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Buried Cables

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W. H. BRENT, B.Sc., A.M.I.E.E., and
A. H. BROWN.

This article describes experience which has been gained in the use of mechanical aids for burying cables and indicates the extent of the economy in manual labour which may be effected thereby.

Introduction

A FEATURE of war-time construction work is the provision of circuits in outlying places. Many miles of small cables, principally 20-pair P.C.T. 20-lb. type, have been and are being laid in all parts of the United Kingdom, and the experience gained in the Midland Region in this class of work may, therefore, be of interest. With the shortage of labour and the need for speeding up the provision of these circuits, it is not surprising that standard methods of underground construction have had to be relaxed and new standards for cable laying in open country adopted. These now permit lead-covered cables with or without hessian tape and compound protection, according to the character of the soil, to be laid direct in the ground at a minimum depth of 9 ins., with extra depth and mechanical protection at road crossings. Future development (the main advantage of the use of duct work) can be provided for by selecting routes where there is room for a second cable to be laid with a reasonable clearance, say about 4 ft., from the first. A considerable programme of work of this character was in view, and the opportunity thus presented itself for new methods to be adopted to complete the works to schedule.

Available methods employing mechanical equipment for the saving of labour are: (1) the ordinary deep furrow agricultural plough, (2) the Killefer plough and ripper, (3) the Allen-Parsons bucket excavator, (4) the modified moledrainer, and (5) the modified ripper plough. All these have been tried with varying results.

The Agricultural Plough

The deep digging agricultural plough capable of digging to a depth of 16 ins. and turning a furrow from 14 to 18 ins. wide was first tried out as an aid to laying wood troughing. The results were satisfactory in that the work of excavation was reduced, but it was considered that too much manual labour was still required for the completion of the trench and the subsequent filling in, and that further experiment was warranted.

The Killefer Plough

In several localities the Killefer plough has been used. This is a large double share plough of very strong construction requiring a caterpillar type tractor of 110 h.p. (D8 type) to pull it. A trench is cut to a depth which, under favourable conditions, may reach 2 ft. 6 ins. and of a tapering width 3 ft. 6 ins. at the top and 8 ins. at the bottom. The excavated soil is thrown up on either side, but this tends to fall back so that only a net depth of 1 ft. 6 ins. may be left, and several passes are usually made before a satisfactory trench results. Most obstacles are removed by this plough, and any type of soil can be dealt with, but if difficulties are anticipated the ripper (or rooter) tool, consisting of a plain steel bar ($3\frac{1}{4}$ ins. × 8 ins.) with a steel shoe at the foot, is first dragged through the soil. The overall width of trench with the accompanying mounds of soil is 10 to 14 ft., and choice of route has to be made with this in mind. The soil can be subsequently pushed back into the trench by an angledozer fitting on the front of the tractor.

In locality "A" this equipment was used. An appreciable amount of manual labour was expended to "bottom-up" a somewhat rough trench and to provide an initial filling layer of about 6 ins. of fine soil, so that the cable was not damaged during the mechanised filling operations subsequently carried out by the angledozer. The actual effective time spent on laying 3,980 yds. of cable was 520 man-hours (excluding the tractor operator's time), half of which was expended in levelling the bottom of the trench and the remainder in laying the cable and covering it with a layer of soil. The average rate for comparative purposes was thus 230 man-hours per mile.

The Allen-Parsons Excavator

The Allen-Parsons excavator, having an endless chain of buckets, is well known and is mentioned because trenches opened by this means have been used for buried cables. A good straight-sided trench 12 ins. wide and 2 ft. deep can be excavated in most soils and is suitable with little extra work for laying ducts. A number of such duct laying works have been carried out and a considerable amount of excavating (but not refilling) labour saved. Experience shows that level ground is necessary, both to ensure a vertically-sided trench and to avoid the risk of the machine falling over. It has, therefore, often been necessary to provide a track of timber on the lower side of sloping ground. Clayey soils tend to clog the buckets and retard progress considerably. The machine requires a space approximately 7 ft. in width for operation and, in common with other mechanical appliances, freedom from the obstruction of other services, so that the field of use for this equipment is limited. As, however, the overhanging seat for the driver can be used on either side of the machine and arranged to overhang the road, it is possible for the machine to work on about 4 ft. width of verge. An account of work done by this type of machine is to be found in the October, 1941, issue of this JOURNAL.[1]

The Moledrainer Plough

Some previous experience of laying cables direct in the ground, using a moledrainer, was obtained in 1932,[2] and that experience has been the basis of the more recent work of September and October, 1941. In the earlier works the cable was drawn in directly behind the mole, the leading end being attached to it, and severe stresses were at times imposed on the cable. Following descriptions of recent American and Canadian practices in this field and recent development work in the Cambridge Area in which the cable is fed into the ground through a pipe fixed to the rear of the mole blade, great improvement has resulted. The tensile stress induced in the cable is almost negligible, being only that due to friction in passing through the pipe, and, in consequence, full drum lengths of cable can be laid without joints, whereas with the older method the length of pull had to be strictly limited and the cable protected by a mechanical fuse to restrict the stress which could be induced on the cable. Further, with the cable feed-tube method, not only can the moledrainer be coupled to the rear of a caterpillar type tractor through a mechanical fuse, thus giving greater speed of working, but a straight course is no longer essential, so permitting greater freedom in the choice of route. Finally, tractor-winches necessary for the older method but not for the new are in limited supply, and the transport of a few special machines over long distances is avoided, suitable caterpillar tractors being hired locally as required.

A Ransome C86 type moledrainer having a 2½-in. mole attached to a blade, which is adjustable to a depth of 18 ins. in the ground, was obtained and arrangements made to modify it for cabling work. The modification is illustrated in Fig. 1, and it will be seen that a 1½-in. diameter pipe extending from an extension piece behind the mole to a position above the top of the chassis is attached to the plough. The pipe is rigidly clamped to the chassis by a bracket and is held between two mild steel plates secured to the blade of the plough by countersunk rivets. It is welded to the extension piece at the bottom and terminates in a cup at the top to facilitate entrance of the cable. The Ransome implement digs itself in, has a self-lift mechanism and a simple device for grading the depth of the mole, and these facilities have been used with advantage in practice.

After consultation with agricultural experts as to the appropriate type of tractor, a Caterpillar D6 tractor (45-60 h.p.), with operator, was hired in the

FIG. 1.—MOLEDRAINER MODIFIED FOR CABLING WORK.

vicinity and operations were commenced with a working party consisting of a foreman and five men equipped with a 2-ton Albion stores-carrying vehicle, with driver, from which to pay out the cable. Subsequent experience has confirmed that the D6 is the most suitable type of tractor for the work; the caterpillar track is essential and there is sufficient power to meet all conditions.

Typical Work Employing the Moledrainer Plough

While the plough was being modified, a careful survey was made in locality "B," and from an examination of the subsoil it was decided that the conditions were favourable for the initial trial. To expedite the progress of the work and to reduce the risk of faults, it was considered that the cables should be laid with a minimum number of joints. To this end, therefore, full drums containing 1,000-yd. lengths of cable, PC. 20 pr./20 lb., were conveyed to the site and laid out at convenient points along the track, which had been staked when the survey was made.

One of the drums of cable was mounted on jacks securely bolted to the floor of the Albion lorry, which was brought into a position alongside the tractor at the starting point. The modified moledrainer was hitched to the tractor with a short length of 7/8 G.I. strand wire, which served as a mechanical fuse to protect the equipment against overload stresses. The cup on the plough was filled with sodium silicate petroleum jelly emulsion, which was also applied to the top layer of cable on the drum. The end of the cable was then threaded through the pipe and anchored on the ground.

[1] *P.O.E.E.J.*, Vol. 34, p. 147.

[2] *I.P.O.E.E.*, Printed Paper No. 146.

Three men mounted the Albion, two of them taking positions to turn the drum, the other to spread the emulsion evenly over the sheath and guide the cable as it was paid off. The other two men remained on the ground, one to feed the cable into the pipe and attend to the moledrainer, the other to maintain a bight of slack cable behind the moledrainer as a precaution to prevent damage to the cable in the event of a mishap arising. The foreman mounted the tractor near the operator, in a position which enabled him to keep all phases of the work under close observation and from which any start or stop signals were promptly recognised by the whole party.

The tractor and motor vehicle then moved forward side by side at a speed of about 2-3 miles per hour, and a length of about 200 yds. of cable was laid, without hitch, at a depth averaging 12 ins. Operations were then halted while a brief inspection was made to determine the condition of the cable at one or two points. The cable being satisfactory, the work was restarted and continued until the top layer of cable was drawn off the drum, when another halt was made to apply grease to the second layer. These halts afford a period of respite to the men controlling the drum, whose energies are fully taxed to keep pace with the speed of the tractor, especially when the drum is fully loaded. When the complete length was laid, the working party unloaded the empty drum from the motor vehicle and set up a fresh one for the next length.

While the preparations for the following length were proceeding the tractor travelled back along the track, and its weight compressed and levelled the slight "swell" made by the cut. After this the surface of the ground appears practically unaltered, and where there are special reasons for avoiding obvious signs of trenching, this is a particular advantage of the moledrainer method.

The foregoing procedure was followed generally throughout the work where the track was under open grass-land, but at one point between buildings there was insufficient width for the tractor and lorry to travel side by side, and the cable was laid out on the ground in advance of the tractor and moledrainer. It was then lifted and fed into the cable tube as the machine proceeded. Fig. 2 shows cable being passed into the tube of a moledrainer after being laid on the grass. In another short section the surface was too hard for the moledrainer, so, to avoid making joints, the mole was raised and the cable was paid out through the pipe of the mole-drainer at ground level. It was thus laid out along the ground and subsequently lowered into a trench excavated by hand. A somewhat similar method was adopted where a ditch was encountered which could not be crossed by the tractor. The tractor travelled to the brink of the ditch, where it was uncoupled from the moledrainer and taken by another route to the other side of the ditch. The moledrainer was recoupled with a suitably long length of 7/8 G.I. strand wire and drawn over the ditch on two skid boards. At road crossings, where ducts had been laid in advance, lengths of cable sufficient to reach through the ducts, were passed through the moledrainer pipe before the cable was cut. These lengths were coiled up and drawn in later.

Unforeseen obstructions, such as old foundations and a water-pipe, were encountered, but apart from breaking the fuse and thereby hindering the progress of the work, no serious damage was done to the mole or the coulter. Drawing the machine back from an obstruction on one occasion damaged a short length of cable which had to be cut out, but this can be avoided by excavating to free the cable in the soil before clearing the obstruction. An incident occurred when the Albion lorry was travelling over uneven ground, the tilt of the vehicle causing the cable drum to slide along the spindle; consequently one of the fixing nuts on the cable drum fouled the jack and prevented the drum from turning. Prompt action to stop the operations and the precaution of maintaining a bight of free cable prevented any mishap, and a collar about 3 in. long improvised from 2½-in. steam-pipe fixed on the spindle on each side of the drum has prevented further trouble.

Altogether, during the course of three days' work at locality "B," 2,824 yds. of cable were laid, including 206 yds. where trenches were excavated by manual labour and 150 yds. where the cable was drawn into ducts.

Comparative Costs of the Moledrainer and other Methods.

Having obtained such satisfactory results with the moledrainer in the initial experiment, extended trials were carried out in other localities and, mainly in consequence of the experience gained at locality "B," the results on the subsequent work were even more gratifying. The rate of progress was governed to a considerable extent by the number of occasions it was necessary to cut the cables on account of road crossings or other obstructions and by the number and length of the spur cables, and it is worthy of

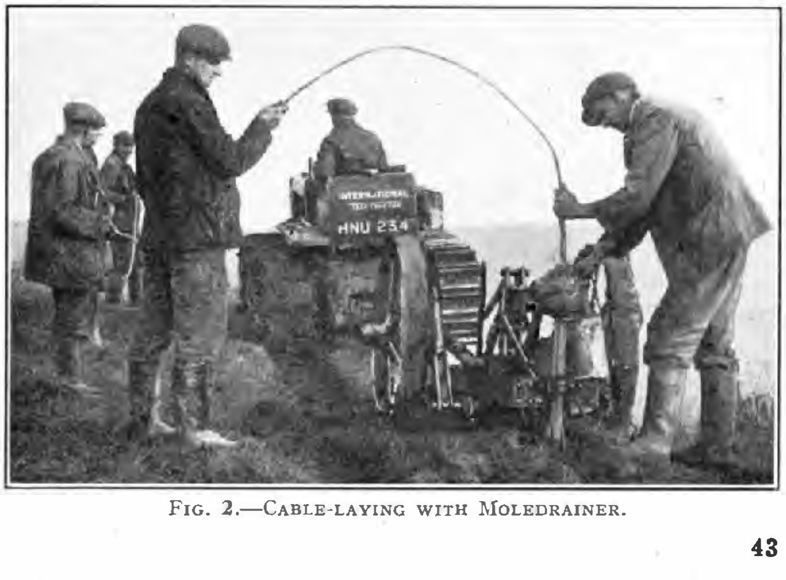

FIG. 2.—CABLE-LAYING WITH MOLEDRAINER.

note that where the conditions were particularly favourable, as much as 3,000 yds. were laid during the course of one working day of 10¾ hours. Details of a series of cable works in which the moledrainer was used are given in Table 1.

TABLE I
CABLES LAID BY MOLEDRAINER

Locality	Total length laid		Effective Manhours	Average rates —Manhours		Charges for hire of tractor
	Yds.	Miles		Per yd.	Per mile	
B	2,468	1·402	213	0·036	152	£23
C	3,500	1·989	146	0·042	73	25
D*	3,150	1·790	216	0·068	121	28
E	4,700	2·670	170	0·036	64	28
F	3,620	2·057	214	0·059	104	24
Total	17,438	9·908	959	—	—	128
Mean	—	—	—	0·055	97	—

* A number of comparatively short spurs were laid and inclement weather was experienced during the course of this work.

From Table 1 it is evident that the cables were laid much more expeditiously and economically than the cable laid in the trenches excavated with the Killefer equipment at locality "A." At the site where the latter was used the subsoil was a dry heavy clay which was thrown out of the trench in the form of large boulders. Many of these fell back into the trench, and it may be that more than a normal amount of time was required to level the trench and to ensure that the cable was not damaged when the trench was filled in. However, several trenches have been excavated with the Killefer Plough equipment in other localities, and it has been remarked generally that the bed of the trench was very uneven, so it seems probable that some clearing and levelling would usually be necessary. The fact remains, however, that the cable could have been laid with the moledrainer at locality "A" at a rate comparable with those achieved in the other localities and, since the running costs of the Killefer equipment are considerably higher than the charges for the tractor and mole drainer, the above contention as to the merits of the two methods seems well justified.

The works referred to in Table 1 were scattered over a wide area, and subsoils of clay, fine gravel and fairly heavy loam were encountered. On one occasion the moledrainer cut through what appeared to be a length of disused brick drain without breaking the fuse or damaging the machine, and the presence of the obstruction was only revealed as a result of an investigation made to determine why the speed of the tractor had been retarded. Although such an event serves to demonstrate the stability of the equipment, it also emphasises the need for making full enquiries to determine the position of any other buried plant when the cable track is being surveyed.

Owing to the abnormal manner in which ordinary lead-covered cables had been laid, special insulation tests were made with satisfactory results on each of the separate lengths before they were jointed, and there is no evidence or reason to believe that the cables have suffered any unsuspected damage during the course of the operations.

Both plain lead-covered and protected cables have been successfully laid with the moledrainer, a mixture of whiting and water being used for the protected type as a lubricant in the tube to prevent the compound sticking.

Conditions on some sites have been such that a wheeled motor vehicle was unable to travel along the track owing to the yielding character of the ground, and this difficulty has been surmounted by laying the cable alongside the route, using the tractor as an aid in pulling out the cable. It has also been expedient to adopt this method for short spur cables, setting up the drum at one end of the spur and pulling off the required length. A further development for work on this class of surface was the construction of a timber sledge on which the cable drum jacks were securely bolted. This was dragged over the ground by the tractor and used not only to get the drums of cable on site but also to pay out cable along the route prior to laying by the machine. On some sections the tractor has pulled both moledrainer and cable sledge and the cable passed from the drum through the pipe into the soil in one operation. This is illustrated in Fig. 3.

From some points of view it may appear to be irrelevant to try to determine the saving in manhours which has accrued as a result of using the moledrainer in lieu of normal methods, but as speed of completion and saving of labour were the main objectives the comparisons given below are of striking interest. In the calculations an attempt has been made to use basic rates consistent with those which would have been obtained if normal methods of construction had been employed, and thus to estimate the time (in man weeks) gained and the expenditure saved on the works scheduled in Table 1.

The direct labour cost of these five works is calculated at £110, which, with the cost of tractor hire, gives a total cost of £240. If the trenches had been excavated entirely by hand, the cable laid and the ground restored, it is estimated that the direct labour cost would have been £1,140 for the 9·9 miles.

FIG. 3.—CABLE-LAYING WITH MOLEDRAINER AND SLEDGE.

For the purpose of this calculation the observed rate of excavation for such work at locality "B" has been taken where the cable was laid in trenches at the same depth as it was laid by the moledrainer. If, moreover, ducts had been laid and the cable drawn into them, the estimated total cost of direct labour and ducts becomes £2,640. The net saving in cost of the moledrainer method over the hand trenching method is, therefore, £900, or, over the use of ducts £2,400, and this shows significantly the extent to which it has been possible to effect economies by using the moledrainer plough.

The speed in the completion of works is also apparent in that the time taken to do the effective work is only 9 per cent. of that calculated to be required to lay cables in open trenches, or 6 per cent. of that required for duct construction. Actually, the whole of the work in the five localities referred to was completed in the course of 13 working days.

The Ripper Plough

The modification of the ripper plough followed in principle, but varied in design from that of the moledrainer. The ripper plough is very strongly built to carry out its original purpose of removing obstacles, and is essentially a chassis constructed of 1-in. steel plate carrying a ripper blade of section 3¼ in. by 8 in., extending below the chassis for a length of 2 ft. 6 in. The weight is approximately 7½ tons. To provide for cable laying two steel plates were welded to the sides of the blade and extended behind the blade to form the parallel sides of a box through which the cable passes. The cable enters the box at the top just behind the blade and passes via two guiding sheaves to the exit tube at the bottom rear. The cable drum in this equipment has been mounted on jacks securely bolted to the rear extension of the chassis, and thus the cable feeds direct into the cable laying device without requiring a second vehicle. The whole is drawn by a tractor of 110 h.p. (D8 type). Fig. **4** shows the plough raised above ground and with the cable drum in place ready for operations, and Fig. **5** shows a near view of the ripper blade with the cable laying modification.

Several works have been carried out with this equipment, but insufficient data is available to quote comparative costs; it is probable that they approach the economies of the moledrainer equipment, but the tractive force required and consequently the running cost is much greater. It has been used to lay cable in soft sandstone. A depth of 2 ft. is easily obtained, and it is obvious that this equipment can be used in difficult soil conditions where the normal moledrainer equipment would be impracticable. On the other hand, very wet conditions have stopped the ripper equipment by reason of the weight—some 9 tons, including the drum of cable—causing it to sink in the soft ground. Any jamming of the cable in the device has to be carefully guarded against, on account of the extreme tension which can be imparted to the cable when this happens.

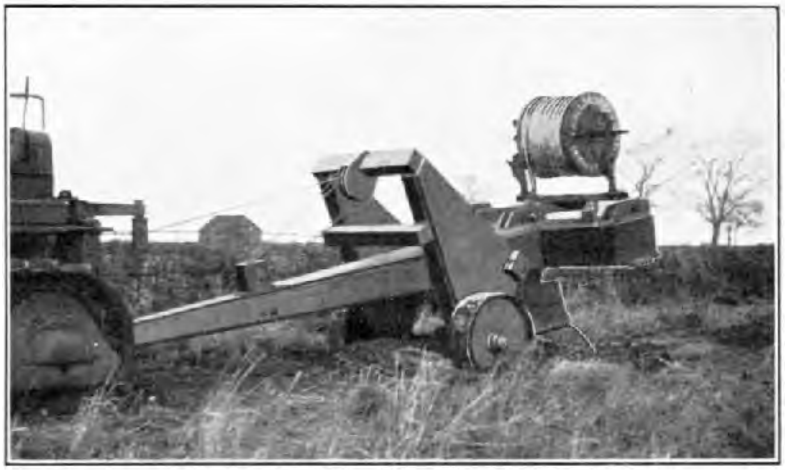

Fig. 4.—Ripper Plough.

Conclusions

It is concluded, from the experience gained, that considerable savings can be effected by the use of mechanical aids, but these must generally be selected to meet, among other factors, the varying conditions of soil. If the conditions permit the use of the modified moledrainer, the greatest savings can be secured by its use. A careful survey by an experienced man must, therefore, be made in advance.

It is worth noting that under open grass conditions all signs of burying the cable quickly disappear, particularly if the moledrainer has been used. For this reason, and to aid maintenance, detailed map records of the position are compiled from frequent measurements taken from permanent recognisable objects. In addition, the standard search coil and head-gear receiver, which picks up the current from a vibrating generator applied to the cable sheath, is a necessary part of the faultsman's equipment.

Fig. 5.—Ripper Blade with Cable-laying Modification.