C.T.C. on the Danish State Railways

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The Danish State Railways have this year completed the first stage in the modernization of the signalling system on the double-track main line across the island of Fyn. In this article the Head of the Danish State Railways 1st Signal Office, Mr W Wessel-Hansen, describes the new signalling equipment and the problems that have been solved in conjunction with its planning and installation. The new equipment comprises relay interlocking plants, block signalling, and centralized traffic control. The C.T.C. office is located at Odense. The signalling and C.T.C. equipment was supplied by L M Ericsson.

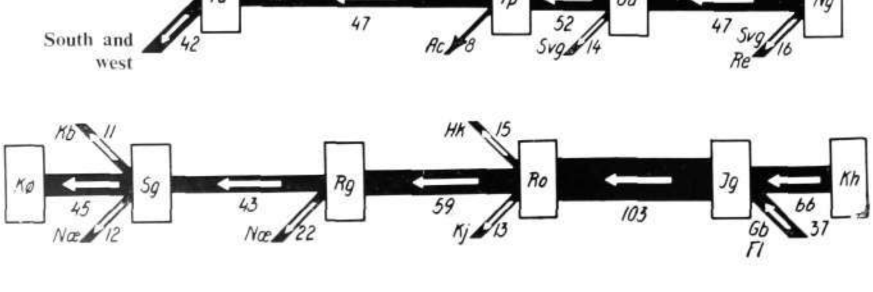
Main Railway Line across Island of Fyn

The Danish State Railways started in 1952 a series of investigations aimed at the progressive modernization of signalling plants. At that time it was, in particular, the main line across the island of Fyn—the section between Nyborg ferry station and Fredericia junction—that had been neglected from the point of view of efficient and up-to-date equipment for train dispatchings.

Fig. 1 gives an idea of the importance of this railway in relation to the main Zealand railway, Copenhagen–Korsør. The movement of every train from, for example, Nyborg to Fredericia demanded 33 persons on train dispatching and supervision of level crossings.

The investigations that were made showed that the simultaneous modernization of station track layouts, interlocking, block signalling, and telecommunication plants, and the introduction of automatic signals at level crossings, would not only lead to improved traffic conditions but also to such savings as would ensure a reasonable profit and depreciation on the capital invested in the new equipment.

In the following an account is given of the problems that have been solved either in connection with the preliminary investigations or as a result of the experience acquired.



X 8050
X 8051

Fig. 1
Train headway, week-day 1955, Copenhagen—Fredericia

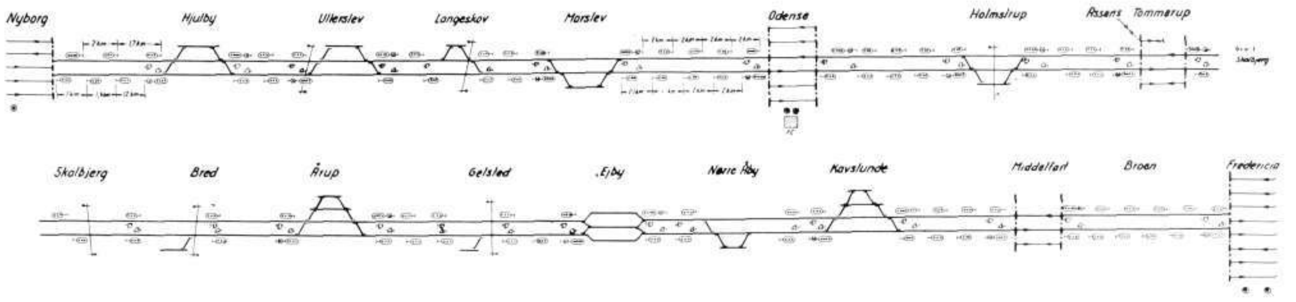


Fig. 2 X 7725 X 9142

Track and signal layout after completion of modernization

- Attended signal plant
- Level crossing

Station Track Layouts

An economic study was made, covering every station, of whether the station track layouts should be reconstructed, for example by reducing the number of side tracks or possibly by eliminating them altogether. In a single case a station was changed to stopping place. A study was also made of the requirement of sidings, both as regards their number and length. It may be mentioned that in recent years the Danish State Railways have replaced a large number of steam locomotives by diesels, which has generally conduced to quicker and longer trains so that a reduction in the number of sidings might be expected. Fig. 2 shows the track and signal layout as it now is or will be in future. One of the stations, Ejby, has a central siding, roughly 1 kilometre in length, which provides the best conceivable passing facility.

Interlocking Plants

The earlier mechanical interlocking plants had become highly unsatisfactory, both from the safety and operational points of view, and were therefore to be replaced by electrical plants. In 1952, however, there were only four quite small, experimental relay interlocking plants in operation. It was not until the Glostrup interlocking plant was put in service (in 1953) that the State Railways achieved a standard design of relay interlocking plant. In conjunction with the installation of this plant, moreover, it was found that the station signalling system used hitherto must be substantially modified to ensure greater safety and more flexible utilization of the track layouts. The main improvements at the stations were the division of the main tracks into signal-controlled sections and the use of speed signalling for approaching trains.

Standardization has had the benefit that interlocking plants for all minor stations (including C.T.C. stations) are now supplied ready-wired and tested from the railway signalling workshop in Copenhagen. At C.T.C. substations signalling, telecommunication and C.T.C. equipment is installed in a relay house which is sent by rail from the workshop to the site of erection.

Since most of the stations that were to be C.T.C. operated did not possess interplatform tunnels, it was necessary to supplement the interlocking plants by entirely new apparatus for the protection of passengers crossing the tracks. A dual system was chosen (fig. 3) consisting of automatically controlled signs, showing "Look out for train" under danger conditions, and automatically controlled loudspeakers which on the approach of trains announced: "Do not cross the track, a train is coming."

Block Systems

In 1952 the Fyn line was equipped solely with manual block, and that only to a small extent. For the most part train movements were directed by telephone. An extension of the manual block system would obviously not meet the present requirements and would be uneconomical, but experience of automatic block was lacking both in regard to the distance over which reliable track circuits can be established and what types of track relay were most suitable.

Fig. 3 X 8052

Protection of passengers when crossing tracks is provided by automatic signs combined with loudspeakers

At certain sites, therefore, 4–6 kilometre track circuits were installed on trial, and a theoretical calculation of long track circuits was started. The aim was to introduce a method of calculation and regulation such that all planning and design work could be left to non-engineering personnel. This standardization work has so far been completed only as regards track circuits of up to 6 kilometres. The standard that has been introduced (for non-electrified areas) is shown in fig. 4. There now remains only the completion of the investigations into 5–10 kilometre track circuits which will be required when single track sections are to be equipped with C.T.C.

The choice of a suitable type of track relay was extraordinarily difficult, the various alternatives being code following relays, frequency-controlled relays, phase-controlled relays or D.C. polarized relays. The latter were selected since on D.C. track circuits fairly simple emergency power plants can be arranged. It had been expected that such plants would be required, as they later proved to be, in view of the fact that the normal power supply would come through small "undependable" transformer stations. The selected track relay is a polarized telegraph relay, in parallel with a neutral D.C. relay (fig. 4). The contacts of the two relays are in series and actuate three auxiliary relays, which are the control relays for signal aspects etc. The operate and release functions of all relays are checked.

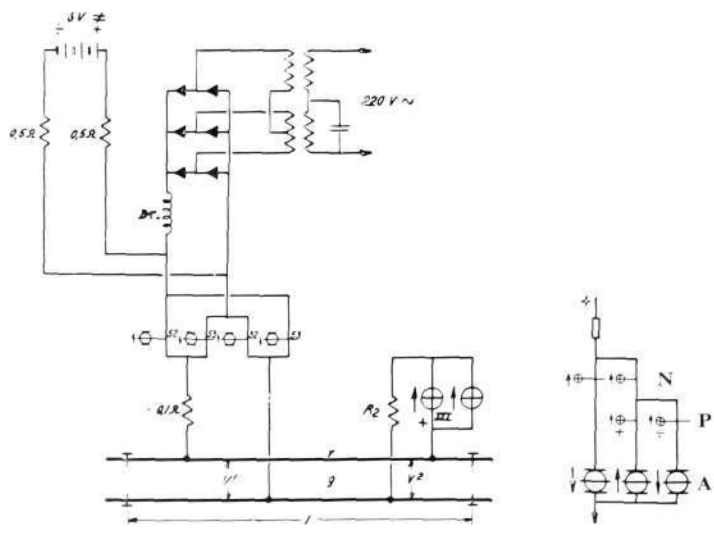


Fig. 4 X 8059

Circuit for automatic block signalling

The rectifier circuit ensures that the feed voltage is maintained constant as long as the current does not exceed 9 amps. At this amperage (train on track) the feed voltage swiftly diminishes.

In order that the emergency supply battery shall not disturb the above-mentioned characteristics of the rectifier, two 0.5 ohm resistors are placed in the battery leads.

On the longest track circuits the emergency supply cannot hold the track relay operated when the ballast resistance assumes the most unfavourable value.

By means of contacts on relays 52 and 53 code impulses are sent from the feed end to the relay end after every train passage.

Length of track circuit	$l_{max} = 10$ km
Rail resistance	$r_{max} = 0.1$ ohm/km
Leakage	$g_{max} = 0.625$ S/km
Track voltage, relay end	$v_{2min} = 1.25$ V

Relay data:

Pick-up voltage	1.0 V
Drop-out voltage	0.7 V

N Neutral D.C. relay
P Polarized relay
A Auxiliary relays

The relay racks, power supply equipment etc. is built into factory-made cabins, which are erected and fully tested at the railway signal workshop at Copenhagen before being despatched to the site of installation.

The standardization of the automatic block system necessitated the introduction of new block signals, the basic principle of which is that a signal shall also indicate the aspect of the following signal.

The arrangement of the block system, moreover, is that trains can run both on the right and left-hand tracks, but for movement on the left-hand track the number of block sections is only about half as great as on the right-hand track. The purpose is to use left-hand track movement only in the event of breakdown and during maintenance work on the track.

Level Crossings

The manual operation of gates at level crossings is inefficient in conjunction with automatic block signalling on high headway lines. The level crossings should either be eliminated or automatic safety arrangements should be installed. Our earlier experience was limited to automatic short-arm gates on single track lines, but in 1953 the decision was made to introduce automatic long-arm gates on double track railroads. In view of the division of the Fyn line into comparatively short block sections (1.5–2 kilometres) it was undesirable to use special control signals for the gate installations. It was therefore necessary to interlock the gate installations and block signals, with the latter checking the operation of the gates. It may be said without exaggeration that the introduction of the automatic long-arm gate installations was the most troublesome part of the whole project.

Telecommunication Installations

The automatic block installations required the laying of cables along almost the entire line. It therefore seemed natural to investigate the desirability of simultaneous cabling of all telecommunication circuits. It was in fact found that, under the existing circumstances, it would be economical to construct a separate telecommunication cable in which long distance calls would be made on carrier circuits. The service interruptions that had hitherto been so common on overhead lines during winter periods would thereby be eliminated.

C.T.C.

During the preliminary investigations of the conditions on the Fyn line it was considered that certain stations might well be controlled from a neighbouring station. A variety of circumstances, however, suggested that even greater advantages would be gained—smaller staff requirements and improved operation—if all stations on the line were controlled from a central location. In 1953 the Danish State Railways decided to introduce centralized traffic control of all stations between Nyborg and Fredericia, with the C.T.C. office located in Odense. The installation work was divided into two stages: Nyborg—Tommerup (exclusive) and Tommerup (inclusive)—Fredericia.

The complete project comprised:

9 stations with sidings
4 stations without sidings
about 77 automatic block sections and
7 automatic gate installations.

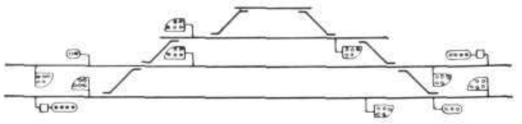


Fig. 5 X 2246

Example of station with siding on double-track line (Hjulby)

CONTROLS
4 entrance routes, right-hand track
4 exit routes, right-hand track
4 routes for left-hand track running
6 call-on-signal aspects
4 stop aspects for entrance and exit signals
4 emergency release of routes
4 selection of method of operation
3 permission for local control of points
7 point lighting and heating, night illumination etc.
3 new complete indication and lock-out of indication transmitter
2 manual intervention in automatic gate functions
19 initiation of telephone calls
7 spares
(7 of the above controls are twin controls)

INDICATIONS
7 station track circuits
8 block track circuits
12 signals for right-hand track running
4 signals for left-hand track running
6 call-on-signal aspects
8 route lockings
20 point positions (every point is indicated in duplicate)
3 methods of operation
4 point illumination and heating etc.
2 announcements of fault in interlocking plant
3 check of automatic gate functions
18 reception of telephone calls
3 spares

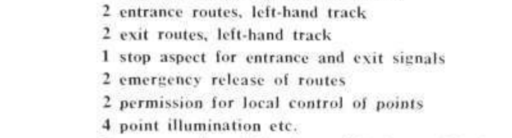


Fig. 6 X 2247

Example of station without sidings on double-track line (Bred)

CONTROLS
2 automatic block through the station
2 entrance routes, left-hand track
2 exit routes, left-hand track
1 stop aspect for entrance and exit signals
2 emergency release of routes
2 permission for local control of points
4 point illumination etc.
2 new complete indication and lock-out of indication transmitter
2 manual intervention in automatic gate functions
13 initiation of telephone calls
4 spares
(6 of the above controls are twin controls)

INDICATIONS
2 station track circuits
8 block track circuits
4 signals for right-hand track running
8 signals for left-hand track running
3 point positions (every point is indicated in duplicate)
2 methods of operation
1 point illumination and heating etc.
1 announcement of fault in interlocking plant
4 check of automatic gate functions
12 reception of telephone calls
2 spares

The work was allocated as follows:

L M Ericsson: Delivery of signals, safety relays, etc. for interlockings and block signalling and all C.T.C. apparatus.

Danish State Railways: Installation of signalling and telecommunication plants.

The contract for the C.T.C. equipment was signed with L M Ericsson at the end of 1954, but it was stipulated that the design should be capable of standardization in the event that The Danish State Railways should desire to extend the use of C.T.C. This decision had the effect of to some extent slowing up construction, but it has brought the advantage that the type of plant now installed can be used for practically all existing C.T.C. purposes.

The centralized control of individual stations was progressively brought into operation as interlocking plants and automatic block installations became completed during the period June 1, 1956 to July 10, 1957.

There now follows a brief description, based on operating experience, of the now standardized installations and of the various factors affecting them.

C.T.C. Installations of The Danish State Railways

Types of C.T.C. Field Stations

Figs. 5, 6 and 7 show the three types of station track layout that have now been standardized in as far as this has been possible in consideration of the many varieties of installation that may occur in practice. The figures also provide information of the required numbers of controls and indications per station. It should be observed that all telephone communications between the C.T.C. office and field locations pass through the C.T.C. apparatus. Since L M Ericsson's transmitters and receivers are supplied for 36 control transmissions and 49 indications, it will be seen that the three standardized types of station require 2, 1 and 1 units respectively.

Methods of Operation of Field Stations

Field locations are equipped with a control board from which the interlocking plant can be operated under exceptional conditions when released for such method of operation. The field locations are normally controlled by one of the following methods:

Automatic operation. The interlocking plant operates automatically, that is to say that trains approaching the station establish route lockings and signal indications without action from the control office. Automatic operation can be employed for one train direction at a time, or for both directions.

Manual centralized operation. The interlocking plant is operated from the control office. Under conditions of manual centralized operation the control office can release portions of the railroad for local operation by means of special local operation push buttons.

In both forms of operation the field location sends indications to the control office, which is thereby enabled to follow the traffic situation at the location. Controls are provided to enable the office to change over from one method of operation to another. Without action from the control office, field operation can be established by means of a Yale key in the field location's control machine. The Yale key is normally kept under seal at the field location.

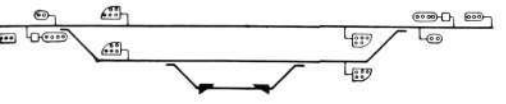


Fig. 7 X 2248

Station with siding on single-track line. The station tracks are long enough to permit simultaneous entrance of trains from both sides

CONTROLS

2 entrance routes
2 exit routes
2 locking of block system for movement from neighbouring station
2 call-on-signal aspects
1 stop aspect for entrance and exit signals
2 emergency release of routes
1 permission for local operation of points
2 operation of points
6 point lights and heating, night illumination etc.
2 new complete indication and lock-out of indication transmitter
2 manual intervention in automatic gate functions
9 initiation of telephone calls
3 spares
(7 of the above controls are twin controls)

INDICATIONS

4 station track circuits
6 block track circuits
8 signals
2 call-on-signal aspects
2 route lockings
10 point operations (every point is indicated in duplicate)
4 point lighting and heating etc.
1 announcement of fault in interlocking plant
2 check of automatic gate functions
8 reception of telephone calls
2 spares

Automatic Recording of Train Times

The C.T.C. equipment incorporates a traingraph for automatic recording of train movements, so relieving the C.T.C. operator of the necessity of keeping a train journal or similar record. It should be observed that all vehicles used on the line are uninsulated, so that all traffic is reported, including trolleys etc.

The traingraph comprises:

a recording chart moving at 60 mm per hour
a colour ribbon with red and blue sections
a number of electromagnetic hammers, one for each block section.

Trains on one track are marked in red, and on the other track in blue. This is accomplished by the hammers striking the red or blue ribbon against the underside of the paper at 30-second intervals, so producing marks on the chart at every 1/2 mm.

The marks punched by the hammers on the chart produce broken lines showing the progress of every train; red for one direction of movement, blue for the other. On a double-track line trains are not recorded on sidings. The graphic timetable is printed on the chart, so that deviations from the timetable can be immediately observed.

Automatic Indication of Classes of Train

The usual indications have been supplemented by automatic indication of train class by means of indicating lamps on a miniature track diagram at the top of the control machine. On each station track and each station-to-station section there is a lamp for each class of train, the present classes being as follows:

green lamps for express through trains
yellow » » slow » »
red » » local trains

The individual train class indication moves automatically as the train advances from one section of line to the next. The indication of a train is started by the pressing of a button on the control board, representing the class of train departing from the terminal station. When the train enters the line, the indicating lamps light accordingly. If there are several trains following one another between two adjacent stations, only the first train is shown. On all panel sections there are buttons for indication of train class, and cancellation buttons which permit cancellation of an indication if a train ends up at an intermediate station. When a train enters a station siding on a double-track route, the train is marked on the siding.

The relay equipment for indication of train class is located in the control office and is actuated by the indications for track circuits.

At future installations it is expected that the number of train classes will be increased, probably to 10, and the "train class" will be used for automatic establishment of routes (to through tracks or sidings) at the individual stations.

Announcements of Train Passages to Terminal Stations

The C.T.C. system is also provided with announcement equipment which enables the C.T.C. office to inform the terminal stations of the "class" of trains approaching those stations.

Connection of Telecommunication Circuits to C.T.C. System

As mentioned above, controls and indications are used to set up telephone connections and to indicate that they have been established. The telecommunication buttons and lamps are placed on the control panel.

Centralized control is used, in particular, for the telephones on the line and at field locations to which, for example, permission can be given for trains to pass "stop" signals. Such telephone calls, passed on in the normal manner to the nearest station in the direction of movement, are connected to the control office via the C.T.C. equipment.

C.T.C. Controls

a. At the first C.T.C. operated stations transmissions of "dangerous" controls (signalling to proceed on call-on-aspect) were effected by means of two "control numbers" in order to avoid the execution of "false" controls. This procedure has now been entirely abolished since the coded control system employed by L M Ericsson has proved to be extremely safe. The Danish State Railways are convinced that in future, the C.T.C. equipment —and, in particular, the transmission of controls—should have roughly the same degree of safety as employed in the normal operation of interlocking plants. It has in fact proved that rules governing the signalling at a station where the interlocking plant fails (fault in point or signals) must inevitably be based on the use of telephonic communication to place the responsibility of safety on the C.T.C. operator. The Danish State Railways assume that C.T.C. operated stations will be unattended and that train drivers cover so large an area of the country that they cannot have local knowledge of individual stations.

A control code is shown in fig. 8. In order that a field location may be able to transmit its "answering impulse", it must have received correct impulsing from the C.T.C. office, that is to say that it must have received 4 groups of impulses, and in each group only one impulse must be of opposite polarity and one must be long.

The execution of the control is carried out only when the C.T.C. office has received the answering impulse and has sent back an execution impulse. If there is the least disturbance in impulsing, the control will not be executed.

b. For certain controls use will in future be made of "twin controls", by which is meant that one control is employed for two objects: for example the first transmission of the control can be used for the changing of a point from normal to reverse, whereas the next transmission of the same control can be used to change it from reverse to normal. An increase in the capacity of the C.T.C. equipment (in some cases by as much as 30 per cent) can be achieved by the use of twin controls.

c. A distinction is made between "blocked" and "stored" controls. If a station receives a *blocked* control, which for one reason or another cannot be executed at the given moment (for example establishment of a route that conflicts with an already established route), the control is immediately marked in the C.T.C. office as blocked without the office needing to await the corresponding indication. *Stored* controls are controls which cannot be immediately executed, but which will be stored for execution when the situation at the station permits.

X 8055

Control: 1,750 ms

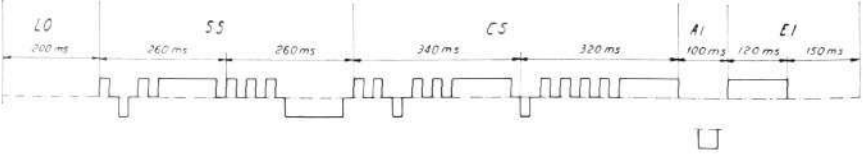


Fig. 8

Code for a control transmission

LO Line occupation
SS Station selection
CS Control selection
AI Answering impulse from field station
EI Execution impulse from C.T.C. office

This method of splitting up the controls has brought with it many advantages, one being the great simplification of instructions to C.T.C. operators. The storing of controls relieves the staff of much work and, in conjunction with the aforementioned automatic operation, means that a single person can without difficulty be in charge of the C.T.C. for a very long railway section.

d. Controls are used to give permission to trains at terminal stations to enter the line before trains can be dispatched. In order to tie up the C.T.C. operator as little as possible, storage equipment is provided permitting the release of three successive trains. The storage equipment is located in the C.T.C. office, which means that a control for clearing the exit signal for the following train is automatically transmitted when the office receives an indication that the first train has departed.

e. A control asking for "new complete indication" can be transmitted to every station. At the C.T.C. office all earlier indications for the particular station are first cancelled, after which all indications assume the most restrictive aspect, indicating, for example, that points are not closed. When the station has received the control, it sends a complete indication transmission to show the position of all signalling equipment. This ensures that the C.T.C. office staff can obtain completely fresh indications at any moment, which is essential if telephonic information or permission is to be given that places the responsibility of safety on the C.T.C. office.

f. At the automatic short-arm gate installations the Danish State Railways have considered it important that the automatic functions of the gates be kept under observation, so that the necessary action can be taken in the event of failure of an automatic function (either up or down). At gate installations on a C.T.C. section certain of the C.T.C. controls have been utilized to put the automatic gate equipment out of action, so as to retain the gates either up or down. This facility has proved an advantage in view of the large amount of work-train traffic for installation and maintenance work that has been necessary up to now on the Fyn line. The C.T.C. office receives an alarm if the gates are not fully raised or lowered within 45 seconds, and when the gates have been lowered for more than 8 minutes.

C.T.C. Indications

The number of indications is considerably greater than the number of controls. An investigation of the C.T.C. circuits on the Odense–Nyborg line (4 field locations, 25 block sections, about 60 trains in each direction) showed that 7,000 indications and 350 controls were transmitted in a 24-hour period.

At the time of planning the Fyn installation there was no experience of how high a level of occupation could be permitted on a pair of C.T.C. wires. If the occupation is too high, an indication may be delayed; in unfavourable circumstances this may mean that it is entirely lost or that two indications are transmitted in wrong sequence. Considerable emphasis was therefore laid on reducing the number of transmissions, which was achieved on the following principles.

If the 60 + 60 trains had transmitted indications corresponding to all signals and track circuits that they pass, the number of indications per 24 hours would have been about 13,000.

The number of indications has been reduced by omitting to indicate the block signals but only the associated track circuits. At the stations, indications are given of the track circuits passed by the train, not singly but in groups of 3 for each direction of movement. By this means the number of indications is reduced from 13,000 to about 10,000.

The coded indication system used by L M Ericsson permits the quick successive transmission of several indications from the same field location, so that two or more indications require only one occupation of the circuit. This brings the aforementioned 10,000 indications down to about 7,000 per 24 hours.

Indication: 1,330 ms

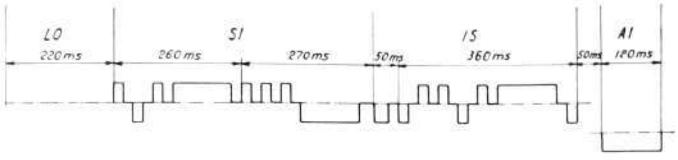


Fig. 9 X 8056

Code for an indication transmission

LO Line occupation
SI Station indication
IS Indication selection
AI Answering impulse from C.T.C. office

In assessing the occupation of the line wires experience has been drawn from telephony, which has possessed efficient methods of calculation since Erlang's first investigation of the theory of occupations, congestion and waiting times. It must be remembered that individual occupations of the C.T.C. circuit are of the order of seconds, whereas on a telephone circuit they are of the order of minutes. In analogy with the "busy hour" employed in telephony, the "busy minute" may be used for the present purposes.

Measurements on one of the C.T.C. operated lines showed the following figures:

24-hour period,	average occupation	4	secs.	per	minute
60-minute period,	» »	9	»	»	»
1-minute period,	» »	30	»	»	»

In view of the aforementioned condition that several indications can be transmitted for one occupation of the C.T.C. wires, the indication transmitting capacity of the line rises automatically with higher level of occupation. At times of light traffic there may be 6 seconds of occupation in one minute, with 4 indications transmitted, whereas under heavy traffic conditions, 30 seconds of occupation per minute, about 40 indications can be transmitted.

The waiting times caused by the fact that several field locations work on the same line are of an order such that a delay of some 5–10 seconds occurs once a month. So rare a delay causes virtually no trouble. And experience shows that the C.T.C. operators have up to now noticed no delay of indication transmissions, so that a higher load than 30 seconds per minute may undoubtedly be accepted.

The process of coded transmission of an indication is illustrated in fig. 9. The indication transmitter first sends two D.C. impulse groups with 4 impulses in each, so informing the C.T.C. office from which field location the transmission comes. In the same way as in the transmission of controls, each of these groups must include one impulse of opposite polarity and the last impulse must be long.

Thereafter follows the impulsing which informs the C.T.C. office which function or functions have changed position since the last indication. The relays which repeat the position of functions are divided into seven groups with seven relays in each group, so that 49 functions (each with two positions) can be indicated. For every 7-relay group there is a common relay which, when picked up, indicates that no change has occurred in the group, whereas the down position indicates a change. To communicate the position of the functions, the transmitter sends a series of D.C. impulses of which every seventh impulse is long. In the case of a relay group in which no function has altered position since the last indication, a normal polarity impulse is transmitted for the entire group. In the case of a group in which one or more functions have altered position, on the other hand, there is transmitted first a reversed polarity impulse after which, for each relay of the group, an impulse is transmitted that is of normal polarity if the relay is up but of reversed polarity if the relay is down. The subsequent relay groups are indicated in a similar manner. But if no alteration has occurred in them, the transmitter stops and awaits a reversed polarity answering impulse from the indication receiver at the C.T.C. office, after which the indication transmitter is disconnected.

Thus, apart from the station selection impulsing, the transmission of an indication does not consist of a given number of impulses. If a function

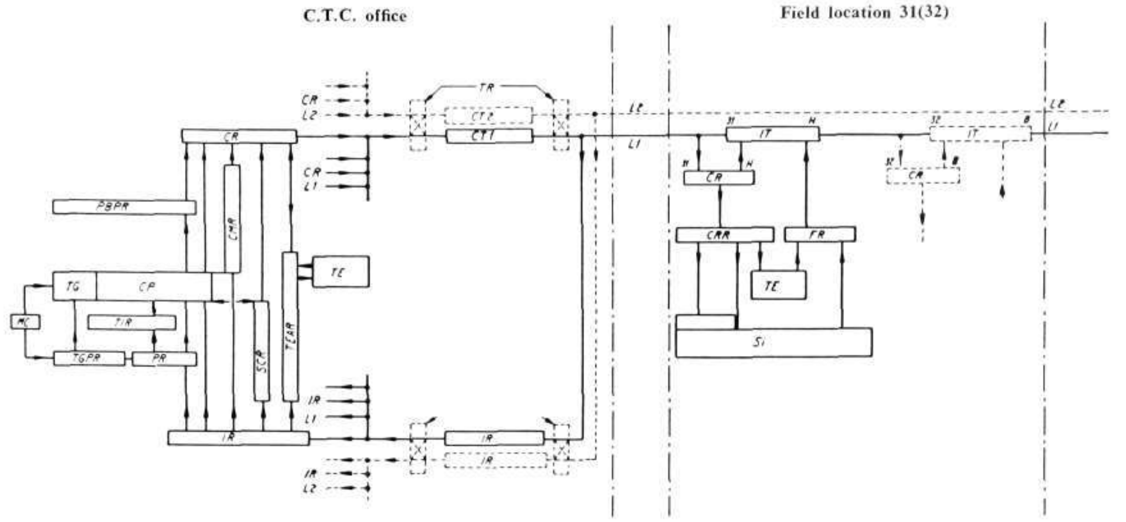


Fig. 10 X 8057

Skeleton diagram of Odense C.T.C. office

CMR	Control memory relays
CP	Control panel
CR	Control register
CRR	Control receiver relays
CT1, CT2	Control transmitters 1 and 2
FR	Function relays
IR	Indication receiver
IT	Indication transmitter
L1, L2	Line 1 and 2
MC	Master clock
PBPR	Push button repeater relay
PR	Repeater relays
SCR	Storage control relay
Si	Signal plant
TE	Telephone equipment
TEAR	Telephone equipment auxiliary relays
TG	Traingraph
TIR	Train class relay
TR	Transfer relays

associated with a relay in the first relay group has changed position, the indication transmitter sends altogether $2 \times 4 + 1 + 7 = 16$ impulses. If the function belongs, for example, to the third relay group, $2 \times 4 + 3 + 7 = 18$ impulses are transmitted. If one or more relays in each of the groups has changed position, $2 \times 4 + 7 \times 8 = 64$ impulses are transmitted.

On the transmission of indications the C.T.C. office checks that the station impulsing is correct, i. e. that the correct number of reversed polarity (2) and long (2) impulses have been received. During indication impulsing, on the other hand, the C.T.C. office checks merely that every seventh impulse is long. Thus the indication system does not possess the same measure of safety as the control system, and it cannot be expected that false impulses will always be discovered. In addition, a sticking group relay will distort the indication of the position of associated functions. The Danish State Railways, therefore, as previously mentioned, have introduced dual indications of the position of important functions, by which is understood that every such function is represented by two relays in different groups.

The Final Arrangement of the Fyn Installation

The C.T.C. plant is shown diagramatically in fig. 10, the left-hand side representing the C.T.C. office and the right-hand side a field location.

The control machine (fig. 11) consists of a common panel and one panel for each field location. In the common panel are the controls and indicating

Fig. 11 X 8054

Control desk in Fyn C.T.C. office. In the middle is the common panel and the desk with traingraph

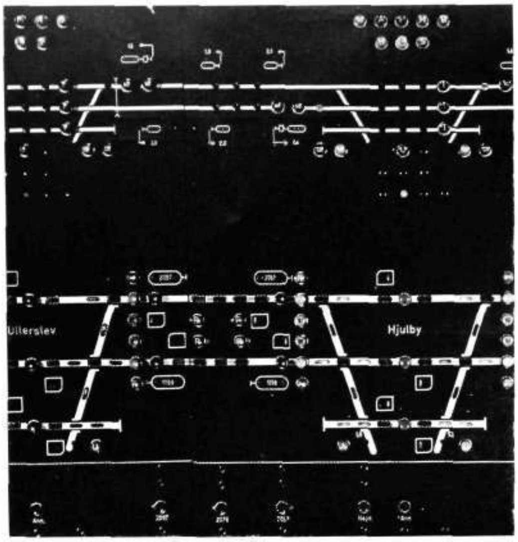


Fig. 12 X 2249

Close-up of control panel. At the top is seen the miniature track network with lamps for indication of class of train. Below are the control buttons and lamps for the interlocking plants at Hjulby and Ullerslev. At the bottom are telephone buttons and lamps.

lamps for all common parts of the installation; for example, the point lighting is switched on and off from the control panel, and faults in operation of the installation are indicated there.

Controls are transmitted from the common and field location panels by pressing two buttons simultaneously (with the exception of telephone controls), fig. 12. When two corresponding buttons are depressed, the control is stored in one of the control registers until the control transmitter has passed it on to its destination. There are two control transmitters and two indication receivers, which normally operate on separate lines. But by means of transfer relays each can be connected to both lines in the event of breakdown of either a transmitter or receiver.

On the desk in front of the common panel is the traingraph, telephone switchboard, and the C.T.C. buttons which do not place responsibility of safety on the C.T.C. operator; for example the marking of train class and the methods of station operation are controlled from keysets on the desk.

The first stage of the project was completed in July 1957. Stage 2 will be partly commenced in 1957, but new stations will not be C.T.C. operated until 1958. How long it will take to install C.T.C. right through to Fredericia will depend upon the progress of reconstruction of the sidings, but it is expected that this will take place in 1960.

Future C.T.C. Projects

The extremely good experience obtained with the C.T.C. installations already in service has encouraged the Danish State Railways to introduce the system on other important lines.

Remote control of Masnedø station on the 15-kilometre line from Orehoved via Storstrømsbroen to Vordingborg was introduced already in July 1956.

The following projects are at present being considered:

Tommerup–Fredericia, 45 km double track with 8 stations
Nykøbing F–Gedser, 23 km single track with 4 stations
Vordingborg–Nykøbing F, 29 km single track with 6 stations
Lunderskov–Padborg, 77 km single track with about 12 stations
Glostrup–Korsør, 99 km double track with about 11 stations.

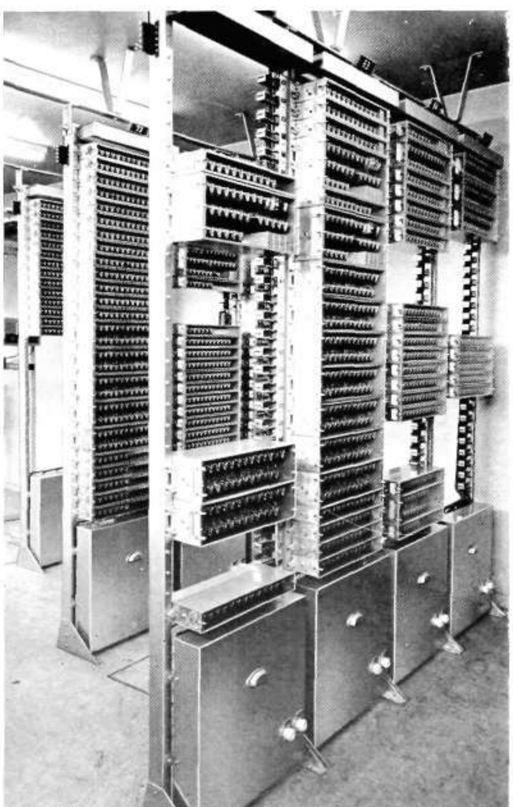


Fig. 13 X 2250

Relay racks in C.T.C. office.