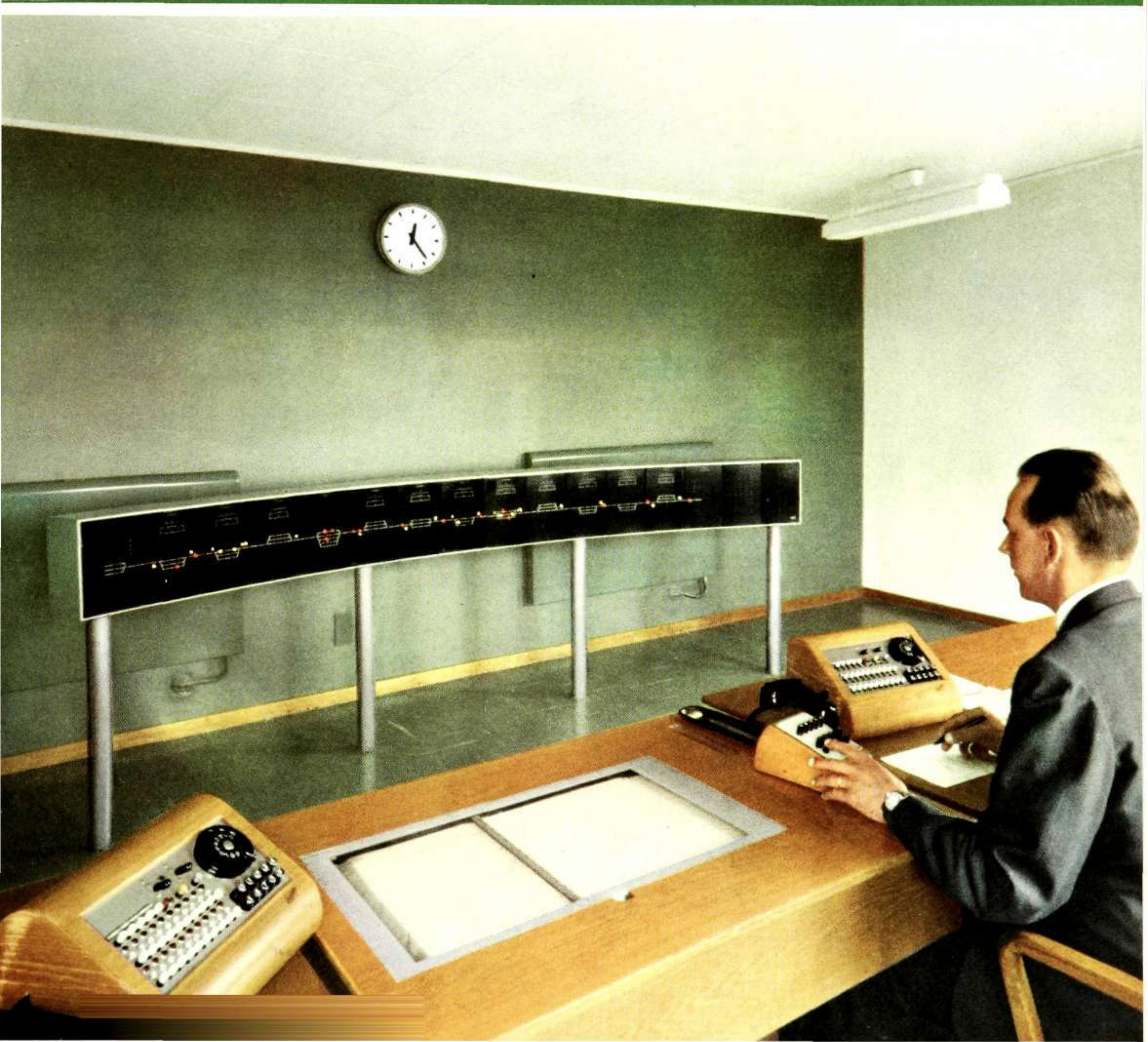
ERICSSON Review

3
1960



L M Ericsson's C.T.C. Makes Headway

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UDC 656.259.12
LME 86

L M Ericsson's C.T.C. systems have been described in Ericsson Review Nos. 4, 1954 and 2, 1958. The traingraph used with the C.T.C. system was described in Ericsson Review No. 2, 1956. This article will present a summary account of the characteristic properties of L M Ericsson's C.T.C. systems, followed by brief descriptions of the major plants sold in recent years.

L M Ericsson's C.T.C. is an electromechanical system made up of telecommunication relays of standard type. It is so rapid in operation that no cause has yet been found to change to an electronic system, which would at present be more expensive. The C.T.C. equipment can be connected to any type of relay interlocking plant. The control and indication devices can be designed to any railway requirements, and the C.T.C. plants delivered by L M Ericsson up to now show that these differ very considerably. L M Ericsson especially recommends its keyset system, however, which has achieved considerable successes.

1. Characteristic Features of L M Ericsson's C.T.C. System

Relay equipment

The relays in the C.T.C. office and C.T.C. field stations are made up in relay sets of plug-in type, which have been standardized to the greatest possible extent. They have plexiglass covers (fig. 1) for assistance in fault tracing and maintenance.

Information between C.T.C. office and field stations is transmitted on a two-wire physical circuit in the form of groups of d.c. impulses. Four impulse groups of six impulses each are used for the control system. In each group one impulse is of reversed polarity and the last impulse is longer than the remainder. The impulses for the indication system are differentiated on similar principles. So effective is this method of impulsing that the probability of distortion causing a wrong control or indication is remarkably small. In fact, no such occurrence is known from practical operation. The system is therefore very reliable.

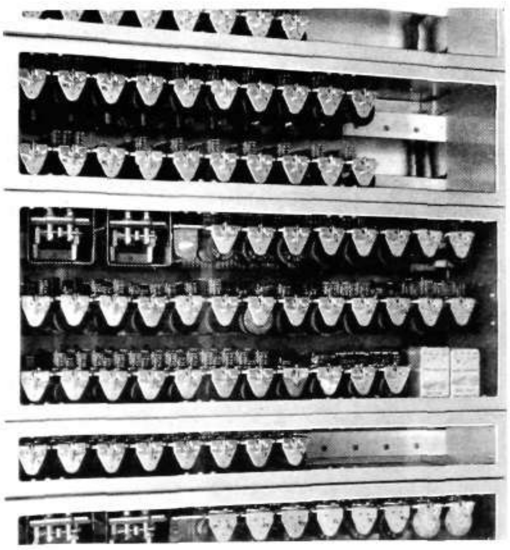

Fig. 1 X 2522

Plastic covers over relay sets facilitate maintenance.

C.T.C. systems may be described in terms of different kinds of capacity. L M Ericsson's standard system comprises 36 controls and 49 indications per field station and can be wired for connection of 36 field stations. The total capacity is therefore $36 \times 36 = 1{,}296$ controls and $36 \times 49 = 1{,}764$ indications. This control and indication capacity, however, may be limited by the capacity of the transmission line. Only under conditions of light headway would it be possible to have 36 stations on one C.T.C. section. As a rule the number of indication transmissions per station is up to 10–20 per train passage. If, for example, 20 stations are connected to a C.T.C. section with 4 trains per peak traffic hour and 15 indication transmissions per train passage, the number of indication transmissions would be $20 \times 4 \times 15 = 1{,}200$ per hour. On top of this come the control transmissions. If each transmission were to take 3 seconds, the line would obviously be fully loaded. In L M Ericsson's system, however, the impulse frequency is as high as 25 c/s and the transmission time per control or indication less than 2 seconds. In addition, the indication system is so wired that if a transmission is delayed on account of the circuit being engaged, and one or more changes of function occur during the delay

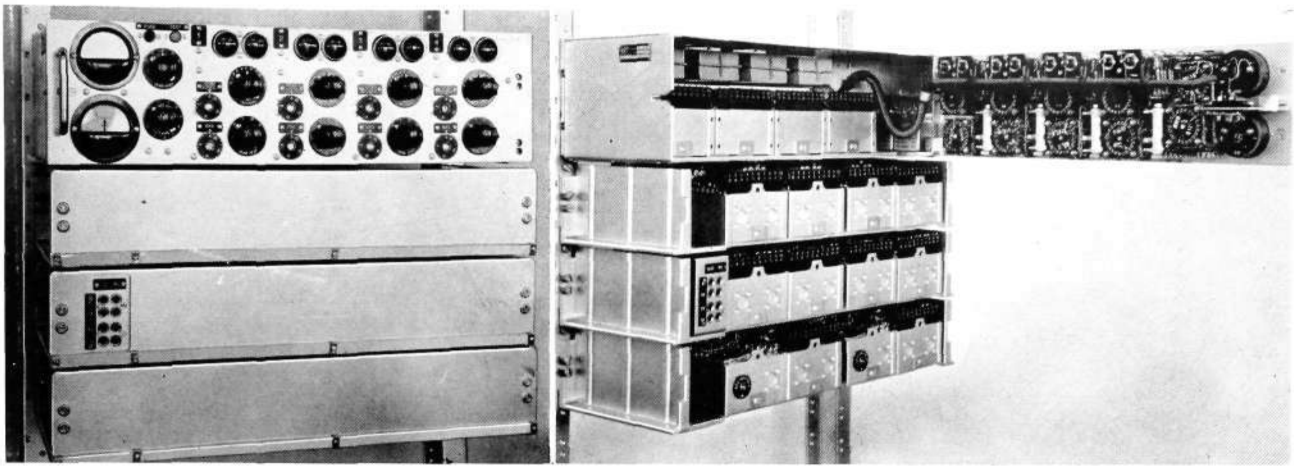

Fig. 2 X 7785

V.f. terminal equipment for four telegraph channels

Two channels are required between the C.T.C. office and each C.T.C. section with the exception of the section nearest to the C.T.C. office.

period, all these indications are thereafter sent in a single transmission so that the time per indication is greatly reduced (49 indications are sent in 4 seconds). The problem of delay is nevertheless a factor to be taken into account, and the maximum delay time must be calculated for each individual plant. As a rule it should not exceed 15–20 seconds, but shorter delay times are to be preferred.

In order to increase the capacity of the C.T.C. system still further, L M Ericsson has introduced the principle of "partial indication". The personnel in the C.T.C. office do not generally require to know everything which takes place in the station signalling plants. Normally, therefore, it suffices to send only certain indications, "partial indication". Only in response to a special control from the C.T.C. operator is a "total indication" returned. This reduces the number of indication transmissions and permits a larger number of stations to be connected to the same circuit.

When a C.T.C. line is divided into sections, transmissions between field station and section boundary are by d.c. impulsing, but between section boundary and C.T.C. office on two telegraph channels. These channels can be placed in the v.f. band or in a carrier circuit or radio link (fig. 2).

A telephone exchange can accept a fault rate of 1 per 5,000–10,000 connections. A fault rate of this order would be impermissible in a C.T.C. system. In the example mentioned earlier, with 1,200 indication transmissions per hour, this would involve several disturbances every day, which cannot be tolerated in train operation. The reliability must be of a very much greater order, involving a fault rate of about one hundredth or one thousandth of the above figure. This has been successfully achieved.

Different types of control and indication system

In the oldest system the control and indication panels were combined into a single unit and equipped with lever keys or buttons for the transmission of individual controls to signals, points etc. The system has been in use since 1927 and is still being supplied by many firms, including L M Ericsson.

The control and indication system can be designed on similar principles to modern relay interlocking plants, i.e. with Line-To-Line (LTL) equipment. This means that controls governing the establishment of an entire train route are sent by means of keys or buttons located along the lines on the C.T.C. track diagram. This system is simple and L M Ericsson has delivered several LTL type C.T.C. plants.

Recently some firms have supplied systems with the control panel separate from and placed below the centre of the indication panel. The control panel has only *one* set of buttons or keys per station, which may be used for individual operation or for LTL. When a control is to be sent to a field station,

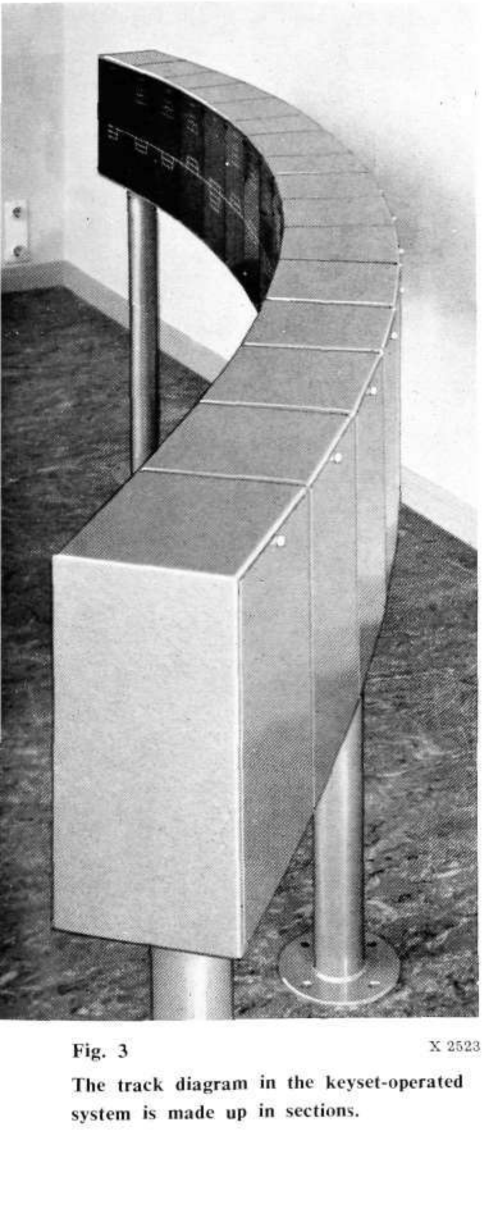

Fig. 3 X 2523

The track diagram in the keyset-operated system is made up in sections.

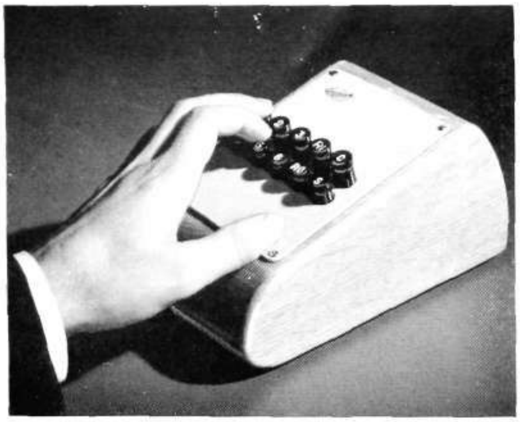

Fig. 4 X 2524

The simple control machine in the keyset system has push-buttons for keying four-digit control numbers, as well as auxiliary buttons.

the station's control register is first connected to the control machine, after which the control can be transmitted in the manners described above. This more modern system was introduced *subsequent to* the keyset-system described below and has certain of the advantages of the latter. The keyset system was developed by L M Ericsson in 1954 and several such systems have since been delivered.

Keyset system

The track diagram is separate from the control machine and is made up in sections (fig. 3). Additions or alterations to the track diagram can thus be easily effected.

The control panel consists of a keyset (fig. 4) for sending controls to all stations by keying a four-digit number and pressing a start button. With a logical numbering scheme it is extremely easy for the operator to remember the different control codes.

The chief advantages of the keyset system are:

The operator can remain in one position from which he can perform all operations with one hand.

The operator always has a complete survey of the *entire* track diagram from his desk.

One or more keysets can be installed in one office so that the number of operators can be varied during the twenty-four hours of the day.

Train category or train number systems etc. can be controlled with the keyset without adding to the complication of operation.

Alterations and additions to control and indication equipment can be easily effected.

Automation

All the control and indication systems referred to above can incorporate arrangements for more or less automatic operation. L M Ericsson supplies a destination indication system with which the C.T.C. operator can "mark" every train with a destination which thereafter "follows" the train across the track diagram. The destination indication automatically controls all signals and points up to the final destination.

Traingraph

L M Ericsson's traingraph can be connected to any control and indication system whatsoever (fig. 5).

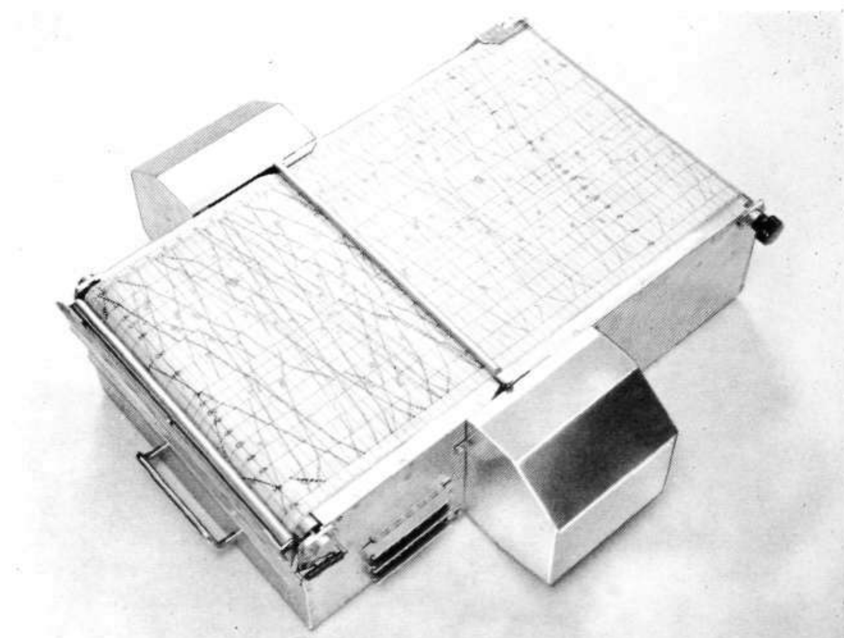

Fig. 5 X 8225

The traingraph records train movements (on left) so as to provide a direct comparison between the actual and scheduled train times (preprinted on the diagram).

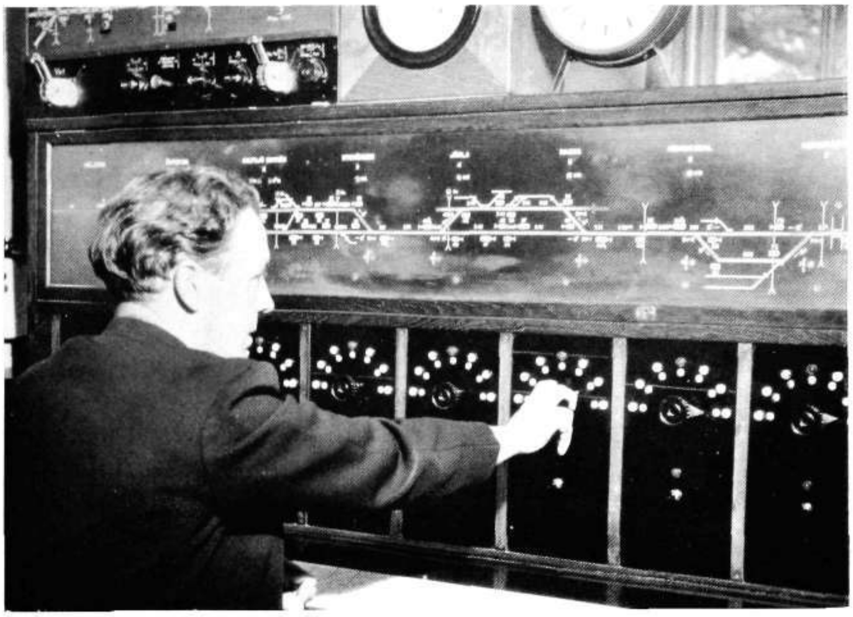

Fig. 6 X 8226

L M Ericsson's first C.T.C. system was installed in 1938 on the Stockholm—Saltsjöbaden line.

Fig. 7 X 2533 X 9151

C.T.C. plants of the Swedish Railways installed and scheduled. All plants have been or will be delivered by L M Ericsson.

■ C.T.C. office

▮▮▮▮▮ C.T.C. line

2. L M Ericsson's First C.T.C. Installations

L M Ericsson's first C.T.C. installation was built as early as 1938 on the Saltsjöbaden line between Stockholm and Neglinge, a distance of about 7 miles with 5 field stations (fig. 6). The installation is still in operation and has hitherto functioned satisfactorily. The system is based on rotary selectors.

In 1951 the Gilserud installation was built in Sweden, and in 1952 the Lieråsen plant in Norway. Both systems are based on relays alone without rotary selectors. Their design is essentially similar to that of L M Ericsson's most modern C.T.C. systems, although the impulse frequency is lower, about 10 c/s. There is only one field station in each installation.

In 1955 the first rapid operating C.T.C. installation was opened in Sweden on the 20-mile single-track Ånge–Bräcke line with 4 field stations. In the following year the first installation was completed in Denmark on the Vordingborg–Masnedø line. The latter had only one field station. In 1956–1957 a longer C.T.C. line was brought into operation, from Nyborg to Holmstrup, with 27 miles of double track and 5 field stations. These installations have provided L M Ericsson with valuable experience which has led to a number of improvements, often at the suggestion of the two railways.

3. New Installations

Sweden

The C.T.C. installation on the single-track line between Kiruna and the Norwegian frontier, the entire length of which runs north of the Arctic Circle, must be the northernmost C.T.C. installation in the world. The line carries very heavy iron ore traffic from the mines in Kiruna to the Atlantic port of Narvik with, at present, a maximum of 65 trains per day. The ore trains are up to 470 m in length and weigh up to 3,100 tons. The line also carries passenger traffic. The C.T.C. office (see front cover) is equipped with a train-graph, which is also used as train journal.

The C.T.C. system is likewise used to control and indicate the positions of circuit breakers and disconnecting switches in the catenary line and auxiliary power line systems.

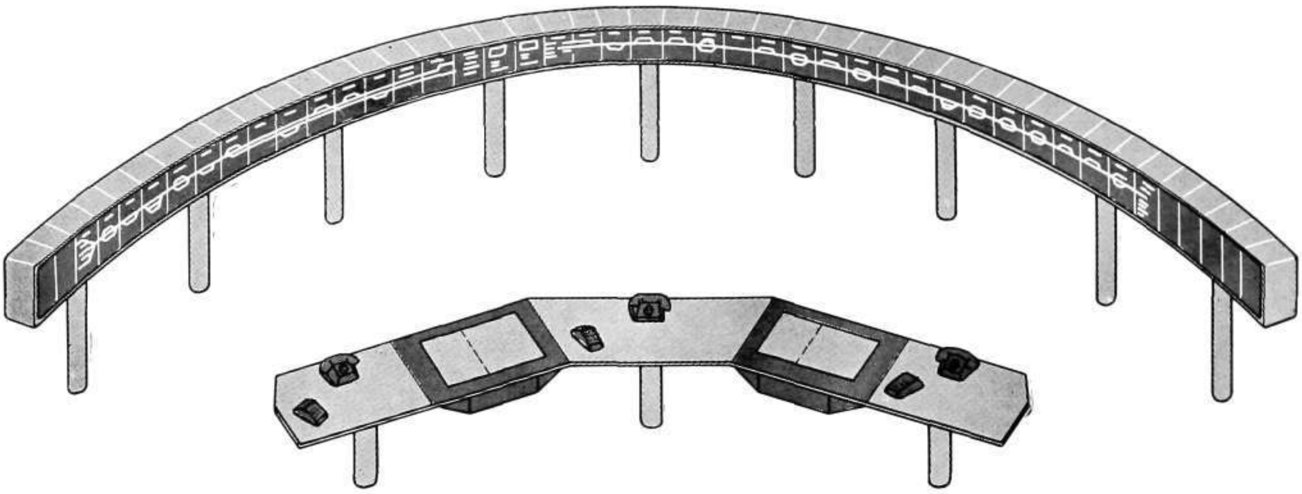

Fig. 8 X 7792

The new C.T.C. office at Ånge, which will be commissioned in the winter of 1960.

It will control 33 stations and will have two traingraphs and three operating positions, with operation from the outer positions during peak traffic and from the centre position during low traffic periods.

The C.T.C. installation is now being extended southwards to Gällivare and will then comprise 22 field stations extended over 144 miles of line. The southern line as well will carry principally iron ore traffic destined for Narvik.

The Kiruna plant was needed in order to bring up the railroad capacity to cater for the successively increasing ore transports. Since the introduction of C.T.C. it has been possible to reduce station staffs, a considerable advantage to the railway both from the economic aspect and also because it is difficult to get people to work at such remote stations as exist in northern Sweden.

The Swedish Railways are at present building the largest European C.T.C. installation between Ljusdal and Mellansel in northern Sweden, a distance of 224 miles with 44 field stations. The line is mainly single-track and carries mixed traffic with altogether 60 trains a day. It is at present so heavily loaded that delays can generally not be avoided. It is calculated that the C.T.C. plant will increase the capacity and make operation more economical. There will be one C.T.C. office at Ånge (fig. 8) for control of 33 stations and one at Vännäs for, initially, 11 stations. The plant will later be extended northwards about 125 miles with some 22 additional stations.

There will be two traingraphs in each C.T.C. office, from which the circuit breakers and disconnecting switches of the catenary line and auxiliary power line systems will also be controlled.

All Swedish Railways C.T.C. plants have keyset operation.

Denmark

As already stated, C.T.C. has been in operation on the Nyborg–Holmstrup double-track line, with C.T.C. office at Odense, since 1956–57. The plant is now being extended to Fredericia and the entire C.T.C. line will then be 58 miles long with 12 field stations. More than 120 trains run per day, most of which carry passenger traffic. In view of the directional bias caused by the ferry connections between Nyborg and Zealand, the plant has been constructed to allow left-track operation in certain cases on the line which is normally used for right-hand traffic. The plant is operated on the Line-To-Line principle, and a destination indication system, to be controlled from a small separate control panel under the track diagram, is now being installed. Once the destination of a train has been marked, the signal system is controlled automatically and successively until the train reaches its destination.

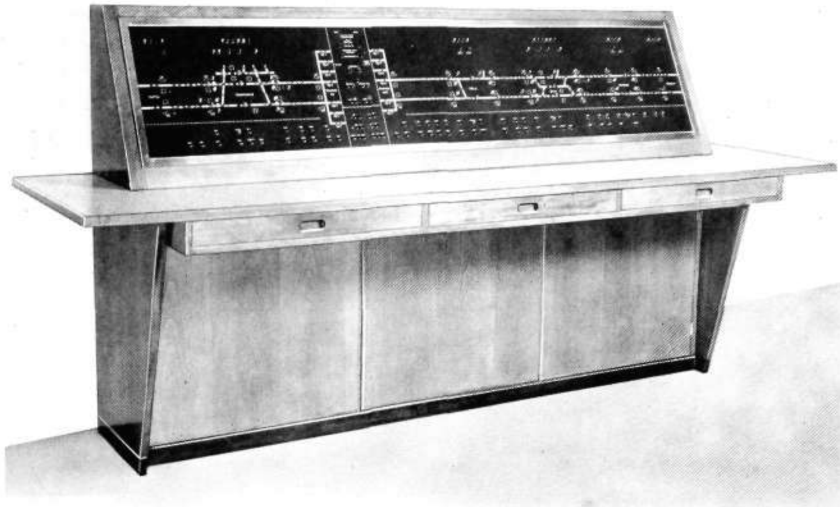

Fig. 9 X 8228

Control panel and track diagram for provisional C.T.C. office at Roskilde, Denmark. Operation by LTL method.

This year the Danish State Railways have brought a C.T.C. installation into commission between Nykøbing and Gedser, a part of the important single-track line across Falster carrying traffic between Denmark and Germany. Another C.T.C. plant has been opened between Tåstrup and Ringsted (fig. 9), which forms part of the double-track line between Copenhagen and Korsør. Both these plants have provisional C.T.C. offices which will be replaced by permanent offices when the plants are later extended. The Danish State Railways are also installing C.T.C. on the single-track Padborg–Tinglev line. This installation is expected to be successively completed during the years 1960–1963.

Poland

The first two C.T.C. plants in Poland are nearing completion, on the Sw. Wojciech–Port of Danzig and Otwock–Pilawa lines. Both lines are single-track. One plant operates on the Line-To-Line principle and the other has keyset operation (fig. 10). The Polish railways will thereby gain experience of two different control systems.

Jugoslavia

C.T.C. is being installed on the single-track Doboj–Zenica line which forms a link between Belgrade and Sarajevo and between Zagreb and Sarajevo. The line carries mixed traffic with up to 90 trains a day. Every station has three

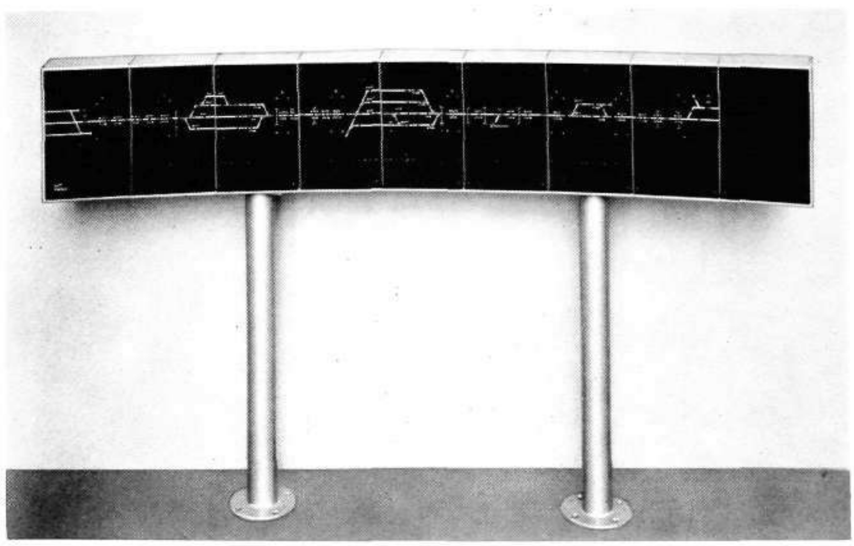

Fig. 10 X 8229

L M Ericsson has delivered two C.T.C. installations to the Polish Railways. The photograph shows the track diagram in one of them.

tracks. Delays are at present usual. It is anticipated that C.T.C. will not only eliminate delays but will also allow more trains on the line. The first third of the plant is already in operation and the remainder is expected to be completed successively during 1960–1961. The system is based on keyset operation and incorporates a train category indication system. From his keyset the C.T.C. operator can give every train a category indication which follows the train across the track diagram. A traingraph is also provided.

Portugal

L M Ericsson has been granted the opportunity of building for the Portuguese Railways a C.T.C. system of a type which differs from the normal. The double-track stations are not equipped with electrical point machines but the points can be operated, if necessary, by hand. Signals and point locking are controlled from the C.T.C. office and the points are normally positioned for movement through the stations on the left-hand track. This simplified form of C.T.C., which is of course cheaper than the normal design, is adequate for the existing traffic requirements. It will, in fact, greatly increase the capacity of the line and at the same time reduce the operating costs. This line, between Setil and Vendas Novas, is single-track, its main object being the carriage of goods between Lisbon and the south-eastern areas of Portugal. The expected headway will be 25 trains per day. The C.T.C. system will be keyset operated.

Formosa, China

The longest and most important railway line in Formosa is between Kaoshiung in the south and Keelung in the north. It runs quite close to the west coast, passing, among other places, Tainan, Changhua and Taipei. Part of the line is single-track and part double-track. It carries considerable traffic, about 70 trains per day, but the capacity must be increased to above 100 trains per day. Railways are still the predominant means of conveyance in Formosa, where road traffic has not yet obtained much importance.

L M Ericsson is now conducting the final tests on a large C.T.C. installation along part of this line, between Changhua and Tainan, a distance of 94 miles with 26 field stations. The large number of stations and the dense headway, with many indication transmissions, has necessitated division of the line into two sections, and information between the C.T.C. office and the most remote section is transmitted on telegraph channels in a carrier system. The C.T.C. office is shown in fig. 11, from which it will be seen that the

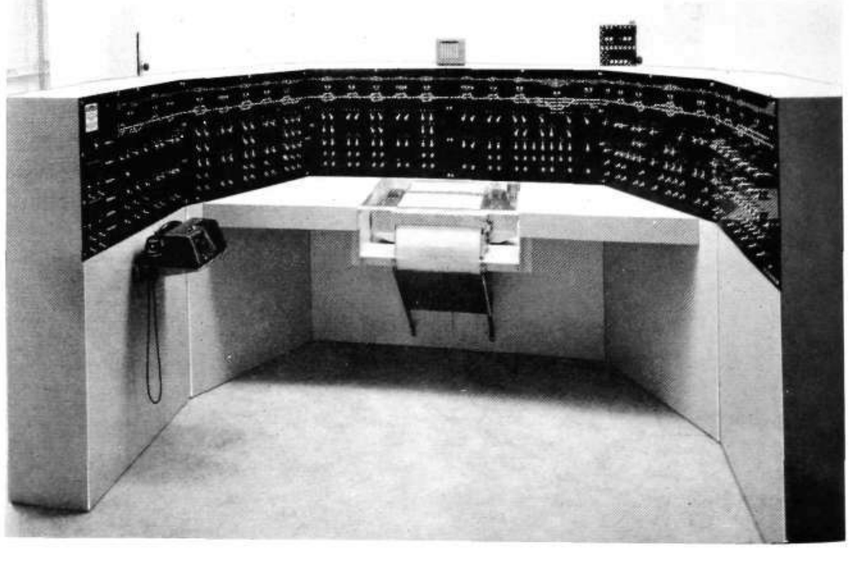

Fig. 11 X 8230

The C.T.C. system in Formosa was designed to American specifications with lever keys for individual switching of points and signals. The system comprises 26 field stations. The traingraph is seen in the centre.

control machine has individual lever keys. This was demanded in the Railway specification which was based on the American pattern. The system is equipped with a traingraph.

Pakistan

The North Western Railways in Pakistan had planned to install relay interlocking plants and block signal systems for the Karachi–Landhi line with indication of train positions at an office in Karachi. On L M Ericsson's recommendation, however, it was later decided to replace the indication system by a complete C.T.C. system. The line, which is double-track and carries both long-distance and local traffic, has at present about 50 trains per day. The traffic capacity needs to be increased, however, which will be achieved through the installation of C.T.C. Both tracks will be equipped with signals for reversible running. The C.T.C. office will be keyset operated and equipped with train category indication.

Ceylon

The railway traffic to and from Colombo is extremely heavy, and the capacity of the present double-track line is inadequate. The Ceylon Government Railways therefore decided to introduce C.T.C. over a distance of about 44 miles. The C.T.C. office will be at the capital and the system will permit reversible running on both tracks. The number of trains is expected to rise to 160 per day with a strongly directional bias in the mornings and evenings. The plant is to be successively installed during the years 1961–1962. It will operate on the Line-To-Line principle and be equipped with a traingraph.

4. Use of Keyset System

Anyone who knows the keyset system solely from descriptions and diagrams may have the idea that it is complicated and, above all, that the operator will have difficulty in remembering the numbering scheme, even though constructed on logical principles. A demonstration of a plant in operation, however, gives an entirely different impression, and people are often immediately convinced that the keyset system is simple and easily comprehensible. A new C.T.C. operator does, in fact, learn the system within a single day's duty and can thereafter perform 99 % of his operations with the same ease as a trained comptometer operator handles her machine, that is to say entirely automatically.

As already stated, the keyset system is employed by the Swedish Railways. L M Ericsson has also delivered keyset systems to Poland, Jugoslavia, Portugal and Pakistan. For India, L M Ericsson has constructed a model railway with complete C.T.C. for one of the railway universities. It is equipped both with keyset and Line-To-Line equipment in order that the Railway may acquire experience of both systems.

5. Need for C.T.C.

It is a fact that the railways of most countries in the world are finding it difficult to pay their way. This is due to the revolution in transport, with increasing use of air and road transport. It does not mean, however, that the railways are becoming superfluous. On the contrary they will retain and often increase in importance within certain categories of transport. Adaptation to the new conditions, however, requires investment and modernization of plant. One important measure is to increase the capacity of lines and to reduce train operating staffs. C.T.C. offers a suitable and comparatively cheap means of achieving this aim, and the railway administrations of almost all countries are now engaged in planning or installing C.T.C. Developments have naturally proceeded further in some countries than in others, but the tendency everywhere is the same.