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The President (Mr. E. G. BRENTNALL, B.E.M.) in the chair

After the minutes of the Technical Meeting held on November 22nd, 1955, had been read and confirmed, the President announced that the Council had decided to award prizes for the two best papers read during the session, the first prize being of the value of £8 8s. and the second to the value of £5 5s. He then called upon Mr. W. L. Cartwright to read his paper on "Testing of Mechanical Interlocking."

Testing of Mechanical Interlocking

By W. L. CARTWRIGHT (Associate Member)

Diagrams—Inset Sheets Nos. 25-29

Introduction

The testing of interlocking whether mechanical or electrical is one of the most important features of the work in bringing into use any signalling installation and is a subject demanding a thorough knowledge of interlocking theory, practice and application, electrical controls, also traffic requirements, rules and regulations.

This is a subject which cannot be adequately covered in a paper of this length and therefore is limited to a broad outline of the arrangements and general principles involved in carrying out a final test.

It is the purpose of this paper to provide a brief explanation of testing methods for the benefit of those who have had little or no experience of the subject, to draw attention to some of the problems that confront an experienced tester and to present a few observations on the limitations of testing methods.

Where major alterations to signalling involve alterations to locking it is essential that a meeting be held between representatives of all departments affected in order to prepare a detailed programme of the amount of time required by each section concerned including testing, so that the whole of the work may be co-ordinated and completed in a specified period of time. Therefore, the method of testing locking and the efficiency and speed with which it can be accomplished is very important by virtue of the fact that it is not generally possible to connect the altered point and signal connections or to test the electrical controls until such time as the locking test has been completed.

Preparations Prior to Final Test

1—In all cases where testing of locking is involved, it is essential that there should be co-operation and understanding between the operating departments' representative and the tester in order that the test may be carried out with a minimum of inconvenience to all concerned. The question of a disconnection depends upon the magnitude and nature of the work involved and generally speaking falls into the following categories :—

(*a*) *Routine Testing—No Disconnection.* In the case of a routine test of a locking frame it is not customary to have a disconnection, therefore, it is essentially a matter of co-operation with the signalman but under no circumstances must levers be operated without his permission.

(*b*) *Minor Alterations—Part Disconnection.* Disconnect all points and signals which are likely to cause unnecessary delay to the completion of the test, one example being a P.Way train standing on points, F.P. Lock or Clearance Bars, etc. Again, levers which have not been disconnected, should not be operated without the signalman's permission. In this case it is advisable to make a note for reference when testing of the numbers of the points and signals which have been disconnected so as to prevent any misunderstanding between the tester and the signalman regarding the pulling of levers, and injury to persons operating levers.

(*c*) *Major Alterations—Total Disconnection.* Total disconnections are necessary in cases where there is a complicated layout or where a frequent train service has to be maintained during the time that the engineering operations are being carried out.

(*d*) In all cases of testing locking where a level crossing is involved, it is advisable to arrange for the gates to be disconnected and worked by hand if there is any likelihood of road traffic being unduly delayed.

2—The following detailed checking should be carried out by the supervisor responsible for the work :—

(*a*) The locking mechanism be checked in such a manner as to ascertain that it is in accordance with the details shown on the locking chart.

(*b*) Where loose locks are operated by studs fixed on the locking bars, make sure that the studs are correctly placed behind the relative locks.

(*c*) In the case of swinging tappets of the lateral moving variety, ascertain that the turned-pins connecting the tappet to the lever will allow the tappet to move freely in a lateral direction.

(*d*) Where cotter pins are used in tappets, connecting links, etc., ascertain that they have been properly fitted.

(*e*) In all cases of tappet locking, ascertain that each bar travels freely in its relative trough, also that the locking on each bar is tested at the time it is installed.

(*f*) In the case of gravity type restoration locking make sure ramplocking tappets are clear of the locking box lids and that suitable precautions have been made in the design of the mechanism to prevent the ramp locks from moving out of position and thus rendering the locking ineffective.

Where restoration locking is effected through the medium of springs make sure the springs are properly fitted, also ascertain that there is no possible likelihood of the locks sticking due to excessive friction in the locking trough.

3—It is very important when carrying out a test of mechanical locking where electric locks are fitted, to make sure that the locks are either disconnected by wedging the lock armature in the energised position in the case of a gravity type lock, or that when a lever fitted with an electric lock is being tested the lock is energised at the instant the mechanical lock should be effective.

4—Where P.Way Renewals are concerned, liaison with the P.Way Supervisor on site is essential as instances have occurred in connection with P.Way renewals (especially where stage work is involved) when the layout has not been installed in accordance with the original planning due to unforeseen circumstances, thus involving last minute amendments to the locking on the site which of course is very undesirable and may lead to serious consequences and also delay the completion of the whole of the work.

Object of a Test

The purpose of any test is to ensure that the interlocking conforms with the following requirements :—

(*a*) That the locking is such as to enforce the necessary requirements of the M.O.T. and C.A. whilst at the same time allowing the signalman to be in a position to operate the installation with maximum freedom, e.g., shunting signals to read all ways or ability to make parallel moves simultaneously.

(*b*) Abnormal force to be applied to levers or catch handles when being tested, so as to ensure that it is not possible to force them when they should be locked.

(*c*) So far as tappet locking is concerned, the test should be one which will reveal the existence of any conflicting notches. Fig. 1 illustrates correct and incorrect examples applicable to a two channel box of direct lever locking using two types of lock shapes with broad and small noses.

(*d*) To ensure that where conditional locking is provided it is not possible to destroy its effect through a faulty design of the mechanism.

(*e*) To confirm that the locking detail shown on the chart is correct.

Procedure

Where alterations to existing frames are involved, it is advisable to test the whole frame, but there are cases where the alterations to a large frame may only effect a few levers and under these circumstances it is not always a practical proposition to make a complete test, therefore, one is constrained to make a part test of the frame which is not an easy task as it sometimes results in omitted locking not being discovered. Whenever a part test is to be carried out, additional precautions should be taken in order to make certain that the test will be satisfactory. Examine the locking chart and tabulate a list of all the levers concerned with the alteration, then peruse the signalling layout showing the alterations and again tabulate a list of levers concerned or likely to be concerned ; all levers tabulated should then be tested.

It is not advisable to apply the principle of part-testing after an alteration or overhaul where it is not practicable to make a satisfactory check of the mechanism such as on ex-Midland Tumbler, Saxby & Farmer Grid, stud locking, etc., otherwise omitted locking may go undetected and be a potential danger until such time as the omission is discovered and rectified.

The following simple illustrations show how easy it is for one to say dispense with a signal or point connection and not fully appreciate the implication so far as the interlocking is concerned.

Fig. 2. The abolition of 2 signal creates a position whereby 6 and 8 points become conflicting points and therefore should interlock one another otherwise an accident could occur if a movement from the up siding to up main through 6 reversed was being made at the same time as one from the down main to up main through 8 reversed.

Fig. 3. The abandonment of 4 points up main to up siding and 3 signal without the necessary alteration to locking and detection being carried out simultaneously could result in a signalman being able to clear 7 signal by pulling 4 spare lever without making a "cut off" into the siding, thus permitting a movement to be made along the up main in the facing direction without the necessary protection of a "limit of shunt" signal.

Fig. 4. Illustrates another fault arising on tappet frames which can be the cause of locking being omitted. In this case the stud and bar attached to the double lock between 9/10 is shown to be removed but it is intended that the double lock, 9 locking 10, remains. If the note "lock to remain" is omitted from the locking chart it is quite likely that the double lock would be removed along with the bar and not replaced and the possibility of finding that 9 locking 10 has been removed in error would be remote if only a part test was carried out.

Normally, when making a complete test it is an advantage to test initially all the point levers in numerical order, i.e., the locking between points only. This method of approach not only proves in the initial stages of the test that all the point levers are free to be operated when required but also it reduces the lever movements to an absolute minimum by virtue of the fact that the locking between points and signals is tested in conjunction with the relative signal levers concerned. After the point locking test has been completed satisfactorily the next step is to commence testing the remaining levers, i.e., signals, facing point locks, releases, gate stops, etc., in numerical order.

After the whole of the locking on a lever has been tested all levers should be restored to their normal positions in the frame before continuing.

In all tests a constant check should be maintained on those responsible for pulling levers to ensure that the levers are being operated as requested by the tester, otherwise the inadvertent operation of a "wrong" lever may render the test negative or misleading.

Where the test of a large or complicated interlocking is involved it is necessary for a simultaneous cross-check to be carried out on the locking table by a responsible person in order to ensure that any discrepancies which may arise between the actual test and the details shown on the locking table may be investigated and if necessary rectified.

Method

Assuming that all the necessary preliminary arrangements, checking, etc., mentioned earlier in the lecture have been carried out, the methods by which the final test of a locking frame can be made fall into two categories, namely :—

1—Testing directly from the locking table.

2—Testing from a signalling layout plan with a simultaneous cross-check against the locking table.

The question as to which method to apply depends, to a large extent, upon the experience and capability of the tester but, unless one has had a considerable experience in the preparation of locking tables and mechanisms, the application of Method 2 will prove to be very exacting and may probably result in an unreliable test. Therefore, so far as say, linemen and others who have not had the necessary experience, etc., are concerned, Method 1 will undoubtedly prove to be the best way of carrying out a test but, as will be apparent later, it is *not* the correct way to test locking.

Testing by Method 1 has the following disadvantages :—

1—Generally it is found to be long and laborious due to the fact of being unable to set up routes in a correct sequence due to the difficulties of sorting out the indirect releasing of levers from the table, for example, if 5 is released by 4 : 4 released by 3 : 3 released by 2 : 2 released by 1, therefore in order to test No. 5 it is essential that 1, 2 and 3 be reversed first. Whilst this is a simple example it can become most involved especially where conditional releasing is concerned.

2—It is not always certain that every possible route that a signal may read has been tested.

3—Inability to detect faulty design of mechanism or locking table.

In carrying out a test from a signalling layout plan it is essential that the plan used should be one showing clearly all fouling points, track circuits and levers fitted with electric locks. It is also advisable in the case of a complete test to have a print of the locking table, as it should be after the alteration has been carried out, with the point locking coloured in, say blue for easy reference. (Fig. 5).

The testing of a locking frame by Method 2 is the most comprehensive test to which a frame can be subjected and, the following details will tend to substantiate this point of view :—

(*a*) Every possible route that a signal may read is thoroughly tested.

(*b*) The "breaking down" of conditional locking is made more practicable, thus ensuring that any defect in the mechanism which may possibly have been overlooked in the design will be made apparent.

(*c*) The lever movements are reduced to an absolute minimum which consequently results in a test being completed in a minimum of time; in a specific case of a 106 lever frame it took 18 hours to test during traffic by Method 1, but in a subsequent test under similar traffic conditions, Method 2 was applied and the test completed in 4 hours.

(*d*) Any overlapping of electrical controls and mechanical locking should be revealed such as sequential locking or both-way locking on points which are track-locked.

(*e*) A final check on the locking table is achieved and should any discrepancies arise they can, generally speaking, be rectified immediately.

Examples of Testing

The following examples illustrate the elementary principles of testing locking :—

1—*Locking.* Fig. 6 is a simple illustration of 1 locking 2 and conversely 2 locking 1, hence the test would be :—

Pull 1, try 2 which is locked normal.

Replace 1 normal, pull 2, try 1 which is locked normal.

It is important that the converse test 2 locking 1, be made in order to prove that a reverse notch has not been inadvertently cut in 2 tappet which would in effect mean that 1 would lock 2 b/w instead of 1 locking 2 normal and *vice versa*. This feature of testing so-called "dead" locking must be applied in all cases as it often happens that an additional notch is cut in error. Where alterations to existing locking are involved, a normal lock may have to be fixed in position where previously a release lock has been in existence, thus if the lineman accidently overlooks the fact of the reverse notch the inevitable happens.

2—*Releasing.* Fig. 7 illustrates 1 released by 2.

Try 1, it is locked normal.

Pull 2, pull 1, then try the reverse lock or back lock on 2, thus proving that there is not a reverse notch in 1 tappet.

Fig. 8 illustrates 1 released by 2 and 3.

Try 1, pull 2.

Try 1, pull 3.

Pull 1 and try the reverse locks on 2 and 3.

The sequence of pulling 2, 3, 1 has only proved that 1 is released by 3 and therefore 2 tappet may have a normal as well as a reverse notch in it. To ensure that there is not a normal notch in 2 tappet, the levers should be restored in the following way to complete the test.

Restore 1 and 2 normal respectively, leaving 3 reverse and try 1 which of course should be locked normal.

This method of testing releasing must be applied in all cases in order to prove that only reverse notches have been cut in the releasing tappets.

3—*Both-way Locking.* Fig. 9 shows 1 locking 2 b/w (where b/w is the symbol used for the term both-ways, that is both in the normal and reverse positions).

The procedure to test is as follows :—

Pull 1, try 2, which is locked normal.

Replace 1 normal, pull 2, then pull 1 and try the reverse lock on 2.

4—*Sequential or Restoration Locking*

This type of locking is non-reciprocal and is installed where necessary to enforce the restoration of signal levers normal after the passage of a train in order to ensure that certain electrical controls are completely effective for one movement only.

In the examples shown in fig. 10 it will be seen that if such locking were not provided and the signalman failed to restore No. 2 signal to danger after the passing of a train, the "line clear" release and the track circuit controls on No. 1 signal, figs. 10X and 10Y respectively, would not be effected.

The method of testing 2 released by 1 normal is as follows :—

Pull 2 then pull 1 ; by virtue of the ramped tappet on 2 lever it is possible to restore 2 normal as its tappet will slide over the ramp lock until the lever almost reaches its normal position when the tappet drops down to the normal tappet position and locks 2 normal. Thus, after trying the normal lock on 2, restore 1 towards the normal position and make sure that 1 lever can be electrically locked normal before the mechanical locking allows of 2 being pulled again.

5—*Releasing Arrangements of Gate Boxes*

Fig. 11. In this illustration the level crossing at the gate box is electrically released from the signal box and the gates are worked by hand, the road and rail stops being controlled by 1 lever in the gate box. When testing an installation of this type it is essential to ensure that it is not possible to restore the gate stop lever (1) normal unless the gates have first been placed in their normal position across the roadway, otherwise, it is obvious that if it were possible to restore the gate stop and release levers normal in the gate box with the gates across the railway it would in turn permit the signalman at the signal box to restore his

release lever 15 normal and thus be in a position to operate the level crossing protecting signals 1 and 2. The usual method adopted in order to eliminate the possibility of such an occurrence is to provide a bolt-lock arrangement between the gate connections and the stop lever so as to prevent the stop lever being placed normal unless the gates are across the roadway. The purpose of this type of interlocking is not always apparent to maintenance personnel therefore there is always an element of risk that an interlocking arrangement of this kind may be neglected and thus become ineffective. Therefore, when testing interlocking at this type of installation, one must also test that the bolt lock arrangement is in order.

6—*Conditional Locking*

Fig. 12 shows typical examples of conditional locking mechanisms used on the direct lever locking type frames. Conditional locking is obtained by the use of a swinging tappet, this tappet is half an inch narrower than the ordinary tappet and thus will travel that distance in a lateral direction as indicated by the arrows. The sketches illustrate that any one of the three tappets may be used as a swinging tappet in order to obtain the condition 1 locking 3 when 2 reversed. In sketch (i), when 1 is pulled the double lock between 1 and 2 is driven into 2 tappet, then if 2 is pulled its tappet is driven to the right by means of the bevel and thus moves the lock between 2 and 3 into 3 tappet. This principle of operation applies in cases (ii) and (iii). In sketch (iv), 1 lever is locked normal until either 2 or No. 3 lever is reversed, if 2 lever is reversed then the operation of No. 1 lever will drive the double lock between 1 and 2 tappets into the reverse notch in 2 tappet thus locking 2 lever reverse, likewise if 3 lever is reversed instead of 2 then the operation of 1 lever will drive 2 swinging tappet in the direction indicated by the arrow on the tappet so moving the lock on the left of 3 tappet into the reverse notch in 3 tappet, thus locking 3 lever in the reverse position. This principle of operation applies in cases (v) and (vi).

Fig. 13. In order to test 1 locking 5 when 3 reverse.

Pull 3, then pull 1, try 5, which is locked normal.

Replace 1 normal, pull 5, try 1 which is locked normal.

Replace 3, pull 1 and 5, try 3 which is locked normal, thus proving that it is not possible to "break down" the condition under which the locking is to be effective.

The testing of conditional locking is a very involved task and it is imperative that the test should be made from a layout plan in order to eliminate the possibility of the conditions being ineffective due to the sequence in which the levers may be operated.

Fig. 14. In this example it will be seen that in table (A) No. 6 signal is released by (2 or 4-5). If the locking on No. 6 was tested from the table, one would try 6, pull 5, try 6, pull 4, pull 6 and try the reverse locks on 4 and 5, see fig. (D) but, it is apparent from the table and mechanism that there is nothing to prevent 2 lever from being pulled also, which would of course make the reverse lock on 4 ineffective, see fig. (E), and thus permit 3 points to be moved with 5 and 6 levers reverse. This type of fault arises from two general misconceptions regarding the design of locking mechanisms :—

1—That any one of the tappets concerned in a set of conditional locking may be used as a swinging or travelling tappet.

2—The way in which the conditional locking concerned is described in the locking table.

It is almost certain that an error of this type would not be overlooked in the preparation of the locking mechanism if the releasing on 6 was as shown in table (B) as in this particular case it would be more apparent to the designer that 5, having a normal and reverse condition, should be used as the swinging or travelling tappet and the mechanism designed accordingly. Fig. (F) shows the correct method of mechanism design.

Fig. 15. Whilst this is a similar example to the previous one it is a further illustration of how important it is to try every possible way to break down the conditions in order to prove that both the design of the mechanism and table is correct.

It will be seen that the releasing for 64 is shown correctly in the table whereas the design of the mechanism in fig (*a*) is incorrect in that when 58 and 63 are reverse, see fig. (*b*), it is possible to reverse 64 lever without being required to pull 62; this in turn allows 77 or 78 levers to be operated with 62 lever normal.

The correct method of mechanism design is shown in fig. (*c*).

Fig. 16. This is a further example of how releasing in the form shown in table (A) for 66 lever can be misleading to anyone from the table, as it is not apparent that 66 should lock 67 b/w. For

example, try 66, pull 71, try 66, pull 70, pull 66, try the reverse lock on 70 but, as neither 71 nor 70 lock 67 in this particular case, it would be possible to operate 67 points with 66 and 70 levers reverse, Once again it is almost certain that the possibility of an error of this type arising would be remote if the releasing on 66 had been shown as in table (B) because it would be more apparent to the tester that he should make sure that the condition be held in normal and reverse positions either by virtue of a b/w lock or point and point locking so as to prevent the conditional locking being made ineffective.

Fig. 17. In this example 19 is incorrectly released by (12 or 14) in the mechanism and under normal circumstances, providing the signalman always pulled 12 to release 19, the reverse-lock on 12 would be in order as 10 locks 14, but it is apparent from the layout that it would be possible to pull 14 and then operate 19 lever. This is fortunately a very unusual and rare type of fault which would not normally be found by the orthodox methods of testing.

7—*General*

Fig. 18. In certain cases it is only possible to test a lock one way due to say a lever being preceded by another which has in turn already made the lock effective as in the case of testing 1 locking 4.

Pull 1, try 4, pull 2, try 4, thus 1 locks 4 (see fig. (B)), but it is not possible to test the converse 4 locking 1, as 4 is released by 2 and 2 locks 1 b/w, thus when 2 lever is reversed is locked in either the normal or reverse position, see fig. (C), therefore, when 4 is pulled 2 has already locked 1 normal.

The complete test of the locking for this layout would be as follows, using Method 2 and assuming that the principle of testing the point locking first is adhered to.

Lever No.

1—Pull 1, try 5, place 1 normal, pull 5, try 1.

2—Pull 2, try 1, place 2 normal, pull 1, pull 2, try the reverse lock on 1.

3—Try 3, pull 1, try 3, pull 2, pull 3, try the reverse lock on 2, then place 3 normal, 2 normal, 1 normal, pull 2, try 3.

4—Try 4, pull 2, pull 4, try the reverse lock on 2, then place 4 normal-2 normal, pull 1, try 4, pull 2, try 4.

5—Fig. 19. In this case there is no interlocking between points and therefore the locking on Nos. 1 and 3 would be tested in conjunction with the testing of Nos. 4 and 7 signals respectively.

Lever No.

1—

2—Pull 2, try 1. Place 2 normal, pull 1, pull 2, try reverse lock on 1.

3—

4—Try 4, pull 2, pull 4, try reverse lock on 2 and normal lock on 3, place 4 normal, pull 3, pull 4 and try reverse lock on 3, place 4 normal, 3 normal, 2 normal, pull 1, try 4, pull 2, try 4.

5—Try 5, pull 1, try 5, pull 2, pull 5, try reverse lock on 2 and normal lock on 3, place 5 normal, pull 3, pull 5, try reverse lock on 3, place 5 normal, 3 normal, 2 normal and 1 normal, pull 2, try 5.

6—Try 6, pull 3, try 6, pull 2, try 6, pull 4 (the reverse lock on 3 is held through 4 locking 3 b/w), pull 6, try reverse lock on 4, place 6 normal, 4 normal and 3 normal, try 6, pull 4, try 6, restore all levers normal and try 6, pull 3, try 6, pull 1, try 6, pull 2, try 6, pull 5, pull 6, try reverse lock on 5, place 6 normal, 5 normal and 3 normal, try 6, pull 5, try 6.

7—Try 7, pull 2, try 7, pull 4, pull 7, try reverse lock on 4 (the normal lock on 3 is held through 4 locking 3 b/w), place 7 normal, 4 normal, pull 3, pull 4, try normal lock on 7. Restore all levers normal and try 7, pull 1, try 7, pull 2, try 7, pull 5, pull 7, try reverse lock on 5, place 7 normal, 5 normal, pull 3, pull 5, try 7.

Conclusion

In conclusion it should be stated that the various diagrams included in the paper have been simplified as much as possible for ease of explanation, but some of the examples quoted are typical of cases which have actually occurred in practice and many more examples could have been illustrated had time permitted.

It is realised that the paper has not covered all the problems which a tester may encounter, but it is hoped that it will have been instructive to some, interesting to others and that the points mentioned will evoke some valuable points of view in the discussion which it is hoped will follow.

Finally, the author wishes to express his sincere thanks to Mr. A. F. Wigram, Signal Engineer, N.E. Region, for his kindness in permitting him to read the paper and to Mr. C. Myton for his great assistance in the preparation of the paper and the checking of the diagrams.

DISCUSSION

Mr. A. F. Wigram opening the discussion, said that a few years ago Mr. Noel Marshall had given an excellent paper on the testing of power signalling and now Mr. Cartwright had given its counterpart, the testing of mechanical signalling. The papers were of outstanding value, because interlocking, whether electrical or mechanical, was still the foundation of railway signalling, and the testing of its integrity was of paramount importance. Every signal engineer should be able to test a frame, and the author had developed the procedure to a very high degree. He recalled the case of a frame at Newcastle No. 1, which the author and a colleague tested in eight hours. Without such high skill it might have taken at least four times as long. He thought it would be interesting to hear the author's views on the possibility and practicability of training others to do the testing in a high speed manner.

In a reference to fig. 17, the paper mentioned that it would be possible to pull 14 and then operate 19 lever, a very unusual type of fault which would not normally be found by orthodox methods of testing. According to the diagram, 10 locked 14 and 14 locked 10, and in the normal method of testing from the diagram, one would try to pull 10 and pull 14, and would realise that something was wrong. Mr. Wigram could not agree that this particular fault would not be discovered by orthodox testing. Regarding fig. 19, lever No. 6, the paper read: "Try 6, pull 3, try 6 . . ." and later added, "restore all levers normal, and try 6, pull 3, try 6 . . ." This seemed to be a duplication of effort, and the reason for following that sequence of thought was not made clear.

He suggested that the author might explain why testing the point to point locking first speeded up the work so much, and it would be helpful if examples showing a comparison of the two methods of testing could be given, such as how many movements in the one case and how many in the other.

The **Author**, in reply to Mr. Wigram, said that he felt that interlocking, as a whole, had to some extent been lacking in publicity, and too much had been committed to memory in the past.

Regarding the training of staff, he hoped that the paper would help some of the younger members to appreciate and develop the art of testing. The North Eastern Region of British Railways had recently arranged instructional courses on interlocking design and testing, including some practical work, and there was a great scope for that kind of activity for training future staff in the most efficient methods.

Regarding fig. 17, he agreed that 10 locked 14 and although not shown, there was nothing to stop one pulling 14 over, then 19 lever was released mechanically.

As to the question of testing No. 6 released by No. 3 in fig. 19, he had tested that No. 6 was released by No. 3 for the route with 4 signal reverse, and had also tested it for the route through 5 signal reverse. He agreed that there was a slight duplication but it was an advantage to test that release No. 3 was on both routes, because sometimes in the design of the mechanism, a release such as No. 3 might be bound in with conditional locking. In the case quoted, if it was only applied to one route, it might fail; 6 would be released by 3, with 4 signal reverse, but not with 5 signal reverse.

So far as fig. 19 was concerned, the total lever movements, testing the point locking in conjunction with the signals, were 74. Ignoring the point levers and testing the locking in conjunction with relative signals numerically, the movements would number 92. It saved approximately 25 per cent by testing by the point to point locking method.

Mr. C. G. Derbyshire, referring to the question of publicity, mentioned the two excellent booklets by Mr. Such, which had become almost a standard work on interlocking and were familiar to many of the Institution's members. Nearly two years ago a paper on interlocking was given at a provincial meeting at Derby by Mr. Taylor and was well received. It would be seen that there had been a considerable amount of thought and discussion on this very important subject in recent years.

In approaching the subject of the testing of interlocking, one or two points stood out as really essential. It demanded a thorough knowledge of the layout and the signalling, and a close study of the locking table. If the tester were not fully conversant with these, the test would be of little value. A very important item was the selection of staff for the work and a little briefing from the tester could be most valuable.

Also of great importance was the preparation of a suitable type of table. The table that appeared on the diagrams in the paper did not seem to be quite the best, in so far that the reciprocals of ordinary locking were shown, but the reciprocals of both-way locks and releases were not shown. There was great value in preparing a special table with all the reciprocals on it, so that each individual one could be ticked when it had been tested.

Under 1 (*b*), the author, after saying that it was necessary to disconnect points and signals, added that it was advisable to make a note for reference. Mr. Derbyshire felt that this should be expressed more strongly and considered it was vital that the numbers of all disconnected points and signal levers should be entered in the train register, signed by the signalman and countersigned by the tester. In addition, some collar arrangement should be put on such levers to remind the signalman that they were disconnected.

In addition to points (*a*) to (*f*) mentioned in the paper, he would look for guide bars which were necessary to hold other working bars in position and also to hold down any loose locks that might be uncovered. He would expect the supervisor to check the stops across the locking bars to ensure that when the tester was working upstairs, the locking did not lift and free itself.

He thought it was necessary to differentiate between checking of the locking table and the locking diagram in the drawing office before the details were circulated, and the test that was made before bringing the work into use.

Under (*e*) it was stated that it should be confirmed that the locking detail shown on the chart was correct. Mr. Derbyshire did not think this was a matter for the tester. It should be ensured before the plans left the drawing office, as it was the responsibility of the chief draughtsman.

With regard to (*b*) and the use of abnormal force. It was essential during a test of that kind to decide whether the locking was too tight or too slack. If too tight, it could be embarrassing to the signalman and caused delay. If notches had been cut too deep or too long, there might be an amount of slackness which in time would be dangerous, although it might not be possible to force it on the day of opening.

He asked the author to describe how he tested for conflicting notches during a test on opening day. For example, did he instruct the man to continue pulling the lever while the lever at the opposite end was being pulled, in an effort to push a broad nose lock into a small slot?

He could not entirely agree with the author's suggestion as to how to undertake a part test, because although it was useful and necessary to make a note of the levers that were affected by the alterations and to tabulate them, it often occurred that in putting in some additional locking, or in making alterations, the bottom as well as the top bars had to come out and there was no guarantee that the bottom bars had been put back in the right place. The whole of the locking in the box which had been disturbed should be tested throughout.

Testing directly from the locking table was what he would call a functional test from the signalling diagram. He did not agree with the author that method 1 would undoubtedly prove to be the best way of carrying out a test, but that it was not the correct way to test locking. In his opinion, it was the correct way, providing that the tester knew the route, the signals applying to it, and the essential things about the signalling and locking.

With regard to fig. 14, he agreed that it was wrong and unsuitable to use 2 for a sliding tappet in that case, but he could not see any objection to using 6 as an alternative to 5, for achieving the same object.

The **Author** agreed with Mr. Derbyshire that the booklets by Mr. Such were excellent, but they did not deal with the details of testing. The present paper referred to testing, and not mechanical locking design.

Regarding the selection of staff for testing ; it was the practice to arrange for certain men they considered as suitable to form the first shift. These made the alterations to the locking, then the men best suited for testing and pulling of levers performed the testing. They held a conference on the methods to apply, and the question of disconnections was discussed with the men.

So far as the table in the diagrams was concerned, in addition, he preferred to have the numbers down in front of him or a plan for reference purposes. In some boxes, there were not sufficient collars to cover all the levers which were disconnected, and in such cases levers which had been disconnected were marked with chalk. With regard to locking table design, he did not entirely agree that there was the need for the converse of the release locks.

It depended upon the class of supervisor whether the tester relied upon the mechanism before the final test. He agreed that the locking inspector should take up the question of putting in pins to hold the bars down. That should be left to the supervisor.

He agreed that the words " abnormal force " could be misinterpreted. In practice, while one tester might give a lever a shake and say that it was locked, another might exert considerable strength and pull it straight over. In use, the signalman pulled the lever—not just tried it—and for that reason, the question of force applied should be known by the tester. In certain cases, the author had appointed someone to watch and make sure that the right levers were operated, as if a man pulled the wrong lever, that part of the test was rendered useless.

With regard to conflicting notches, he thought the man should keep trying to enter the lock into the slot, although one relied to a great extent on the locking supervisor to check the plungers and tappets.

Referring to part tests, he agreed that the testing of the whole of a box of locking should be carried out.

Mr. P. R. G. Guyatt referred to instances in connection with permanent way renewals, where it had been necessary to make last minute alterations to the locking on site, and he could not visualise a situation where, during stage work, it would be safe to hurry last minute alterations to locking.

The **Author** replied that he knew of such conditions which had been due to a late start with the permanent way alterations or due to weather conditions. For instance a signalling gang had disconnected a bar, and passed same into scrap material. It was later decided that the permanent way were not going to renew that particular pair of points, so the discarded pieces had to be collected again. Similar instances had occurred on many occasions. It meant, perhaps, putting in temporary track or making temporary track circuit connections, so that one could lock the points without the locking bar.

Mr. C. C. Bennett asked if the author preferred locking above or below the floor. If below the floor, adequate lighting was often a problem. From his experience, it was very dirty if in an inacessible place, and very badly lighted, especially since blackout conditions made bricking under windows a necessity.

The **Author** replied that locking above the floor was preferable from many angles, but had certain disadvantages. Where the locking was below the floor, it was often necessary to provide hatches to enable one to get to the locking from the signal levers. Unless the hatches were covered with linoleum, a good deal of dirt and water would find its way through the crevices when the signal box was cleaned. Upstairs, with the relative position of the frame and the front wall and back wall to be considered, it had the advantage from an assembly point of view only.

Mr. P. A. Langley agreed with Mr. Derbyshire that there was no objection to testing from the locking table, which should have been checked with the layout in the drawing office. He personally would prefer to start at No. 1 and test straight through from the locking table, but agreed that this was seldom possible under traffic conditions. In the circumstances, it was best to have a caller to mark off the figures and converses and keep an eye on what was being done, to avoid unnecessary moves. The tester manipulated the levers and had helpers under his charge, according to the size of the lever frame. Locking which could not be tested immediately, could be left until later, because it could be found from the sheet what had not been marked off. Advantage could be taken of routes set up for traffic, as soon as the traffic movement had been made.

He was also in agreement with Mr. Derbyshire regarding figs. 15 and 16, where it seemed that the essential both way locking was missing. This should be incorporated by the use of locking on both sides of the wing tappets. The same remarks applied to fig. 17. The conditions were not found in the automatic method of testing, but it was most unlikely that such locking would pass from the drawing office. With regard to level crossing gate locking, he could not see the purpose of release lever No. 4. No reference had been made to superfluous locking, but he could not remember a mechanical locking of any size that did not contain some. It was a good thing to make sure that superfluous locking was clearly marked before testing commenced.

The **Author** agreed that the drawing office check was basic, but added that testing from the layout plan enabled one to break down the locking, which one could not do from the table. He also agreed that the conditions on fig. 17 should have been found in the drawing office.

Regarding level crossing gate locking, lever No. 4 acted as a switch lever. Once the signalman had given permission to operate the gates, the pulling of lever No. 4 immediately released the locking in the signal box and allowed the gateman to operate the level crossing gates. If he wished to put them over right away, he could hold them without the signalman putting lever 15 back to normal. It was like a two-lever ground frame ; one release and two points. One pulled over No. 1, which was the release lever and that allowed the signalman to release No. 2 lever, locking with the ground frame.

As far as superfluous locking was concerned, it could not be tested, so he saw little point in showing it on the table.

Mr. A. E. Matthews did not favour the use of either paper collars or chalk marks to indicate disconnected levers. Paper was untidy and became torn, and then did not show which levers had been disconnected. Similar confusion was caused, when chalk marks had been crossed out once or twice. A better method was to attach a small label to the lever. Everyone would know what the labels were for, and as a lever was disconnected outside, a label would be taken by the supervisor and placed in the box.

The **Author** appreciated the untidiness of paper ; and for that reason had mentioned chalk marks, though they could be, of course, removed in the course of the day. The attaching of a separate label was a good method, but the ideal was a proper collar on the lever, provided for the purpose. At times, there were not sufficient lever collars for a large disconnection, and not all gangs were provided with additional collars.

Mr. T. T. Ramsey said the question arose whether the testing of interlocking was the testing of the design or of the installation. It seemed that the author relied upon the supervisor installing the interlocking to say that it was correct. Mr. Ramsey contended that one was testing the installation as put in by the locking fitter or lineman, and it should be a test from the locking chart and not from design, which was decided in the drawing office.

The **Author** replied that the purpose of testing the design was to ensure that it had been put in in accordance with the drawing, and however well interlocking was designed, there were occasions when it broke down. One had to rely upon a responsible supervisor for the general fit of the locking, as the tester could not be expected to check every detail part.

Mr. E. H. Willis thought that it was the duty of the supervisor to see that there were sufficient lever collars in the box before the work started. He asked for the author's views on sequential locking, as he considered that in most cases it could be dealt with better electrically than mechanically.

The **Author** agreed that if possible the required number of collars should be obtained before the work was carried out. He believed that most of the installation gangs were provided with additional plates for that purpose, and that they had the letter " E " marked on them.

He entirely agreed that sequential locking could be carried out electrically with advantage.

Mr. C. F. Challis remarked that it had been said that there was some confusion as to where testing stopped. He thought it was quite clear that, in testing signalling alterations or new signalling, the ultimate aim of the tester was to ensure that the signalling was safe for use by the signalman or operator. But testing was not carried out by any one man ; there was a team, and somebody should co-ordinate the test. Two speakers had mentioned that, in their view, the drawing office locking table should be accepted as correct. This view did not take into consideration the question of last minute alteration which were not unusual and which could not always be controlled by the drawing office.

The **Author** said that to an extent one had to rely upon the supervisor, as the tester could not look into every minor detail. It was the minor details that became a matter of team work and co-operation. Co-ordination and co-operation produced satisfactory results. Last minute alterations were a problem and he did not like having to alter locking sketches on site, especially as time was often short. If anything untoward happened, such as permanent way people deciding not to complete stage 1 or stage 2, one had to look into the question of control, which was of great importance and under conditions obtaining, may lead to danger. There was no one to check as to whether it was right or wrong and one had really to take full responsibility, and do the best in the circumstances. Therefore, one had to have a person who was capable of taking that decision and altering drawings.

Mr. T. G. Robinson said that no one had mentioned the difference in testing methods on various Regions. While the general principles were the same, they differed in detail.

The **Author** replied that, basically, interlocking was the same, wherever one went, although there were certain variations in method which obtained in various parts of British Railways.

Mr. R. R. Evans (*in a written contribution*) said that the paper contains a timely reminder that the mechanical locking frame still plays a most important role in signalling and will continue to do so for many years. It is therefore, most useful in drawing attention to, and showing the methods used to discover, the most likely faults to be found in the apparatus, and should prove of great assistance to younger staff in their appreciation of mechanical interlocking.

Undoubtedly, the only method which ensures a complete test, both from an operational and mechanical point of view, is to test the frame from the signal box diagram or a signalling lay out plan. This not only checks the mechanism but also the locking table, as the tester virtually prepares a table as he progresses, and experience has taught that a certain traffic operation may appear in quite a different light when viewed from the signal box, due to peculiar local conditions which might not be apparent when the locking table is prepared in the office.

A table test would not reveal this, and so the opportunity to give effect to the revised conception during the initial occupation would be lost.

Routine maintenance tests may be made from the locking table, but even then reference to the lay out plan is a distinct advantage in route setting and saves a considerable amount of time.

Total disconnection of a locking frame for testing constitutes the ideal and is also of great benefit to the operating department in cutting down the length of the occupation, but the present difficulty in providing a sufficient number of hand-signalmen makes this impracticable except in isolated cases.

The advantage in testing point locking only as an initial test is questionable, as it would seem that the ideal method is to commence with lever No. 1 and work through the frame in numerical order.

It would be a distinct advantage if sequential locking could always be effected electrically, and thus avoid the necessity to provide spring or gravity locks on a mechanical frame.

The **President** said that interlocking was the basis of signalling safety, and therefore, the testing of it was of the utmost importance. The design of locking tables was highly specialised and, by the nature of mechanical interlocking itself, it was also a design of the actual mechanism. Most people had to learn how to test interlocking by experience and the author had done very good service in going so deeply into the intricacies of the subject. As pointed out by many speakers, the paper would be of infinite value, particularly to young signal engineers. He moved a very hearty vote of thanks to the author for his excellent paper and the way in which he had dealt with the points raised during the discussion, the vote was carried with acclamation.

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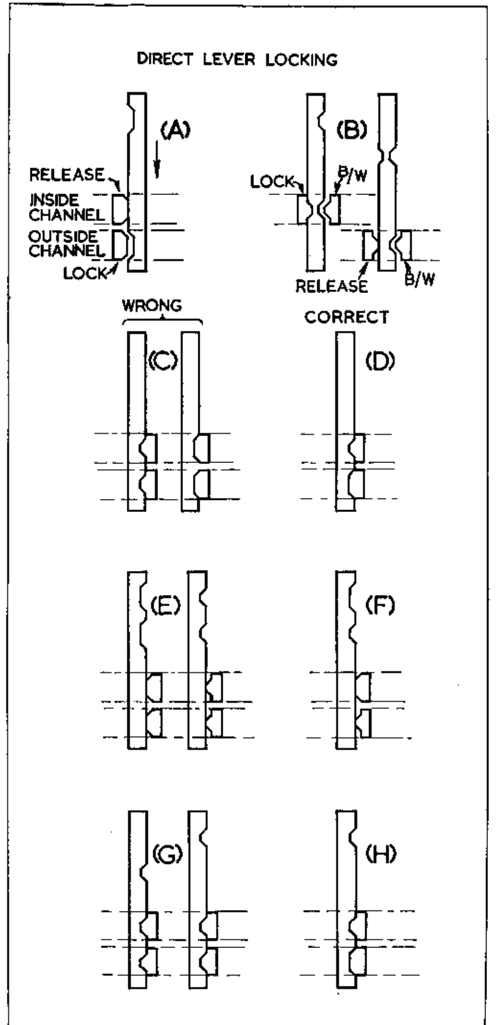
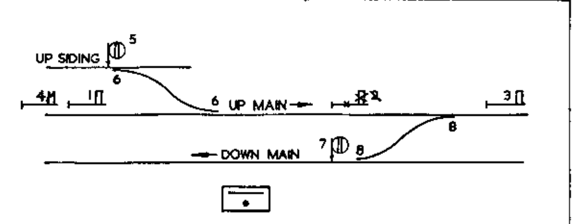


FIG. 1.



Nº	RELEASED BY	LOCKS
1.		6.8.
2.	SPARE	6B/W.8
3.		6B/W.8B/W.
4.	1.2.3.	
5.	6.	
6.		1.8.
7.	8.	
8.		1.2.6.

FIG. 2.

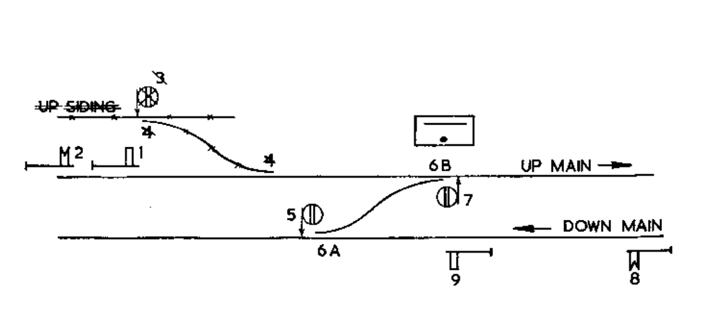


FIG. 3.

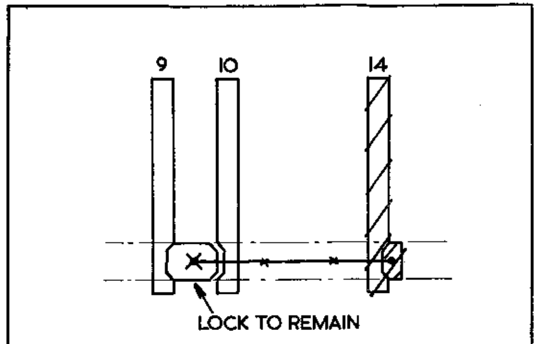
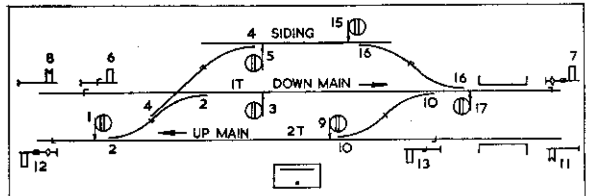


FIG. 4.



Nº	RELEASED BY	LOCKS
1.	(17N W 2R)	2B/W.3.4B/W.5.(7W 4R)12.13 (17W 2R.4N OR 10R)
2.		6.10.13.16
3.	2.	1.4.
4.	2.	3.
5.	4.	1.
6.		2.10.16.17.
7.		(1W4R) 17.
8.	6.7.	
9.	7N.10.	17.
10.		2.6.13.16.
11.	12.13.	
12.		1.2B/W.4B/W.
13.		1.2.10.
14	SPARE	
15	7N.16.	17.
16		2. 6. 10.
17	(12N W 10R)	(1W 2R.4N.OR 10R) 6.7.9.10B/W.15.16B/W.
18	SPARE	
19	SPARE	
20	SPARE	

FIG. 5.

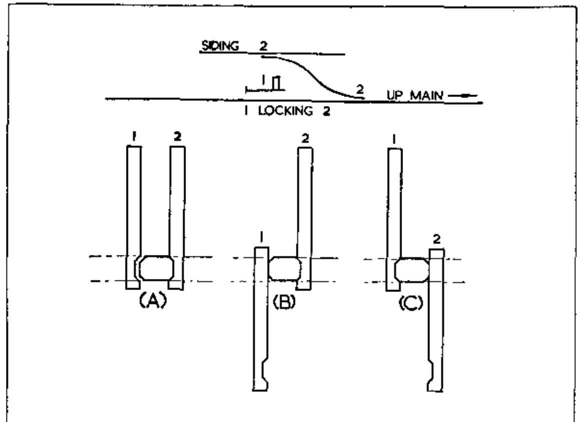


FIG. 6.

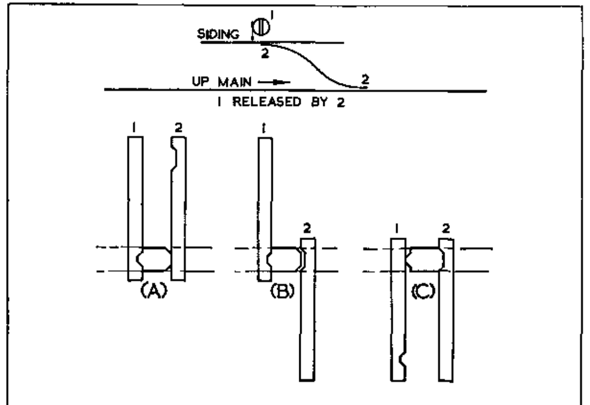


FIG. 7

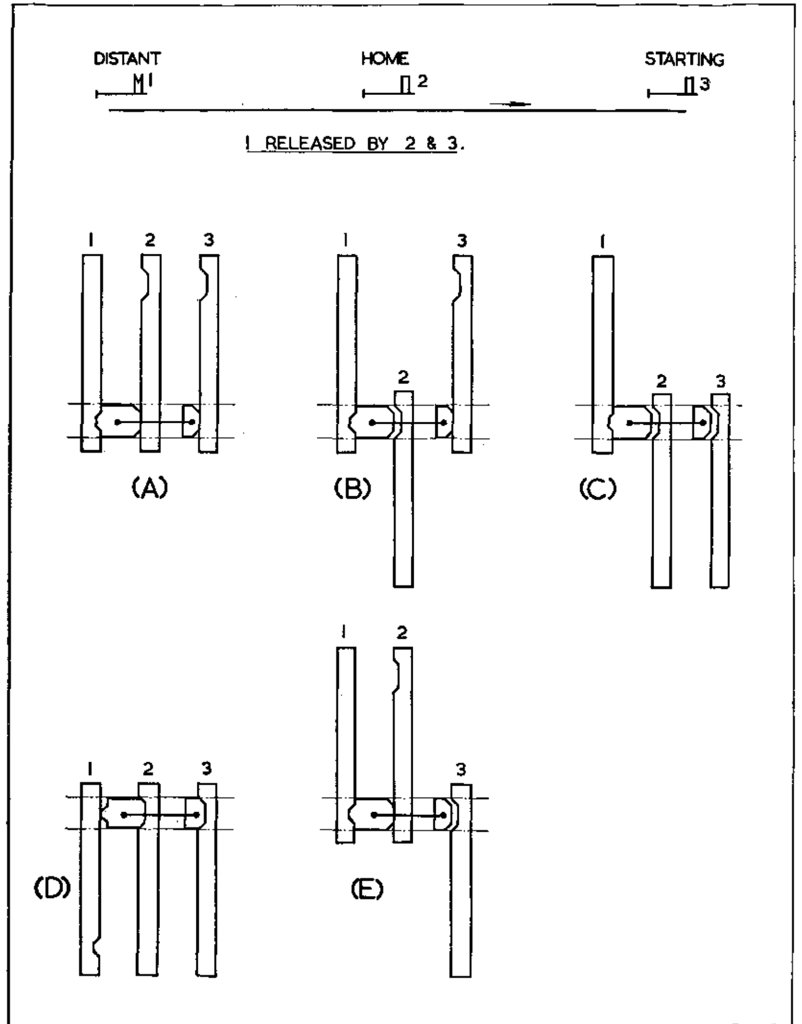


FIG. 8.

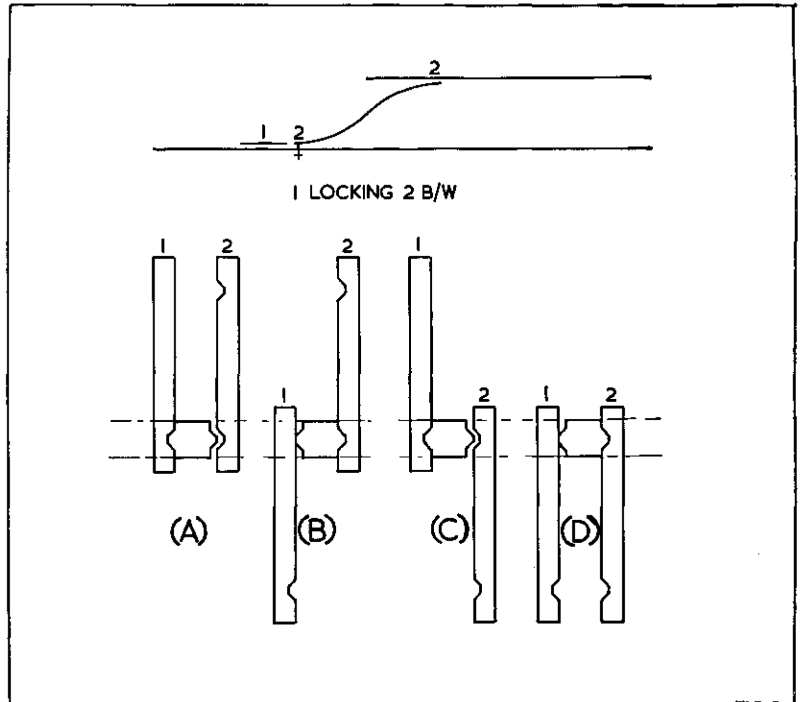


FIG. 9.

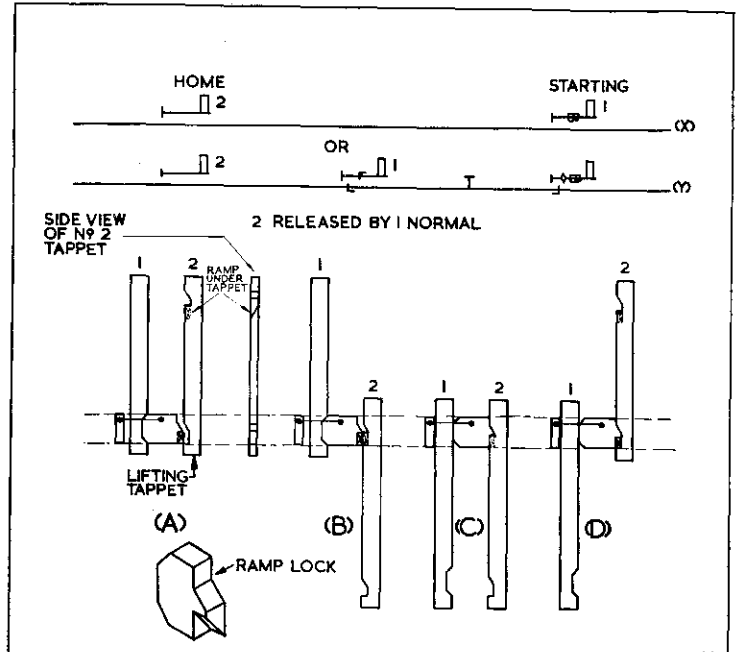
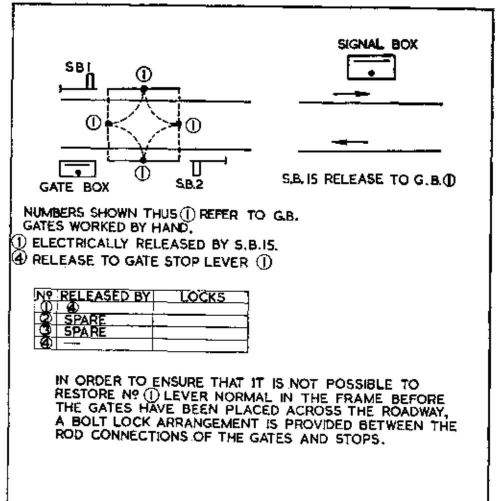


FIG. 10.



Nº	RELEASED BY	LOCKS
①	④	
②	SPARE	
③	SPARE	
④	—	

FIG. 11.

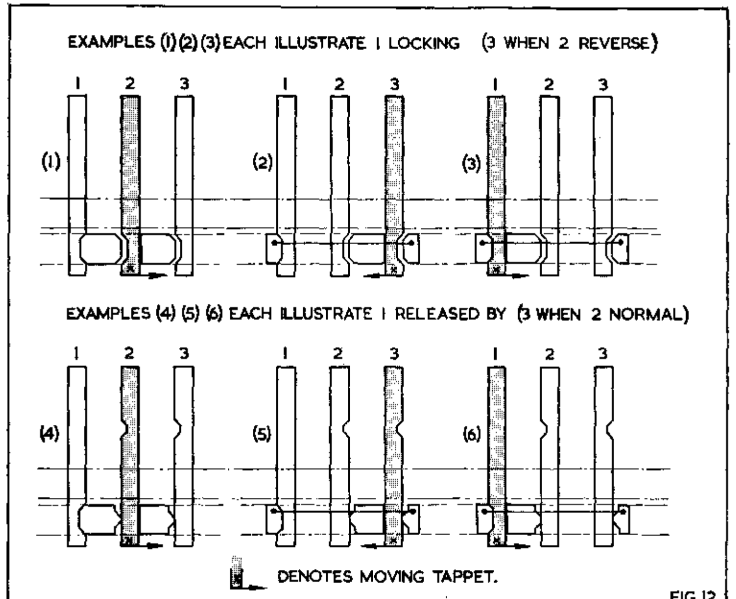


FIG. 12.

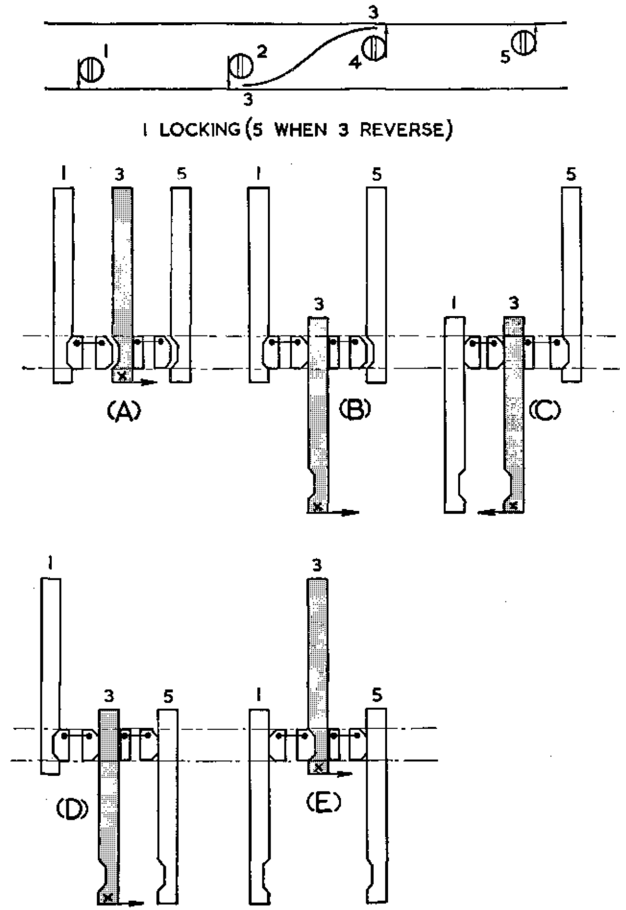
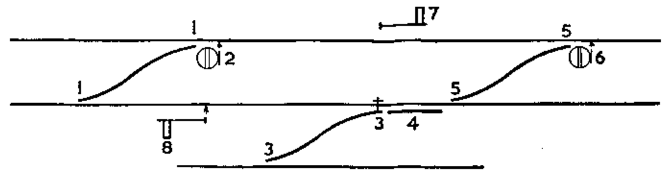


FIG. 13.



(A)

Nº	RELEASED BY	LOCKS
1		8
2	1	7
3		8
4		3B/W.
5		7
6	(2 OR 4,5)	5B/W.
7		1B/W. 2, 5.
8		1, 3, 4B/W. 5B/W.

(B)

Nº	RELEASED BY	LOCKS
1		
2		
3		
4		
5		
6	(2W5N) (4W5R)	5B/W.
7		
8		

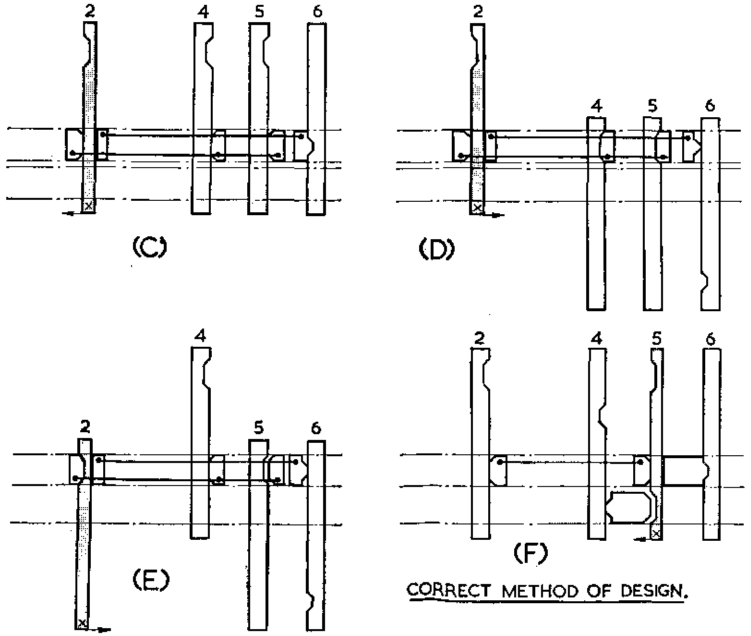


FIG. 14.

Testing of Mechanical Interlocking

(Cartwright)

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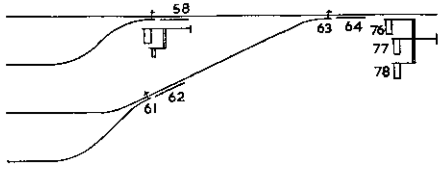

Nº	RELEASED BY	LOCKS
61	63.	
64	(58W63N) (62W63R)	63B/W.
77	63, 64.	61.
78	61, 64.	

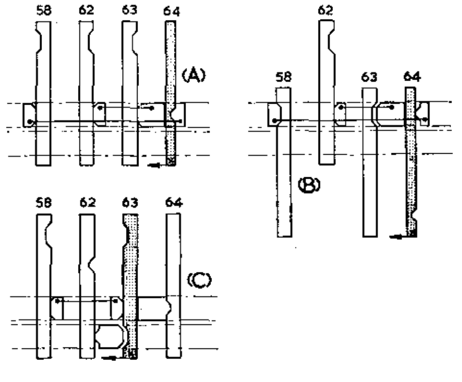

FIG. 15.

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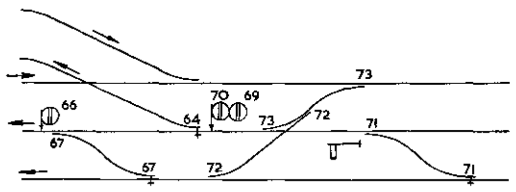


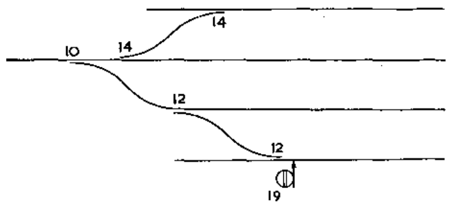
(A)

Nº	RELEASED BY	LOCKS
66	(67OR 69OR7O)	
67		(73W64N)

(B)

Nº	RELEASED BY	LOCKS
66	(69OR 7OW67N)	67 B/W.
67		(73W64N)

FIG.16.



Nº	RELEASED BY	LOCKS
10		14
12	10	
14		10
19	12	

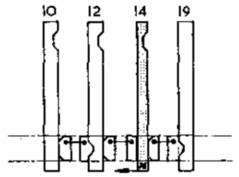
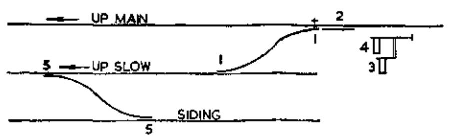


FIG.17.



Nº	RELEASED BY	LOCKS
1.		4.5.
2.		B/W.
3.	1.2.	
4.	2.	1.
5.		1.

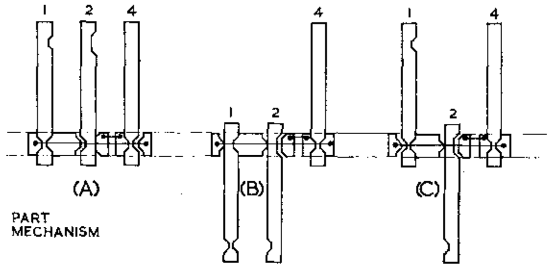
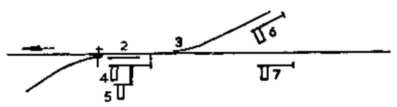


FIG 18.



Nº	RELEASED BY	LOCKS
1.		4.
2.		1B/W
3.		7.
4.	2.	1.3B/W.
5.	1.2.	3B/W.
6.	3(4OR5)	
7.	(4OR5)	3.

FIG.19.