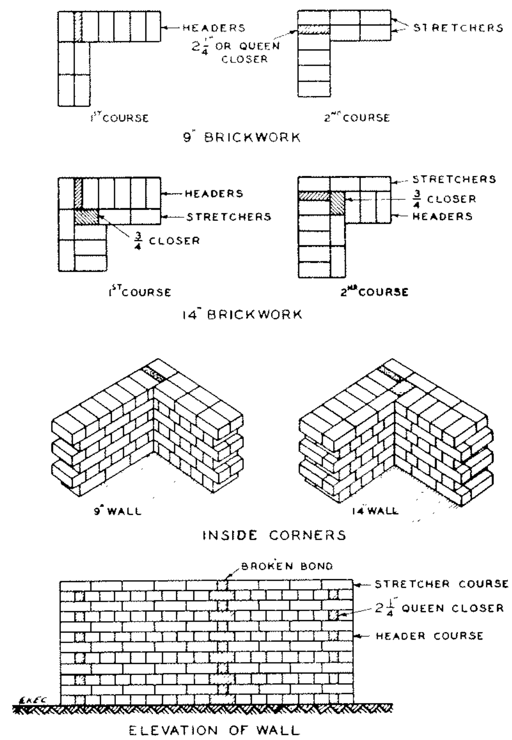

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Fig. 30

The brickwork above the ducts is supported by reinforced concrete lintels as shown in Fig. 30.

The roof is constructed in reinforced concrete in a similar manner to the roof of a reinforced concrete manhole. Before placing the concrete in position however a $\frac{1}{4}$ inch thick layer of cement mortar is laid on the top of the brick walls to make a suitable joint between the brickwork and the roof.

CONSTRUCTING A MANHOLE IN WATERLOGGED SOILS

In order that manholes and jointing chambers shall be watertight, it is essential that the concrete be thoroughly worked in all directions so as to form a dense mass without voids or air channels, and that free water be prevented from coming into contact with the material before final setting takes place. The exclusion of running water must be complete as even a slight trickle, by carrying away the cement, will leave a continuous channel as a leakage path. It is essential therefore to drain the site of an excavation for a manhole in waterlogged ground.

PREVIOUS PRACTICE

Some measures which have been used in the past in dealing with subsoil water are:-

(i) The use of a dam formed from a folded tarpaulin, the water level being kept below the dam by continuous pumping from an independent sump outside the manhole excavation.

(ii) The placing of a rubble course beneath the concrete floor, and communicating with an independent sump shaft. Water is continuously pumped from the rubble floor via the sump shaft and does not reach the concrete.

(iii) As a variation of (ii) a special cast-iron sump pot is used. Pumping is effected via a screwed union. When pumping is completed the sump is closed by means of a screwed cap and the lower part of the sump filled in with concrete.

Generally, these methods of controlling water are slow, cumbersome, and costly. The method selected has been governed by the type of subsoil, e.g. sand, silt, or gravel, by the anticipated quantity of water, and by whether the flow is likely to be periodical or continuous. Running sand, in particular, has always presented a difficult problem, the separation of sand from water pumped calling for special measures. (In the past, straw packing was often used as a filter). It has been known for the withdrawal of sand with drainage water to constitute a serious risk to foundations of roads and buildings. More recent methods, designed to overcome these difficulties, will now be described.

CURRENT PRACTICE

The level of the water within the site of the excavation for a manhole can be lowered below the required depth of excavation by one of the methods known as ground water lowering. In the methods in use at present a borehole has lowered into it a perforated tube wrapped with a fine mesh gauze. The annular space between the tube and the borehole is filled with sand or gravel. Each such unit forms a filter well, the number of wells being so chosen and spaced that, by pumping, the ground water level is lowered within the area surrounded by the wells. This enables excavation and concreting to be carried out quickly by normal methods. One type of wellpoint will be described in some detail.

The Wellpoint (Moretrench) System

The wellpoint consists of a 2 in. diameter pipe, carrying at its lower end a triple lap bronze gauze screen, in which one fine mesh gauze is between the inner and outer coarse mesh gauzes. Fig. 31 shows the lower end of the wellpoint. The wellpoint is sunk by a process which is known as "jetting". Jetting consists of pumping in water from a centrifugal pump connected by hose to the top of the tube.

The top hard surface of the ground is first broken by ordinary methods, and the tube inserted. When the pump is started water is discharged down the tube and emerges at the lower end at sufficient pressure to erode the soil, and the pipe sinks under its own weight. The end of the pipe is serrated, as shown in Fig. 31, so that sinking of the wellpoint may be assisted by rotating the tube. To secure full use of "jetting" water it must be prevented from escaping through the filter during the "jetting" process and for this purpose check valves are provided inside the tube as shown in Fig. 32. The ring valve closes the water passage from tube to screen during "jetting" (Fig. 32(a)) and the ball valve prevents the entrance of soil at the bottom of the tube during the suction stage (Fig. 32(b)).

When the wellpoint has been sunk to the required depth the pump is stopped and the suspended sand and gravel settle to form a porous lining round the wellpoint screen. Any sand and gravel deposited on the surface by water escaping from the wellpoint hole can be shovelled back to complete the lining round the wellpoint, and any deficiency should be made good from other sources.

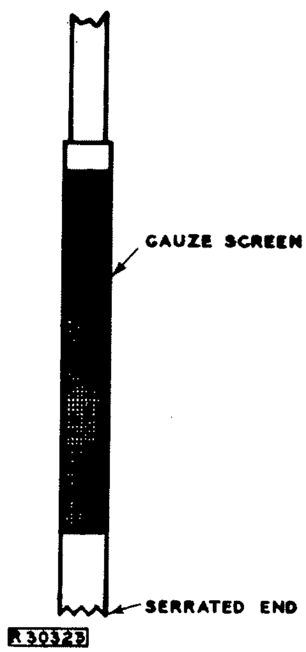

Fig. 31

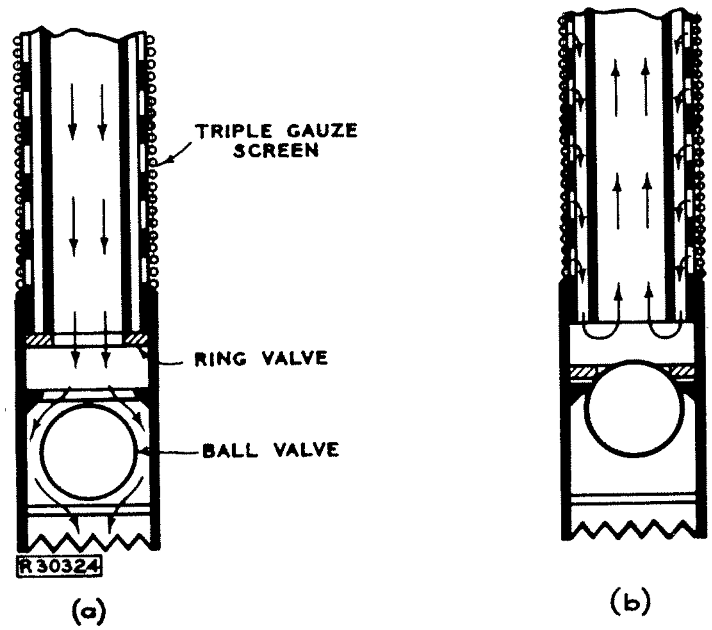

Fig. 32

In some soils the jetting process may not produce an adequate cavity round the wellpoint for the necessary sand refill, e.g. resistant layers of clay may not be eroded to the same extent as other soils encountered; on the other hand certain soils may be penetrated so easily that during the jetting operation the resistance at the serrated end of the tube may not be great enough to produce radial discharge of water, the water merely eroding the soil sufficiently to provide an escape path round the wellpoint. In such cases a jetting chain is attached to the serrated end of the tube as shown in Fig. 33. The free end of the chain is attached to a rope secured at the top of the tube. The bore is enlarged by rotating the tube during jetting, the chain acting as a cutter. Release of the rope on completion of jetting allows the chain to drop off and be hauled up before placing the sand refill.

For jetting the first wellpoint water must be provided from some external source, but further wellpoints can be sunk by water drawn from the first unit.

After each wellpoint has been installed it is connected to a suction pump via a header main of suitable capacity, and the pump is kept going to ensure that water is kept below the excavation level during excavation, and placing and setting of the concrete.

For the smaller manhole four wellpoints disposed one near each corner would be sufficient, whereas for the larger type of manhole eight wellpoints may be required.

Usually excavation for manholes can start at the same time as pumping from the wellpoints is commenced. As excavation proceeds the amount of timbering required will become apparent - usually sparse timbering will be all that is necessary since de-watering by the "wellpoint" system imparts considerable compaction to the subsoil.

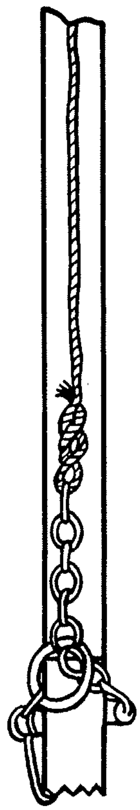
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Fig. 33

The manhole is constructed by normal methods, the pumping from the wellpoints being continued all the time. After placing the concrete, pumping is continued for a further 24 hours, and the wellpoints can then be drawn, and the water level allowed to rise as this will assist in curing the green concrete.

Ingress of water into the complated manhole is prevented by use of rapid hardening cement in the mixing of the concrete; alternatively, a waterproofing agent should be included in the mix. Conduits entering the manhole should be plugged.

The speed at which well points may be sunk depends largely upon the composition of the ground where the work is to be carried out. When operations were carried out on ground consisting of loose stratified silting sand with occasional thin seams of gravel, it was found that the average time taken to sink a well point was 45 seconds. At this rate it was possible to construct four or five manholes per week, whereas by normal methods which entail digging and refilling of independent sump holes and providing hard core drainage, construction would probably have been at the rate of one manhole per week. The comparative saving in cost is of the order of 60 to 75%.

DRAINAGE OF UNDERGROUND ROUTES

It is desirable that manholes should be kept as free from water as possible. Where water flows or is likely to flow into a manhole through the conduits to such an extent as to constitute a nuisance, e.g. it becomes necessary to carry out considerable pumping before working in a manhole, one of the preventive methods described below is adopted.

DIRECT DRAINAGE

A direct drain from the bottom of the manhole to a ditch or surface-water drain may be provided when a new manhole is being built. Frequently, however, it will be found necessary to drain existing manholes where no provision for drainage has been made previously. Normally the drain should be led from the position of the sump hole in the manhole floor, and the sump hole dispensed with. The normal drain connexion is shown in Fig. 34. For draining to a ditch, however, it may occasionally be found that leading the drain through at the base of a manhole wall, as shown in Fig. 35, will enable the necessary "fall" to be obtained when the former arrangement would not. The second method is, generally, the more convenient one for draining existing manholes.

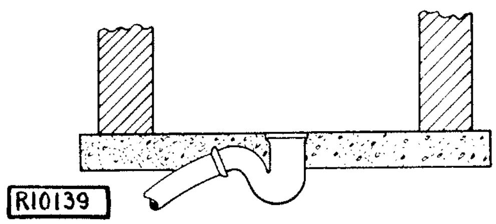


Fig. 34

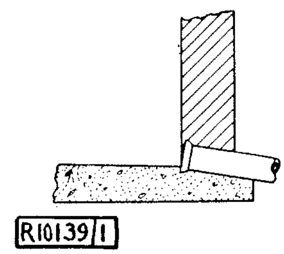


Fig. 35

Ducts are used for connecting the drain to a ditch or culvert.

If there is a possibility of back pressure causing water to flow back into the manhole a ball-valve gully is fitted at the manhole end of the drain, and a grating is fitted over the gully. Where there is no risk of back pressure a syphon trap is fitted instead of the gully, unless the drainage is through the manhole wall to a ditch, when no such device is necessary. In such cases, however, the drain entrance in the manhole wall is closed with a grating, secured in position by a cement fillet, to prevent the entry of vermin. A grating is also fitted over a syphon trap.

INTERCEPTION CHAMBER

If the flow of water into the manhole is very great, or if the necessary "fall" to the drain could not otherwise be obtained, an interception chamber is inserted in the duct line near to the manhole. Whether or not one chamber on the higher side of the manhole will suffice is decided with regard to local circumstances. The method of draining interception chambers is the same as that used for manholes. The types of chambers in use are shown in Fig. 36, 37 and 38.

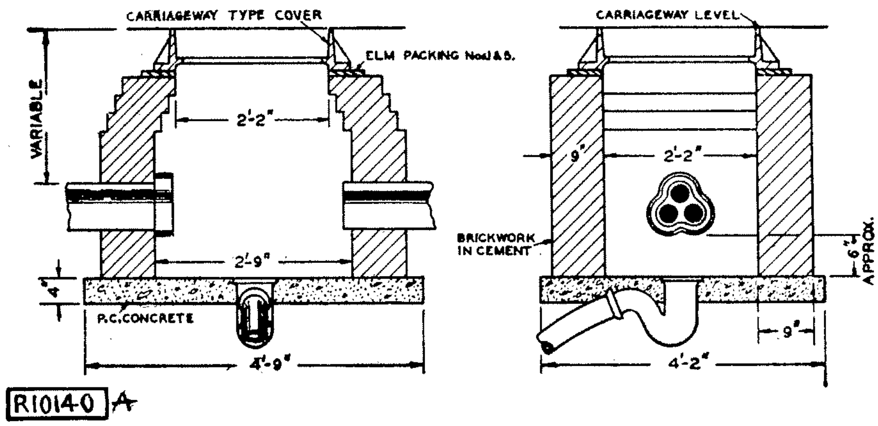


Fig. 36
CARRIAGEWAY CHAMBER

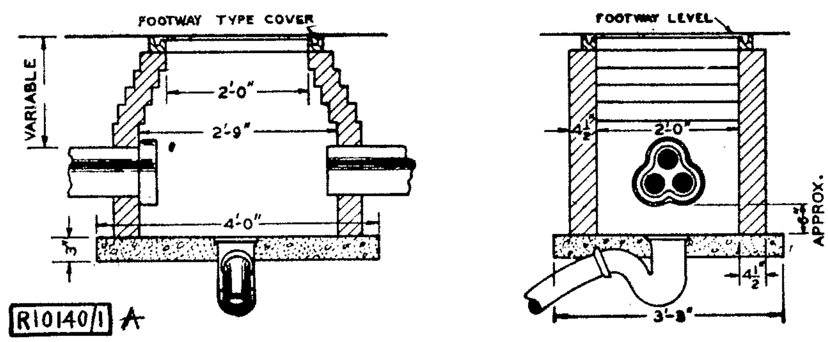


Fig. 37
FOOTWAY SURFACE CHAMBER

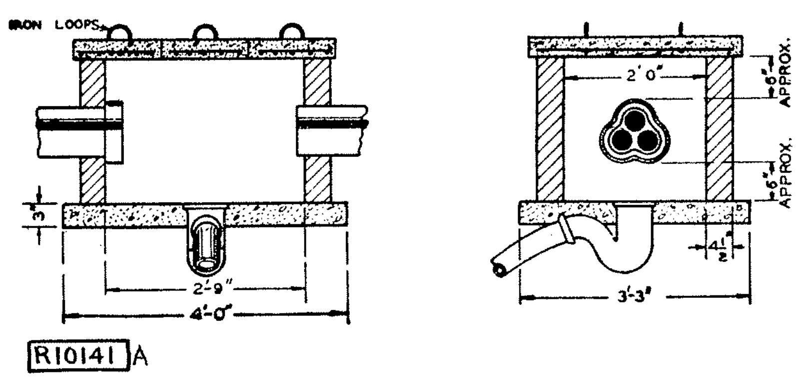


Fig. 38
FOOTWAY BURIED CHAMBER

SURVEY OF EXISTING ROUTES

When draining existing duct routes, a survey should be made to ascertain into which section of the duct line the water is entering. This can usually be done by examining the jointing chambers, starting at the highest point on the duct line. If by plugging the ducts on the down side of the jointing chamber water ceases to flow into the next manhole then the previous manhole should, if possible, be drained. Should water be entering the duct line after plugging the ducts as mentioned above, then water is entering the duct line in that section also. It may therefore be necessary to drain one or more manholes along the route.

PLUGGING OR SEALING CONDUITS

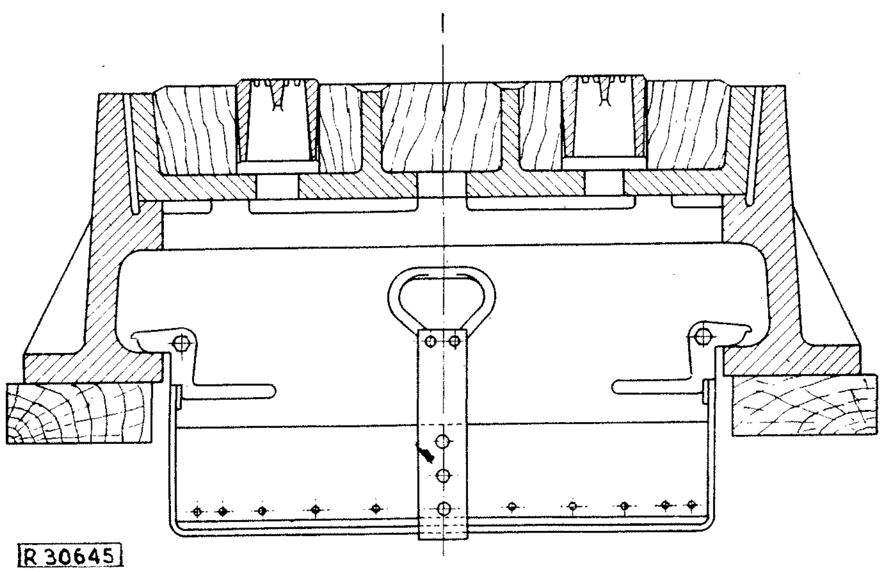
If a surface-water drain is not available, or if the necessary "fall" cannot be obtained, the conduits are sealed in the manhole as follows:-

(a) If the pressure of water is slight, empty conduits are sealed with cork plugs and occupied conduits by cotton waste and a bituminous compound.

(b) If the pressure of water is high the conduits are sealed with a lead seal, which consists essentially of a double lead sheet, perforated to permit the entry of cables, and mounted in an iron frame fixed flush with the wall through which the ducts lead into the manhole. It is important, however, to relieve the pressure of water if in any way possible, as there is a danger of the water forcing through the road surface and causing extensive damage, particularly near the foot of a hill.

VENTILATION OF MANHOLES

In order to prevent the accumulation of gas or foul air in a jointing chamber it may be necessary to provide some form of ventilation. This is usually obtained by using a ventilated type of cover as shown in Figs. 39, 40 and 41. Figs. 39 and 40 show an old round type of ventilated manhole cover in which cast iron grids are inserted in the wooden blocks of the cover and centred directly over the holes in the underside of the casting. A catchpan is fitted beneath the cover to collect road dirt and surface water entering the vents. The catchpan is illustrated in



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Section through Manhole Entrance, showing Ventilating Grids and Catchpan.

Fig. 39

Fig. 40 where it will be seen that a clear air passage remains between the interior of the frame and the catchpan. When unit type frames and covers are fitted sufficient ventilation is usually obtained through the key holes. If further ventilation is required holes can be made through filling and filling support plate.

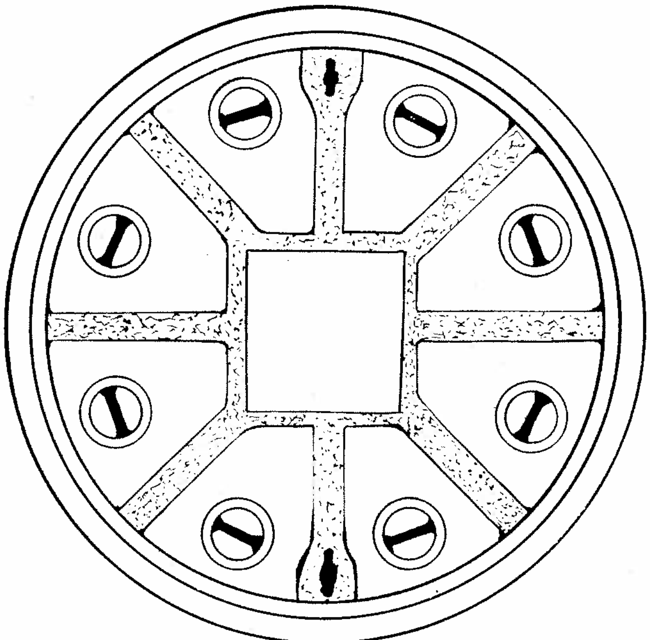

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Fig. 40

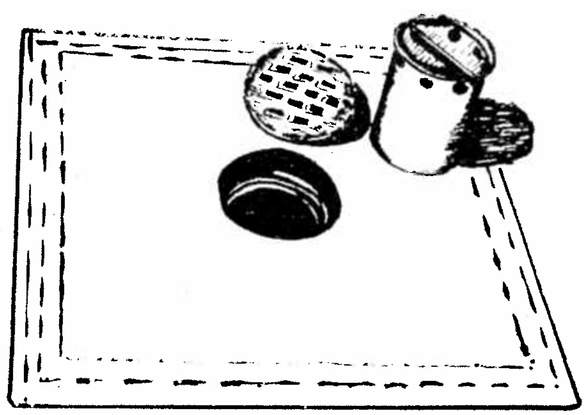

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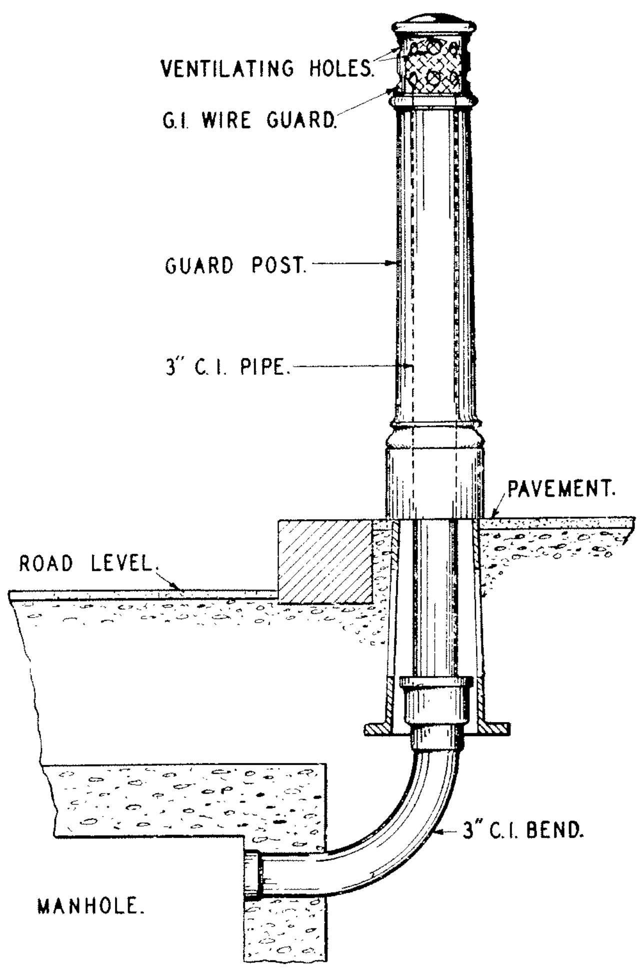
Fig. 41

Fig. 41 shows a ventilated type of footway cover. Before this cover is removed the ventilating grid and catchpan must be taken out to prevent them being damaged when the cover is placed on the ground.

Where ventilation through the manhole cover is impracticable, e.g. cover maintained caulked to prevent ingress of flood water or foul waste water, it may be possible to ventilate by means of a cast iron or steel pipe. In such cases an outlet is led from the highest part of the manhole and exhausts into a guard post on the footway, into a pipe fixed to a building or to a street standard. Fig. 42 shows an example of ventilation through a guard post.



Use of a Guard Post.

R30648

Fig. 42

<u>END</u>

<u>REFERENCE</u> E.P. - Draft Series LINES 2/3