# Keyset-operated C.T.C. System

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*The first C.T.C. installation in the world was put in service some 30 years ago. Since then many new C.T.C. systems have been developed in different countries, each of which has brought some improvement in rapidity of operation or general reliability. But the systems of operation, and the design of the control and indication apparatus, appear to have been neglected and still look roughly the same as they did 30 years ago. This article describes an entirely new system of C.T.C. operation by means of a keyset. In the last few years L M Ericsson has introduced C.T.C. in Sweden, Denmark, Norway, Poland, Jugoslavia and India.*

Centralized Traffic Control—or C.T.C.—has proved an admirable means of improving railway operation. The introduction of C.T.C. on a line will both increase its capacity and reduce the station staff requirements. C.T.C. means that the train despatcher directs all train movements within his section by direct operation of the entire signalling system in that section from a central point, which may be located wherever desired but is usually placed somewhere along the line.

The degree to which C.T.C. can contribute to rationalized railway operation is admittedly little affected by the design of the controlling and indicating equipment at the C.T.C. office. This equipment does, however, appear to have been grossly neglected over a long period. It was not until a few years ago that it began to be realized that C.T.C. could, in fact, be put to very much more effective use if the controlling and indicating equipment were improved. This need has been accentuated by the tendency to place larger and larger sections of track under the control of one office. A more efficient system of control and indication will then lead to direct savings in staff at the C.T.C. office. (This will obviously not apply to small offices which can be managed by one man.) The most important benefit to be derived from greater efficiency in the organization of C.T.C. offices—although not always easy to demonstrate in terms of money—is perhaps the possibility afforded of further improvement in the directing of train movements.

## Development of Controlling and Indicating Equipment for Interlocking Plants

In studying the design of various controlling and indicating apparatus for C.T.C., it may be of interest to consider the development of corresponding equipment for interlocking plants. Interlocking machines came before C.T.C. machines, and there is reason to believe that they influenced the design of the latter. Recently, however, a certain influence in the reverse direction has been noticeable.

It is obvious that the design of the controlling and indicating equipment of interlocking plants has been, and still is, greatly dependent on the devices to be controlled by and indicated to the signalman. When mechanical inter-

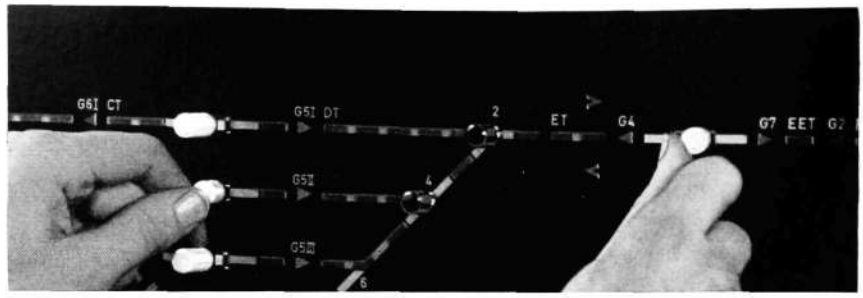



**Fig. 1** X 8081

**Close-up of control machine of modern design for relay interlocking plants**

Line-To-Line control of an entire route is effected by throwing two keys simultaneously in the same direction. The keys are placed on the miniature track on the control machine as shown in the photograph.

locking plants were usual, and both points and signals (semaphores) were mechanically controlled, the system could operate only over very short distances. Indications to the signalman were not considered necessary, nor did resources for transmitting them exist. The work was physically heavy. Later, when points and signals could be controlled electrically, the control machines were reduced in size. Control could be effected over greater distances, and the control equipment for a large area could be combined in one interlocking plant. This brought the necessity of indications; they were of a simple character, and the indicating lamps were usually placed on the control machines. When indications became more and more complete, and track circuit control was introduced, the indicating equipment had to be placed on a special track diagram behind the control panel so as to be visible to the controllers from their operating positions.

The interlockings required between the various controls for points and signals, to ensure that faulty operation did not imperil traffic safety, were initially set up by mechanical means in the control panels. Electrical interlockings were introduced in the thirties and in due course led to all-relay interlocking plants. The size of control panels could now be greatly reduced. Once again the indicating equipment could be placed on the control panel, and the methods of control could be simplified. The usual procedure was that signals and points along an entire train route were controlled by a single manual operation (possibly using both hands simultaneously). There are several designs of such equipment. The only method mentioned here is L M Ericsson's LTL (Line-To-Line) method with keys on the miniature track diagram on the control machine. The simultaneous operation of two keys controls the signals and points of the route on which the keys are placed (fig. 1).

With the advent of relay interlocking plants, larger and larger territories could be controlled from one office. The question now arose whether the control panel and track diagram should still be combined or whether they should again be separated. Different methods were adopted by different railways, but the most practical procedure now appears to be to use a single panel provided that it is not larger than that the operator can reach all controls from his chair. If the panel is too large for this to be possible, it should be split into control panel and track diagram. If the control machine can have the controls placed on a sub-miniature diagram, this alternative would seem to be preferable.

It will be apperent that the initial goal of the designers of interlocking apparatus was to eliminate the need of physical strength in the operator. Later efforts were aimed at the design of controlling and indicating equip-

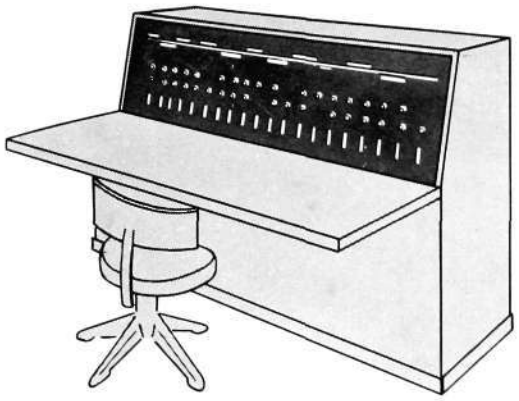


**Fig. 2** X 2312

**Control machine in C.T.C. office, 1927 model**

ment of a kind that permitted every operator comfortably and efficiently to control as large a territory as possible from his position at the machine.

## The Development of C.T.C. Offices up to the 1950-ies

The first C.T.C. system in the world was installed in the U.S.A. in 1927. The line controlled was a very short one, and the little control machine was designed for individual control of points and signals, roughly as illustrated in fig. 2. It probably fulfilled all reasonable requirements at that time. But it is remarkable that the C.T.C. machines produced during the following thirty years closely followed the design of the original model. Most machines delivered even up to 1957 were probably almost identical in appearance and in operating principles to the machine produced 30 years back. In large C.T.C. offices the control machines have admittedly assumed a horseshoe shape and the operator's chair now has runners, but the advance has not been rapid (fig. 3).

It would seem an important point that the C.T.C. operator should have a constant view of the entire track diagram of the territory for which he is responsible. This is quite clearly impossible with the "conventional" design of control machine and operating system. Moreover, according to the notions of our time, it is considered an advantage if the operator can sit still—even if a certain amount of motion has points in its favour. The drawbacks of the conventional design are likely to become more serious in future owing to the tendency to enlarge C.T.C. areas. Quite soon a single C.T.C. office may control an entire railway district covering thousands of miles of track. The track diagram will then have to be divided into sections, as admittedly is done now, but the sections will have to be much larger. It should be possible to cover at least 300 miles and 50 stations from a single control machine of suitable design.

Individual control of points and signals is admittedly fully acceptable for a short length of track. But for large C.T.C. offices the method does not appear satisfactory. In the latter the control must cover entire routes, and should perhaps to some extent be automatic. The larger the C.T.C. office, the more important do these factors become. The introduction of route control on the LTL principle, as described for interlocking plants above, is a case in point. Systems of this kind have been installed by L M Ericsson in Denmark, Norway and Poland.

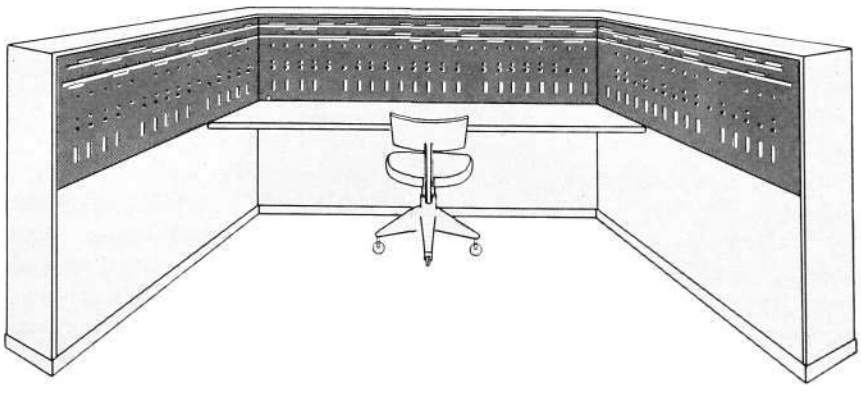


**Fig. 3** X 8087

**Control machine of conventional type, model 1927—1958**

Most C.T.C. offices in the world are still of the design illustrated, and as a rule every point and every signal is still individually controlled. The operator cannot reasonably be expected to have the entire track diagram constantly under his eye while moving about. His chair is normally fitted with runners.

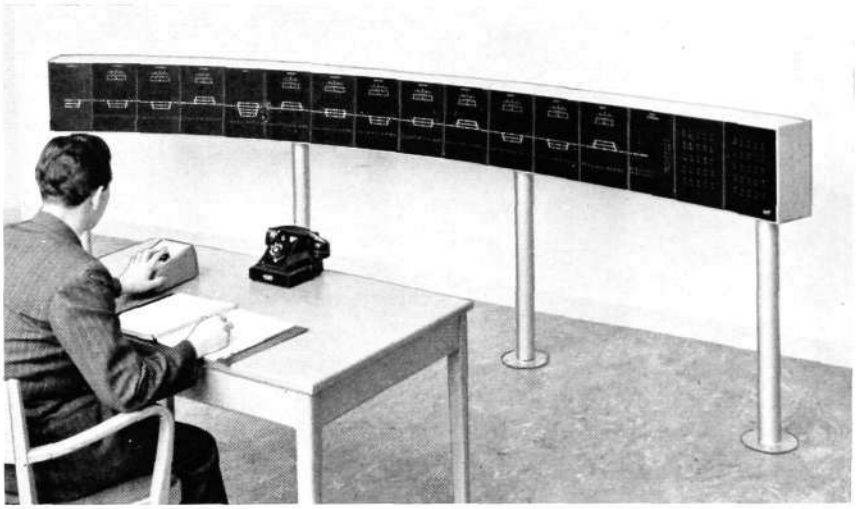


**Fig. 4** X 8082

**Keyset and track diagram for C.T.C. office as supplied by L M Ericsson**

All controls are effected by keying a multidigit number on the keyset. The operator has a full view of the entire track diagram in all situations. (This track diagram was delivered to the Swedish State Railways.)

## Keyset Operation

L M Ericsson's first C.T.C. system was delivered in 1938. The control machine was of conventional design, although with equipment for control of complete routes. The equipment is still in service and operating efficiently.

When L M Ericsson started to redesign its C.T.C. system around 1950, primarily in order to step up the rapidity of operation, it was considered advisable at the same time to modernize the control and indication equipment and the method of operation. After careful deliberation and study the following criteria for a C.T.C. office were set up.

1. The operator should be able to actuate all controls from one position.
2. The operator should have a good view of the entire track diagram from his desk.
3. The operator should be able to actuate all controls with one hand (preferably the left hand).
4. The control panel must be capable of standardization for all C.T.C. offices; and several control panels should be capable of operation in parallel, temporarily or permanently.
5. The normal procedure should be control of an entire route. But individual control of signals and points should also be possible.
6. If indication of category of train on the track diagram is desired, the same control panel should be used for this purpose as for other C.T.C. operations.
7. The track diagram should be semi-circular.
8. The operator should be able to transmit from the control panel information which permits automatic control of the C.T.C. system to a varying extent. The track diagram should possess the necessary indicating lamps for this purpose.

Requirements 1 and 2 meant that, at least in large C.T.C. offices, the track diagram must be separate from the control panel. Since it was also required that the control panel should be standardized, it followed that this separation must apply to small offices as well. An example of the placing of the controller and his control panel in relation to the track diagram is shown in fig. 4.

The control panel would meet the requirements of universal applicability (standardization) and be operatable with one hand (requirements 3 and 4) if it was designed as a keyset of the type used on calculating machines. The keyboard could be large or small, with one or more sets of keys for each digit. The small keyboard would require a rather more complicated intermediate relay set than the large one, but the advantages from the control aspect appeared so great that the small keyboard was adopted (fig. 5). Requirement 4, that several control panels could be used in parallel, was thereby easily met.

Since control was to be exercised through the keying of numbers on a keyboard, the numbers would have to be simple enough for the C.T.C. operator to remember at least those in common use. This did not prove difficult, particularly since, for reasons of rapid operation, an entire route would normally be controlled by keying a single code (requirement 5). An example of a logical numbering system for all routes on a single-track line is shown below. This is only one way of arranging the numbering. Many other systems would be equally logical and equally easy to remember. Easily memorable numbering systems can likewise be made up for double-track lines.

| *Keyset control nos.* | *Route* |
|---|---|
| 11 | *Approach* from south (*northward*) main track |
| 13 | " " " " first siding |
| 15 | " " " " second siding |
| | etc. |
| 21 | *Exit northward* from main track |
| 23 | " " " first siding |
| 25 | " " " second siding |
| | etc. |
| 12 | *Approach* from north (*southward*) main track |
| 14 | " " " " first siding |
| 16 | " " " " second siding |
| | etc. |
| 22 | *Exit southward* from main track |
| 24 | " " " first siding |
| 26 | " " " second siding |
| | etc. |

Odd numbers are used for all controls of trains in one direction, and even numbers for all controls of trains in the other direction. The first digit of all controls is odd for approaching trains and even for departing trains.

Each control, however, must consist of four digits, of which the first two represent the station number. The station number can be indicated on the track diagram so as to be easily visible to the controller from his working position. The control of a route for a train entering the main track at station *34* from the south will be effected by keying number *3411* (fig. 6).

Train categories (goods, express etc.) or train numbers (requirement 6) are indicated on the track diagram by the track circuit lamps or by lamps placed beside them. When a new train enters the C.T.C. section, the category of train must be indicated on the track diagram by operation of the keyset. This can be done for instance in the following manner. The controller first keys the number of the station and of the track on which the inbound train has entered the C.T.C. section. He then keys a letter, signifying the category, or

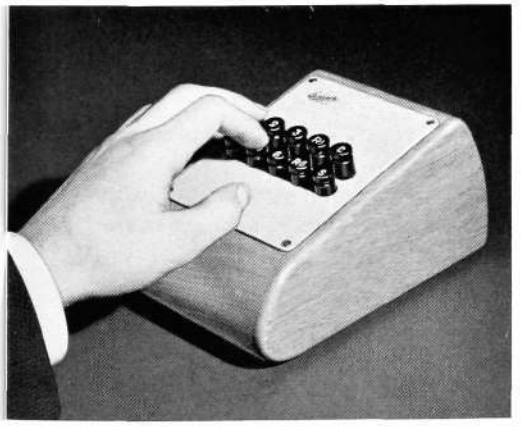


**Fig. 5** X 2314

**Keyset for C.T.C. operation**

**The operator keys a four-digit number to control an entire route. When desired, however, he can control points and switches individually by keying other numbers. With other numbering schemes the operator can indicate the category or destination of each train on the track diagram, after which the indication moves with the train from track section to track section. A trained C.T.C. operator, of course, need not look at the keyset when manipulating the keys.**

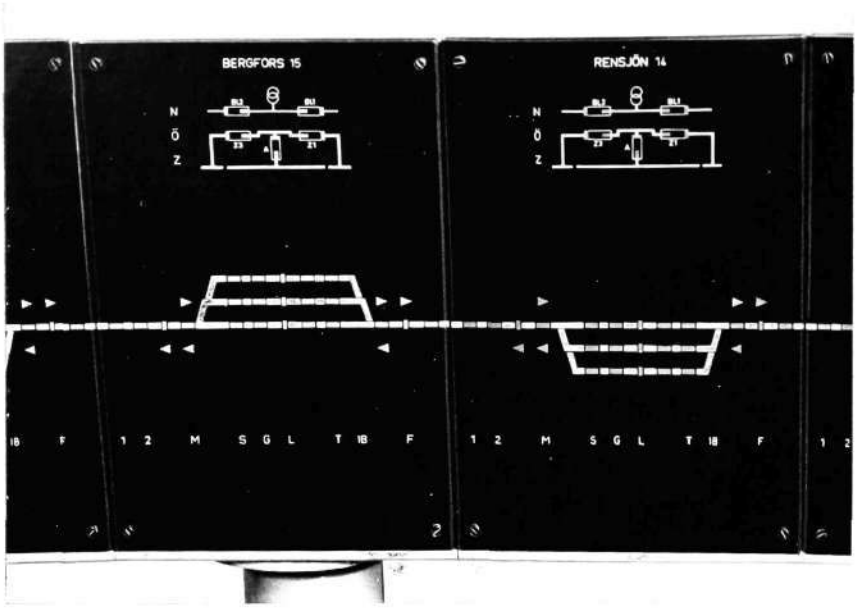



Fig. 6 X 8088

**Part of C.T.C. track diagram**

Every station has its number, which the C.T.C. operator keys when transmitting a control. This track diagram also shows the positions of circuit-breakers and disconnecting switches in the railroad overhead line and auxiliary transmission line. The control of circuit-breakers and disconnecting switches is effected with the keyset in the same way as control of routes etc.

numerals, signifying the number, of the train. The combination *0112G* would provide the following information:

*0* signifies that the subsequent digits and letter refer to the category of train. (The information is not to be transmitted to the C.T.C. control register.)

*11* signifies indication of the category of train at station *11*.

*2* signifies indication of the category of train on track *2* (at station *11*).

*G* signifies goods train.

When using a train number system, the combination *0112324* would permit the entry of train number *324* to track *2* at station *11*. The indication of train category or number moves along the track diagram automatically from track section to track section as the train advances.

Requirement 7 needs no special comment. The track diagram is semi-circular as shown in fig. 4.

Requirement 8 stipulated that the control system should permit automatic operation to varying degrees, and that whatever automatic methods were employed should be adequately indicated on the track diagram. This requirement is dealt with in the following section.

## Automatic Operation

The execution of a C.T.C. control takes very little time. It amounts to a few seconds, and in a small office the actual operating time is a relatively insignificant factor. But it must be remembered that the main job of a C.T.C. operator is to plan train movements, not to execute the actual controls. In a large C.T.C. office, therefore, it may be necessary either to use several C.T.C. operators or to have a single operator and give him additional technical aids. We may take as example a single-track section comprising 25 stations and carrying 60 trains a day. During the period of heaviest traffic the operator would have to execute controls about twice a minute. (In assessing the amount

of work to be performed by a C.T.C. operator, the number of occasions on which he has to execute controls would appear to be a better gauge than the number of controls to be executed.) Even if every action by the C.T.C. operator controls an entire route, he should hardly be made responsible for so great a number of operations if he is at the same time to do his main job of planning train movements.

But the capacity of a train despatcher can be increased by giving him additional technical equipment. This can be arranged in several different ways without needing to add unduly to the expense of the C.T.C. equipment. The Swedish State Railways, for example, have introduced local equipment at the stations for storage of routing orders from the C.T.C. office. The C.T.C. operator can then give advance orders for control of several train movements, and the number of occasions on which he has to execute controls can be easily reduced to less than half. If considered preferable, the storage equipment can naturally be installed equally well in the C.T.C. office. It can also be combined with a certain measure of automatic operation by having station signals and points automatically set for a meet if two trains approach from opposite directions.

The Danish State Railways have chosen another method of reducing the work of the C.T.C. operator. It has been called the "destination indication system"; the destination of every train entering the C.T.C. area is marked on the track diagram by means of the track circuit lamps, or by lamps placed beside them, in the same way as the category of trains. When the train arrives at its destination, the destination lamp on the track diagram darkens and the C.T.C. operator keys a new destination. All signals and points are operated automatically by the destination marking equipment.

Keyset operation of the destination indication system could be carried out for instance in the following manner: When the C.T.C. operator wishes a train on track *2* at station *12* to move to track *2* at station *34*, he keys *0122342:*

*0* signifies that the subsequent digits refer to destination marking. (The information is not to be transmitted to the C.T.C. control register.)

*12* signifies indication of the destination of a train at station *12*.

*2* signifies indication of the destination of a train on track *2* (at station *12*).

*34* signifies that the train will proceed to station *34*.

*2* signifies that the train will proceed to track *2* (at station *34*).

If for any reason the destination of a train requires to be cancelled, this is done by keying the track number and station number of the present position of the train, followed by *0*. Number *01120* would mean cancellation of the destination of a train on track 2 at station *11*.

Like the storage system employed by the Swedish State Railways, the destination marking system can be combined with automatic equipment which sets signals and points at a station for a meet if two trains approach the station from opposite directions.

## Other Designs

Even if L M Ericsson has found that C.T.C operation can best be effected by means of a keyset, it is obvious that other methods may be preferable in special instances. The aforementioned principles of indication of train category and of automatic control by means of storage or indication of destination can be applied to other methods as well.

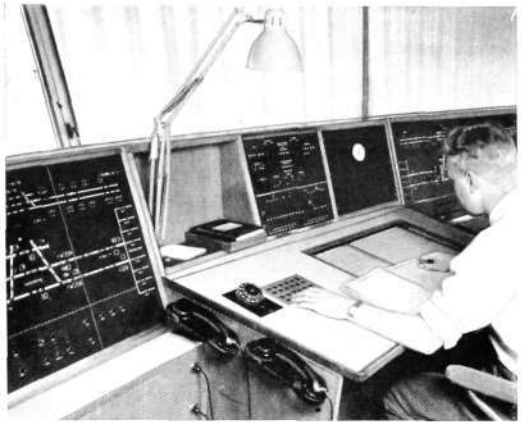


Fig. 7 X 2315

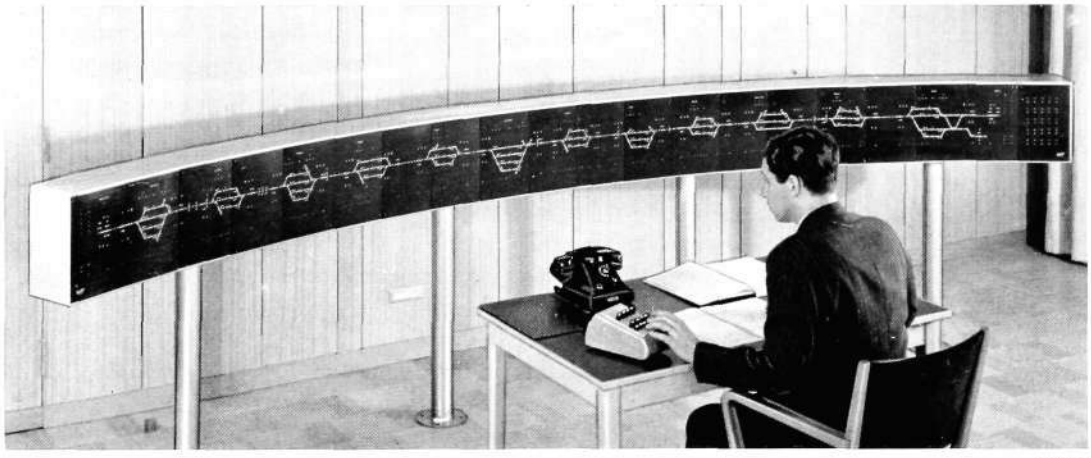
**C.T.C. machine and track diagram with Line-To-Line system**

In the centre of the machine, beside the traingraph, are certain keys with which the controller can perform all normal operations. For special operations, however, he must move over to the track diagram. (This equipment was delivered to the Danish State Railways.)

Particular mention may be made of a method employed by the Danish State Railways, involving the control of entire routes by means of a Line-To-Line system on the combined control panel and track diagram. In parallel with the Line-To-Line controls, however, are keys which are placed in the centre of the control machine beside the traingraph (fig. 7). These keys can only be used for normal control operations, but preclude the necessity of the C.T.C. operator moving from one part of the control machine and track diagram to another, apart from exceptional cases. The use of the destination indication system, with the controls placed beside the traingraph, means that the C.T.C operator should in practice never need to leave his normal working position.

## Experience of Keyset Operation

L M Ericsson's first keyset-operated C.T.C. system was installed on the Swedish State Railways in 1955. The overall experience during these three years has been very satisfactory. The personnel have had no difficulty whatsoever in learning the numbering system, and it has found to be a manifest advantage that the C.T.C. operator should have the entire track diagram constantly under his eye and be able to perform all operations while sitting at his desk.



X 8089

Fig. 8

**C.T.C. equipment delivered to Jugoslavian Railways**

This office, situated in Doboj, controls the roughly 100 kilometres of single-track line between Doboj and Zenica. The main part of the installation will be completed this year and the remainder during 1959.