

JOINTING AND DESICCATING PAPER CORE LEAD COVERED CABLES

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INTRODUCTION

A joint between two paper core lead covered cables must be made with due regard to the following points:-

- (1) Each wire must be joined to the corresponding wire in the other cable. For example, as regards position and code markings in a straight joint, or where a cable is to be balanced the wires to be joined are selected by electrical tests.
- (2) Each joint between wires must have a very low resistance, have a reasonable mechanical strength and be well insulated.
- (3) The cable sheath must prevent the entry of moisture into the cable, otherwise deterioration of the insulation will be caused, it must also protect the cable from mechanical damage and assist in giving the cable a reasonable mechanical strength. Therefore when two cables are joined, the cable sheaths must be joined by a lead sleeve such that these requirements are maintained.
- (4) Since the atmosphere usually contains some moisture, the exposure of the wires to the atmosphere allows their insulation to absorb moisture from it. Sometimes under abnormal conditions the joint may become very wet. Therefore the moisture must be extracted by some means to maintain the insulation resistance at the required level. The method depends on the amount of moisture to be removed, but may involve the application of heat, the use of gases such as dry air or crystals of silica gel.
- (5) Finally, the joints between the lead sleeve and the cable sheaths must be tested by air pressure to ensure that these are airtight, and hence watertight. The method of doing this requires dry air to be forced into the joint and the testing of these joints externally for air leaks.

This means that a hole must be cut in the sleeve to allow the entry of dry air, but since the dry air will also force its way into the spaces between the insulated wires, and thus away from the joint, the hole must be large enough to allow enough dry air to be forced in to maintain a given pressure within the joint. However, since the hole must be sealed on completion of the air test it must be as small as possible to reduce the possibility of leaks through its seal, because it is not practicable to test for such leaks. Therefore, the size of the hole is a matter of compromise; it should be the smallest size which will allow a given air pressure to be maintained.

JOINTS BETWEEN WIRES

There are two types of joint; the first is the twist joint which is used for wires of up to and including 40 lb gauge; the other is the soldered copper tube joint which is used for wires that are larger than 40 lb gauge, because these are too stiff to be twisted satisfactorily.

TWIST JOINT

First a dried paper sleeve is slipped over one of the wires and the two wires are then brought together and given two 180° twists with the insulation in place (see Figs. 1 and 2). Next the insulation is removed with the aid of side-cutting pliers (Figs. 2 and 3). The stripped wires are then given ten twists by means of the "crank handle" method (Fig. 4), and the surplus wire is cut off so that the total length of the completed twist is about 1 inch (Fig. 5). Finally, the twisted wires are folded down and covered with the paper sleeve (Fig. 6); the sleeve should be just large enough to be slipped over the joint without force.

The wire joints should be soldered if:-

- (a) One of the cables is of the enamelled type.
- (b) One or both conductors are of 40 lb gauge.
- (c) 4 or 6½ lb conductors are jointed to 20 lb conductors.
- (d) The cables are to carry junction or trunk circuits.
- (e) The cable is to be balanced.

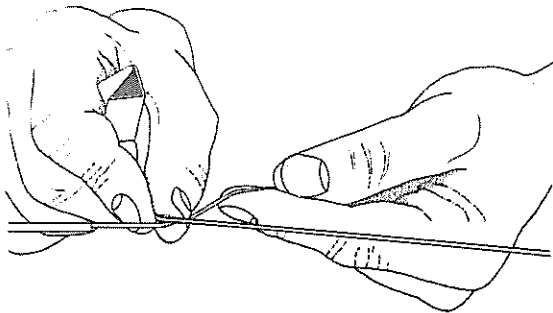


FIG. 1.

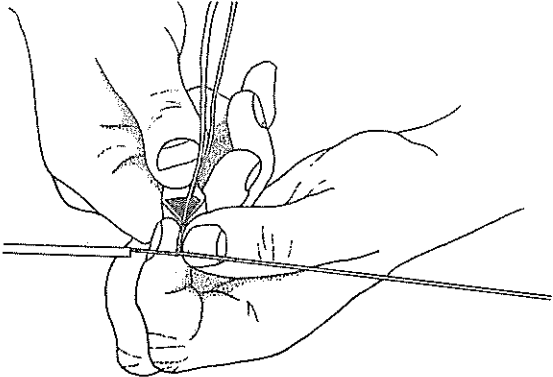


FIG. 2.

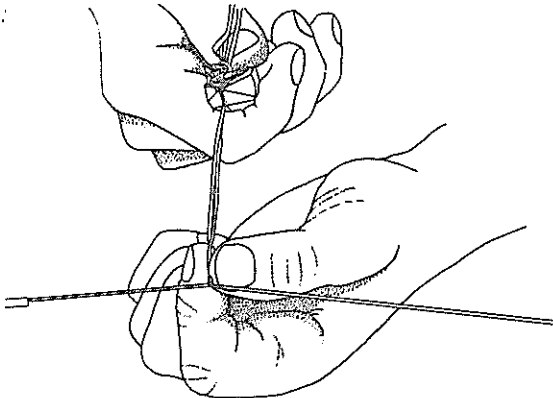


FIG. 3.

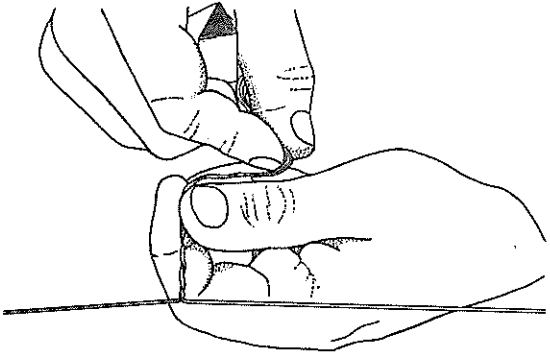
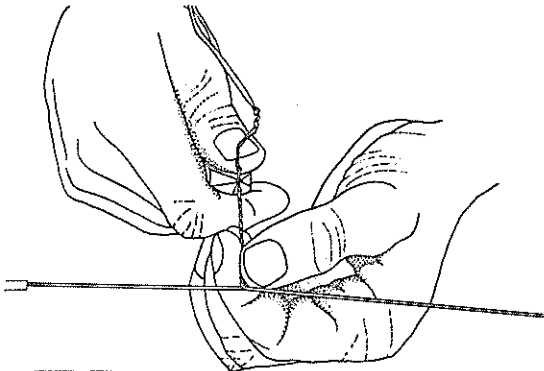


FIG. 4.



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FIG. 5.

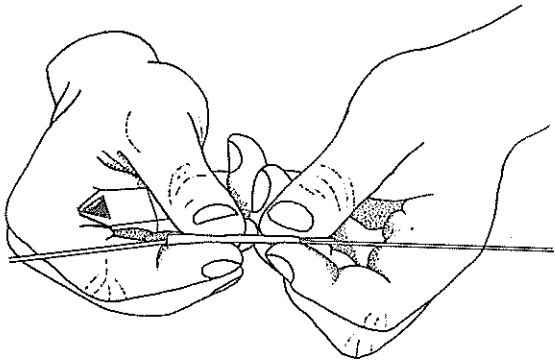


FIG. 6.

SOLDERED COPPER TUBE JOINT

The whipping threads are unwrapped for about 4 inches from the final positions of the wire joints and tied securely. A dried paper sleeve is placed over one wire, and then the insulating paper is carefully unwrapped from each of the two wires to be joined back to the sleeve on one and to the tie on the other. The insulating paper is cut so as to leave an overlap of $1\frac{1}{2}$ inches for covering the completed joint: see Fig. 7. Next, the wires are cut so that they butt closely when drawn out straight. After cleaning, the ends of the wires are inserted in a copper jointing tube and the joint is then soldered. Finally, the two loose ends of insulating paper are wrapped around the joint, one over the other as in the figure, and covered with the paper sleeve.

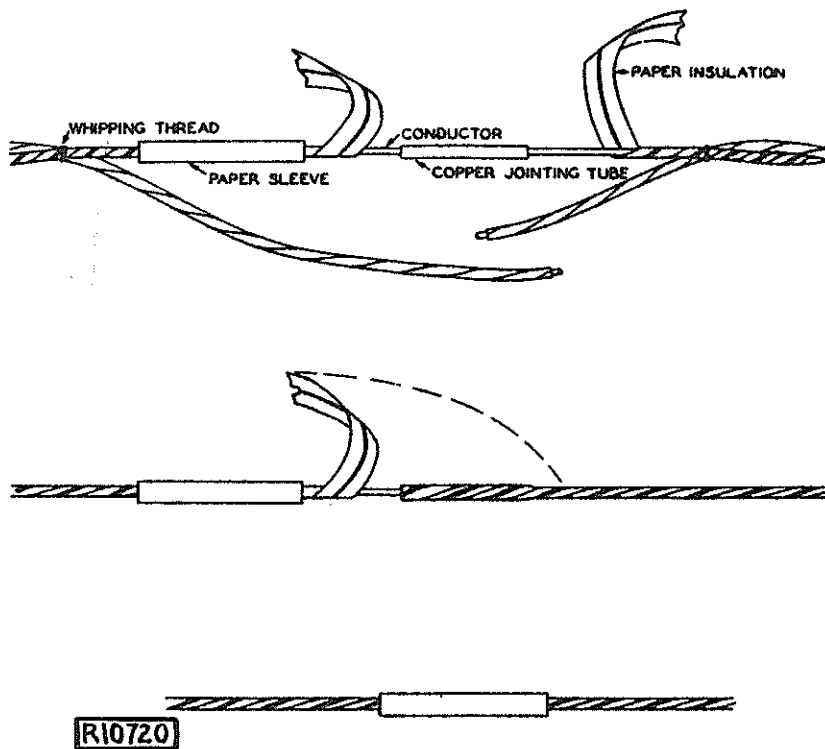


Fig. 7

JOINTING LEAD-COVERED CABLES

Before commencing any jointing operations in a manhole, tests for the presence of explosive gases and foul air are made; these tests should indicate that it is "safe" before the jointing chamber or manhole is entered. If the manhole or jointing chamber contains water, it is then pumped or baled out and further gas and foul air tests are made. The chamber can then be cleaned out with cotton waste if necessary.

If possible, a position is chosen for the joint so that there is room to slip the lead sleeve along the cable clear of the joint, and so that the jointing and plumbing can be done conveniently. If the cable is a small one, such as is used for subscribers' distribution, the lead sleeve is soldered, but with larger cables plumbed joints are made.

The method of preparing the lead sleeve is discussed in E.P. GENERAL 5/1.

PREPARATION OF CABLE ENDS

Sufficient of the cable sheath on the two cable ends is removed so that when the joint is completed the exposed core is about $\frac{7}{8}$ of the length of the sleeve. A cotton tie is made over the core about $\frac{1}{4}$ inch from the end of the lead sheath on each cable and then the paper lappings are removed from around the core. Next, the wires of the outside layer of each cable are separated into two approximately equal groups, given a twist to keep the groups separate, and bent back at right angles to the cable. A tie is made round the remaining wires and the process repeated for all the other layers. If star quad cable is being jointed, the whipping is tied round the quads near the position where the wire joints are to be made. A dried paper sleeve is threaded over each wire of the cable on one of the prepared cable ends in readiness for jointing. Sleeves of two different sizes are used on unit twin cable; a small sleeve over the A wire and a larger sleeve over the A wire joint and the B wire.

ORDER OF JOINTING

Wherever possible, jointing is started at the centre of the joint. If, however, there is insufficient space around the joint for this method to be used, jointing is started at the far side and finished at the near side, i.e. the farther half of the outside layer is jointed first, the farther half of the adjacent layer next, and so on, until the joint is completed.

When jointing quad cables particular care must be taken to ensure that diagonal wires of a quad are used to form a pair. If a mistake is made and adjacent wires are used, the error must be corrected at the joint where it was made and not at a subsequent joint.

POSITION OF WIRE JOINTS

The positions of the wire joints are staggered so that the paper sleeves form two or more distinct banks, depending upon the size of the cable, and do not overlap indiscriminately in such a manner as to cause an unnecessary increase in the diameter of the joint. Thus when all the wire joints are completed, the joint presents the smoothest possible appearance: see Fig. 8.

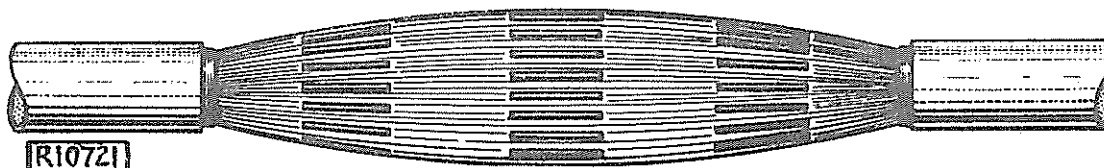


Fig. 8

CABLE TESTS DURING JOINTING

Electrical tests should be made as the jointing proceeds to:-

- (a) Prove the continuity of the wires.
- (b) Prove the absence of wire crosses between pairs.
- (c) Prove freedom from contacts and earth.
- (d) Ascertain the insulation resistance to ensure that it is not less than the required minimum.

DESICCATION OF JOINT

When the jointing operation is completed, it is necessary to provide some means of drying the joint to remove any moisture which may have collected during the jointing process. There are a number of possible methods of drying out the joint. Examples are hot air from blow lamps or electric fans equipped with heaters, and moisture absorbing gases or crystals. Electric fans with heaters are being developed for this purpose, but they do require a supply of electricity which may not always be available. The use of blow lamps requires great care to avoid damaging the cable. However, under normal conditions the amount of moisture to be removed is small, and the use of blow lamps for drying out is avoided by the use of a chemical known as Silica Gel which is more convenient to use than a gas.

Silica gel is a form of silica (SiO_2) specially prepared so that a structure is obtained in which the pore space is greatly in excess of that of silica in its usual forms. This pore space has the property of adsorbing and condensing gases and vapours to a marked degree. Silica gel is capable of adsorbing 40% of its own weight of water without increase in volume. On the application of heat, the water vapour is driven off and the silica gel can again be used to adsorb moisture. This cycle can be repeated indefinitely without loss of efficiency.

For use in a cable joint, the silica gel is placed in cotton gauze pockets which are available in three sizes. Immediately before issue, the pockets of silica gel are baked for about half an hour in a gas oven and then kept in air-tight tins until they are placed in the joint. A completed joint with pockets of silica gel in position is illustrated in Fig. 9. If the cable has above 74 pairs, the wires are slackened to allow the insertion of pockets close to the inner core; this equalizes the rate of drying throughout the core of the cable. The joint is then wrapped with insulating paper which is secured by means of thread. Immediately the silica gel is removed from the tin it adsorbs moisture from the air, and this renders it less effective for drying out the joint. Therefore, the joint should be plumbed as soon as possible to keep the adsorption of moisture from the air to a minimum.

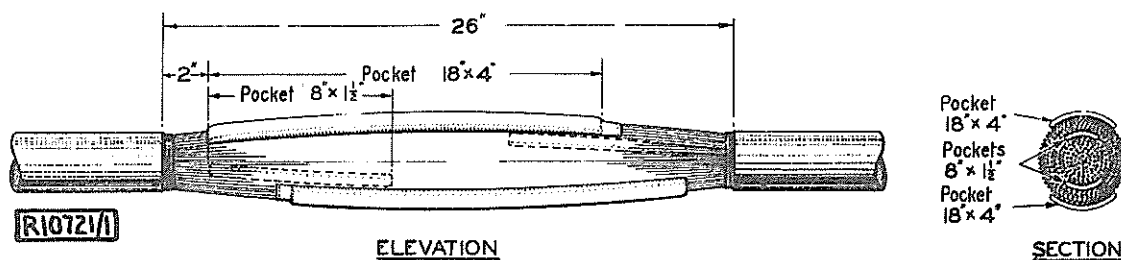


Fig. 9

PLUMBING THE JOINT

The joint is covered with the lead sleeve which is then plumbed to the cable sheaths. The methods of plumbing and pressure testing the plumbing are described in E.P. GENERAL 5/1.

TEMPORARY CLOSING OF A JOINT

Where it is necessary to temporarily close a joint, this may be done by means of temporary plumbing or taping.

Temporary plumbing is formed by finger wiping as indicated in Fig. 10. One end of the sleeve is dressed down and finger-wiped, whilst at the other end a lead disk is butted to meet the sleeve and is finger-wiped to both the sleeve and cable.

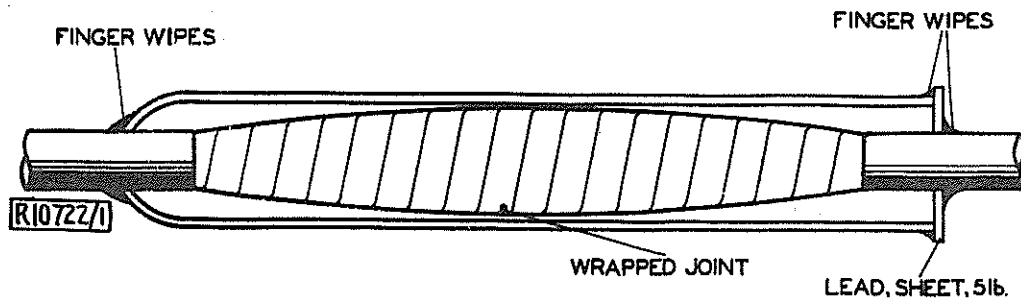


Fig. 10

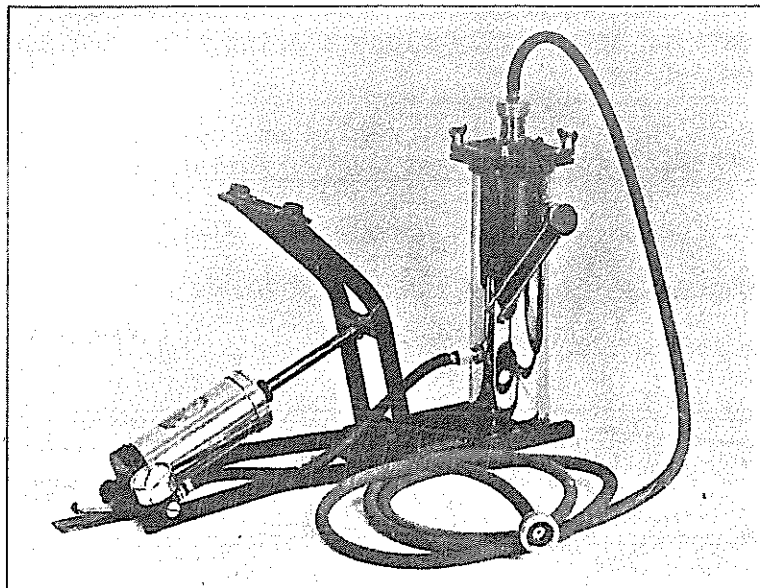
Taping of a joint is carried out by means of a sealing tape, which is a fabric type bandage impregnated with a petroleum jelly paste rendering it adhesive and waterproof. If the tape is re-used, further sealing paste is added to the tape. Taping is not resorted to where the cable chamber is liable to flooding.

DESICCATION OF THE AIR USED FOR PRESSURE TESTING

There is little point in drying out a joint by means of silica gel unless the air used for pressure testing is also dried. It is desirable for the desiccating plant to be small and portable so that it can be carried about by cable jointers as part of their normal equipment. Therefore, the portable desiccator, used in practice consists of a foot-operated air pump fitted with a pressure gauge and non-return valve, coupled to a drying cylinder which contains an air drying agent of crystalline form. A flexible connexion is attached to the delivery side of the drying cylinder to feed the dried air to the cable joint. The non-return valve is contained in a housing beneath the pressure gauge, its function is to isolate the gauge and delivery side of the apparatus from the pump. Hence the gauge reading shows the pressure in the drying cylinder and the cable.

Earlier models (see Fig. 11) of these portable desiccators use calcium chloride for drying the air. The calcium chloride is suspended in a bag from a hook at the top and inside the upright drying cylinder. When the calcium chloride becomes unfit for drying air it is scrapped and replaced by a fresh charge. To determine whether the calcium chloride requires changing it is subjected a visual examination periodically, but this means that the top of the drying cylinder must

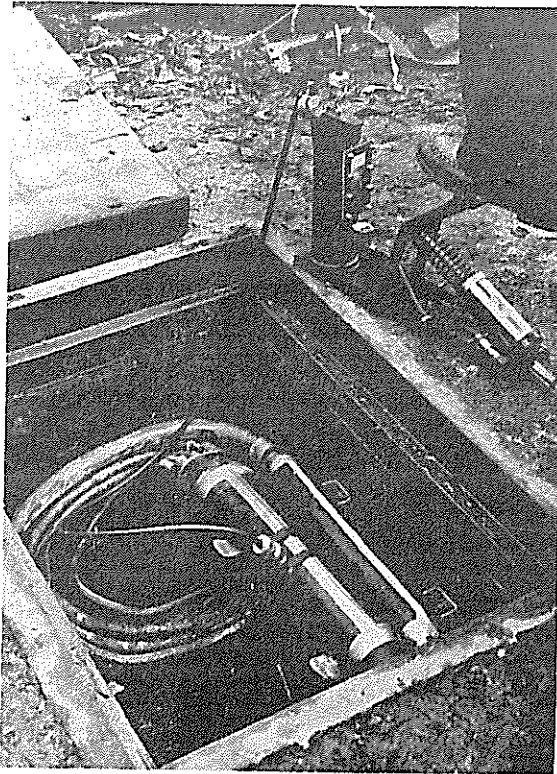
and this is rather inconvenient. In practice this has proved to be unsatisfactory since the checks have not been made frequently enough, consequently, calcium chloride has often been retained after it has become useless for drying air.



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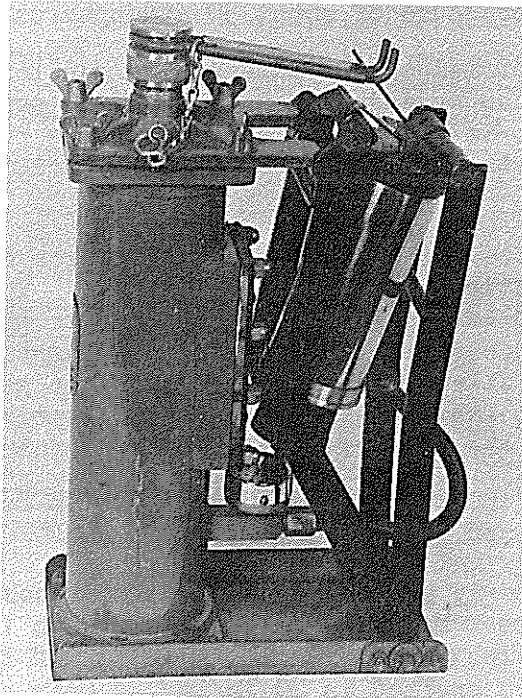
Fig. 11

The disadvantages of using calcium chloride are overcome in the latest type of portable desiccator which uses silica gel as the drying agent. The silica gel is coloured with cobalt chloride and is blue when in a dry and highly adsorbing condition; this colour changes progressively to pink as atmospheric moisture is adsorbed and thereby gives a visual indication of its condition. To facilitate the checking of the silica gel's condition, the drying cylinder is fitted with a Perspex window which incorporates a panel of four coloured strips showing a range of colour changes and indicates the conditions when the silica gel may and may not be used for drying air. Advice about reactivation of the silica gel is also given. Partly porous baffle plates are provided to ensure that the air flow inside the cylinder does not bypass the silica gel contained in the window recess. Fig. 12 shows a portable foot pump desiccator of this type in use, and in Fig. 13 the desiccator is shown folded up ready for carrying.



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Fig. 12



R34799

Fig.13

DESICCATION OF CABLES

Cable failures often arise because of the penetration of water through cracks or punctures in the cable sheath. If a cable is completely saturated at any point the faulty section must usually be replaced because of the effect of electrolytic action on the insulation; otherwise the remedy will depend largely upon the degree of saturation and the extent of the penetration of water. However, there are occasions when the cable can be temporarily restored to service by means of desiccation, and this allows the main repair work to be carried out later without undue haste.

Normally, temporary restoration of the existing faulty cable by desiccation is accomplished by passing dry gas through the cable to remove the moisture. Either carbon dioxide (CO₂) or dry air is used for this purpose. The former is conveniently supplied in cylinders, but it collects in jointing chambers at the discharge points and must be dispersed before the repair work can be continued. Therefore air dried by calcium chloride or silica gel is more suitable. However, calcium chloride has certain disadvantages (e.g. it has to be replaced periodically) and is not as useful as silica gel for this purpose, especially under breakdown conditions. For this reason a motor-driven desiccator using silica gel has been developed for use on cables; the development work is still going on, but it seems likely that this type of desiccator will eventually supersede the carbon dioxide desiccator for general use.

CO₂ DESICCATOR

Dry carbonic-acid gas (anhydrous carbon dioxide) can absorb moisture to a degree which, at saturation point, reaches approximately 0.65 per cent by weight.

CO₂ is supplied in annealed steel cylinders which contain 28 lb of gas, equivalent to 240 cubic feet at normal atmospheric pressure. When supplied, the cylinders are charged to a pressure of about 50 atmospheres, roughly 750 lb/in².

Cable desiccation is carried out by passing the gas through a control valve or automatic regulator, which can be adjusted to reduce the pressure on the cable side within the limits of 5-30 lb/in². At the distant end, a suitable outlet is provided for the release of the gas, together with the moisture absorbed during its passage through the cable.

In passing through the reducing valve the gas freezes on expansion and may choke the valve by the formation of carbonic-acid snow. To prevent this choking effect, cloths soaked in hot water are usually applied to the reducing valve, but in very cold weather it is necessary to fit warming apparatus between the gas cylinder and automatic regulator. In this apparatus the gas passes through a heating coil before reaching the reducing valve; the heating coil is warmed by a small spirit lamp fitted in the base of an aluminium container.

The apparatus required and the method of application for the desiccation of a cable are shown in Figs. 14 and 15.

The gas is turned on slowly by opening the cylinder cock. The reducing valve is adjusted until the low pressure gauge indicates between 10 and 20 lb pressure, depending on the type of cable. For example in cables of the star-quad type the maximum pressure which may be applied is 20 lb/in². Only sufficient pressure for the gas to reach the distant end is necessary. Nothing is gained by passing the gas through more quickly than it can absorb moisture from the cable, and therefore,

steps should be taken to control the flow of gas at the point of discharge. This can be achieved by reducing the size of the aperture made in the cable sheath, or by tightening the screw-cap of the air nozzle.

A characteristic of desiccation by CO_2 is that improvement of the insulation continues as a result of the retention of the gas in the cable. The method of filling the cable with gas, leaving for several hours, and discharging and recharging, may be followed with advantage to avoid prolonged continuous attendance.

CO_2 is heavier than air and consequently tends to accumulate at the bottom of manholes in which it is released. On this account it is necessary to adopt precautionary measures to prevent a dangerous accumulation of gas or, failing this, to take effective steps for its dispersal.

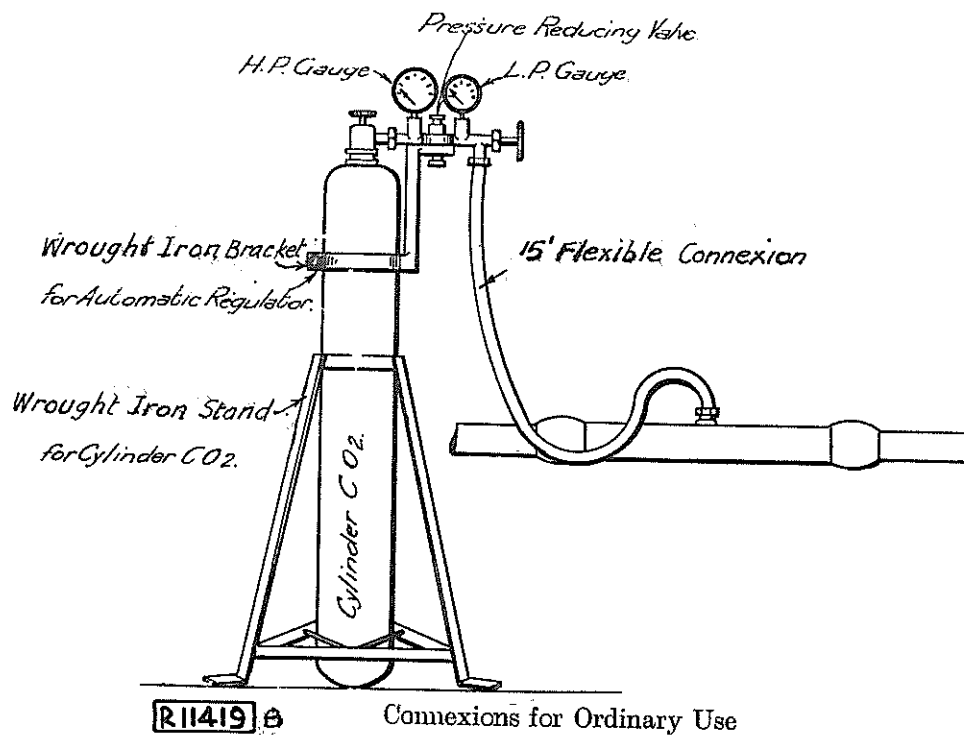


Fig. 14

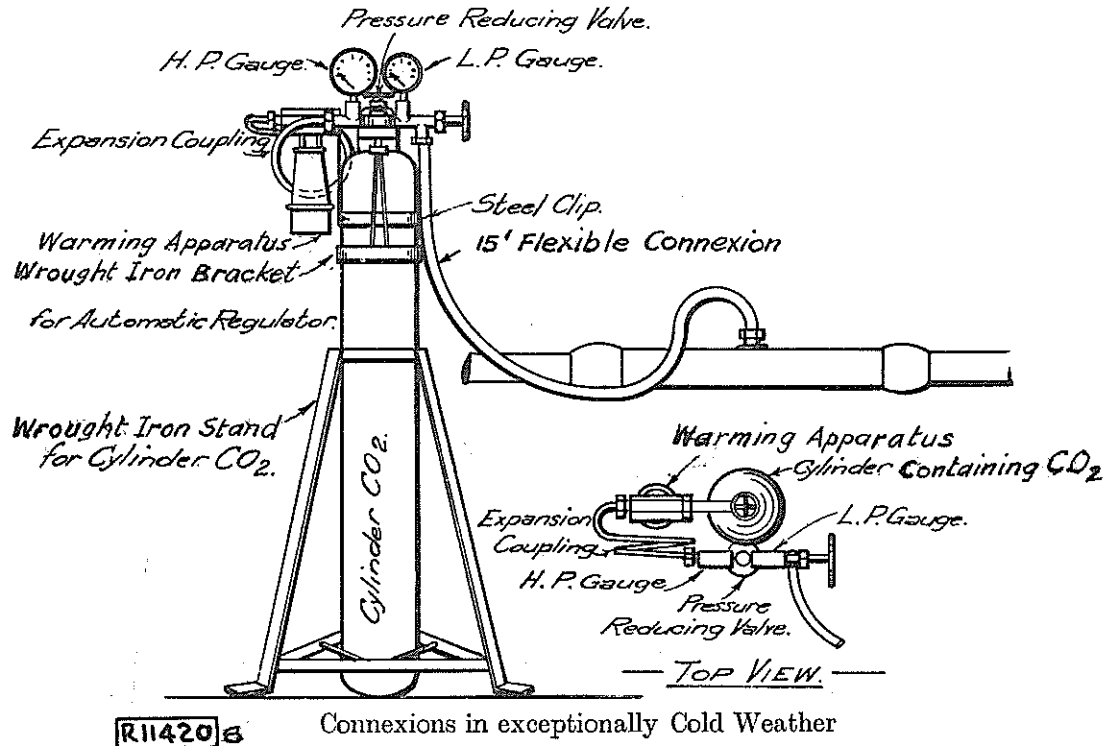


Fig. 15

MOTOR-DRIVEN DESICCATOR USING SILICA GEL

This type of desiccator is a trailer mounted apparatus, and it is shown schematically in Fig. 16. It has two separate beds of silica gel, and when in use, one bed dries the air delivered to the cable whilst the other is being reactivated by air heated by the hot exhaust gases from the engine. The air inputs to and the air outputs from the silica gel beds can be rapidly changed over by the operation of a single lever, hence when in use these beds are made to go through the air drying and reactivation cycles alternately.

The compressor is driven by a petrol or diesel engine via a clutch. Air is sucked in, filtered, compressed and passed to the air receiver. After leaving this receiver the compressed air separates, the bulk going to the silica gel drying bed, while the remainder is heated in the heat exchanger and then fed through the second silica gel bed to dry it by blowing off the water vapour liberated from the silica gel by the heat in this air. Safety and automatic unloading valves are provided in the air receiver: the function of the automatic unloader is to trip a valve in the compressor and so relieve the load on the engine when the volume of air compressed exceeds the volume of air used.

The function of the primary cooling coil is to increase the relative humidity of the compressed air and so facilitate its drying. A further cooling stage ensures that the temperature of the dried air delivered to the cable is not appreciably higher than the ambient temperature.

Although the bulk of the silica gel in each bed is plain, a small quantity is coloured with cobalt chloride and placed in a perforated container behind the small window to indicate the condition of the silica gel. As with the portable foot-pump desiccator, a colour comparison guide is provided adjacent to the window to indicate the conditions when the silica gel is safe and unsafe to use.

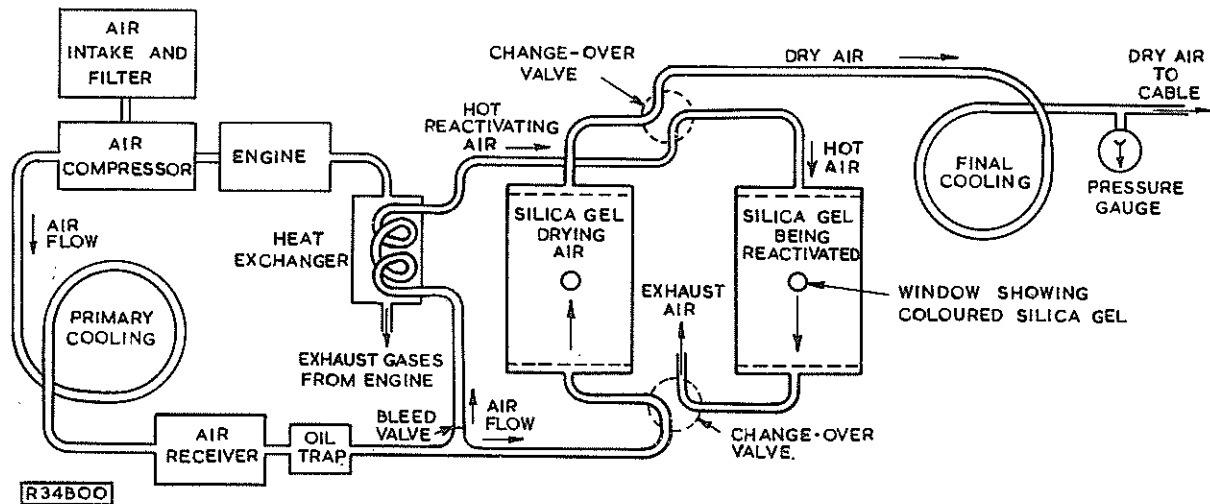


Fig. 16

ENDREFERENCE

E.P. - Draft Series GENERAL 5/1

ACKNOWLEDGEMENT

The information on silica gel desiccators has been taken from I.P.O.E.E. journals.