Relay Interlocking Plant of the Danish State Railways

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The Danish State Railways, in cooperation with Dansk Signal Industri A/S, have designed a new type of relay interlocking plant–called DSB 1964. The system is based on the geographical circuitry principle and was designed primarily for Copenhagen Main Station. System DSB 1964 is described in this article with particular reference to the plant at Copenhagen Main Station.

Reference was made in Ericsson Review No. 3, 1954, to the decision of the Danish State Railways to abandon the *electromechanical* interlocking plants used up to that time and to adopt relay interlockings instead. Special reference was made to the plant at Odense, which was commissioned in May 1954.

Since that time a number of stations have been equipped with the new type of plant, while at larger stations a relay set for shunting routes has been introduced, i.e. a relay set containing the necessary relay equipment for control of a dwarf signal, establishment of the associated shunting routes and automatic release of the routes.

The Danish State Railways' largest relay interlocking plant of this kind is at Nyborg, and it comprises, among other equipment, 148 centrally controlled points, 7 platform tracks, 14 ferry tracks and 6 goods tracks. The plant was commissioned in 1963.

The preliminary investigation of this plant, however, showed that a very large amount of administrative work would nevertheless be required in order to establish the traffic specifications for the plant, since most of its functions related to very complicated shunting movements at the ferry berths.

When it was therefore decided in 1962 that Copenhagen Main Station, Main Line Section, should have a new plant (see fig. 1) in replacement of that installed in 1911 with 6 signal boxes and some 130 centrally controlled points, a technical–and to some extent also economic–cooperation was initiated between representatives of Dansk Signal Industri A/S (DSI) and the Danish

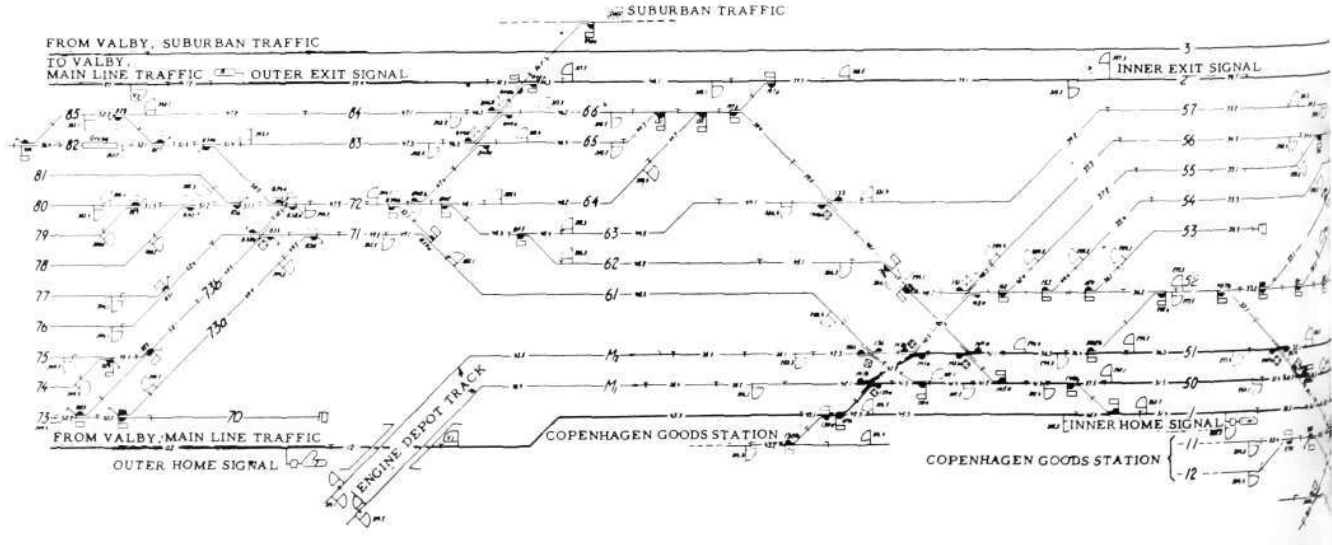


Fig. 1
Schematic track diagram and signalling diagram for the new interlocking plant at Copenhagen Main Station.

Fig. 2
Schematic survey of signal concepts which can be displayed from dwarf and platform exit signals.

State Railways (DSB) with the aim of creating an entirely new type of plant, the three chief objects of which would be:

that the plant could be operated without use of the many operational instructions with associated plans required for earlier types of plant,

that the extent of administrative and qualified design work should be considerably reduced,

that the supervision of the safety functions should as far as possible be automatic.

Before going on to the properties of the new plant it should be mentioned that DSB use a combination of shunting and main signal called platform exit signal (fig. 2). This consists of a dwarf signal and an exit signal for a main line track.

The technical cooperation between DSB and DSI, which started in January 1963, was essentially completed by 1964, for which reason the new type of plant is called DSB 1964. But even if the design principles had then been established, the new type of plant contains so many technical components which had to be designed and tested in production that the plant for Copenhagen Main Station could not be commissioned until 1967.

Characteristic Design Features

The new type of interlocking plant is built up in principle of 17 standard elements (relay sets), each type of relay set being *programmed* to execute a specific traffic function, the extent of which is determined on the basis of what may occur in a large yard with intense traffic.

The individual relay sets are interconnected by cables (*track cables*) in the same way as track sections constitute a connection between points and signals and between sets of points.

The new type of plant has the advantage that a large part of the equipment can be ordered as soon as the first track and signal diagram exists.

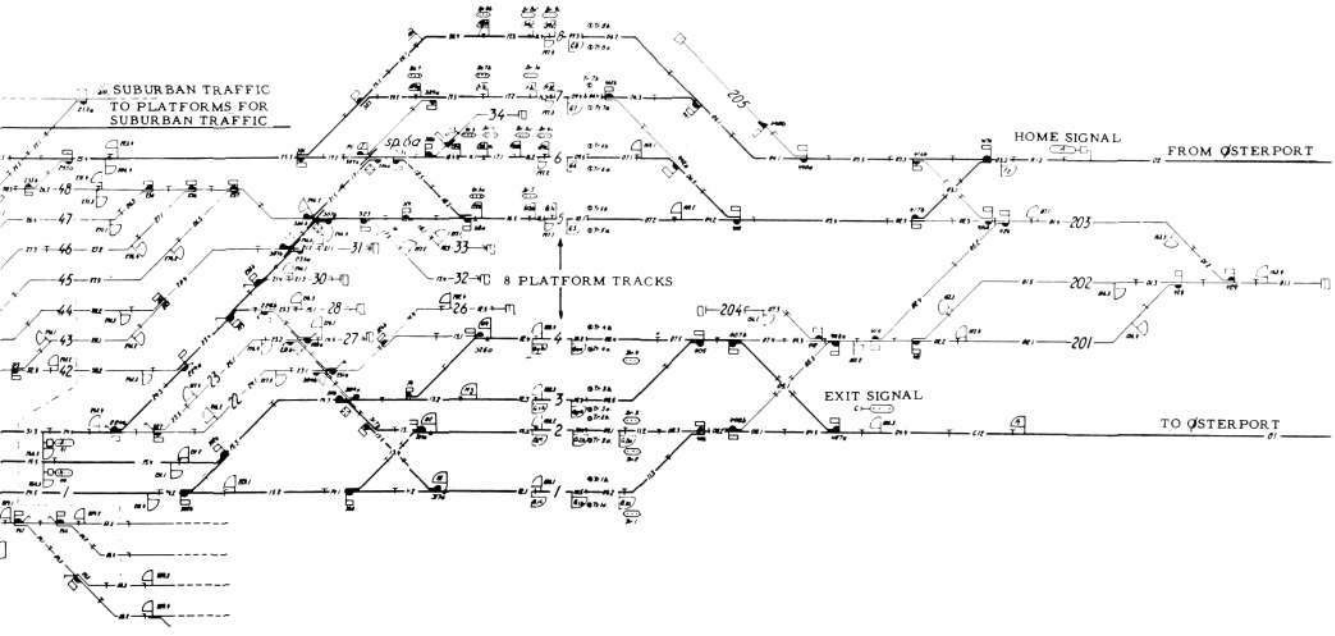


Fig. 3 shows an example of how a given track and signal diagram is converted into a diagram providing information concerning the types of relay sets to be used and how they are interconnected by track cables.

Fig. 4 shows the function of the seven most used relay sets and the rack cables leading to them.

Fig. 5 shows how relay sets for switching of points etc. are linked up with the remainder of the plant.

As will be seen in fig. 6, the relay sets are placed on double-sided racks. The connections between the relay sets are established by means of flexible PVC cables, 40 × 0.7 mm.

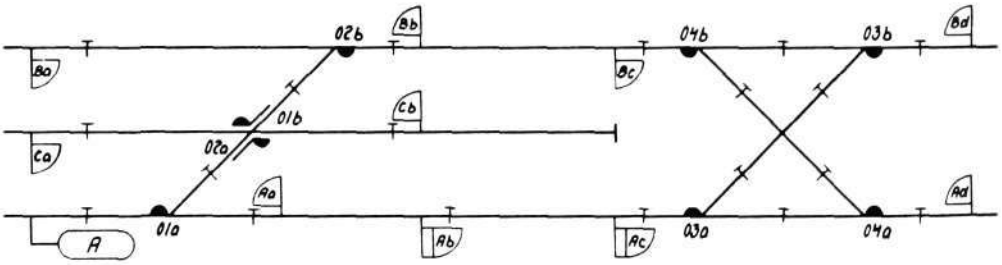
The relay contacts are *not accessible* to the maintenance personnel, but can be observed through a transparent plexiglas window. The relay sets are supplied sealed by DSI and with a test certificate for each relay set (see below). Three test terminals are inserted in the plexiglas.

All cables to a relay set are rendered accessible for testing by pulling out the relay set as shown in fig. 7.

Use is made throughout of DSI's miniature safety relay (fig. 8), which is made in accordance with ORE's 1962 specifications for safety relays with silver contacts. The relay has 10 gold-plated contacts. The magnetic circuit of the relay is made either of ordinary magnetic iron or of steel, in the latter case for applications requiring magnetic holding of contacts which are closed in the operated position.

Fig. 3
Example of the conversion of a track and signal diagram into a relay set connection diagram with associated track cables.

SCHEMATIC TRACK AND SIGNAL DIAGRAM



RELAY SET CONNECTION DIAGRAM

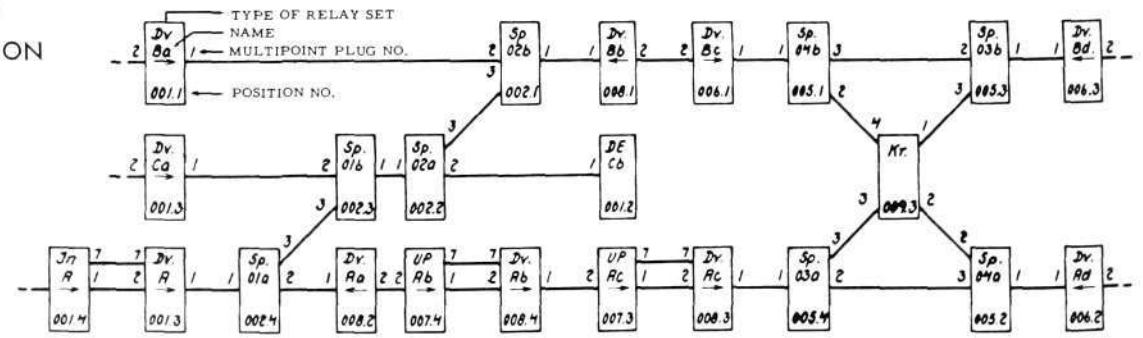
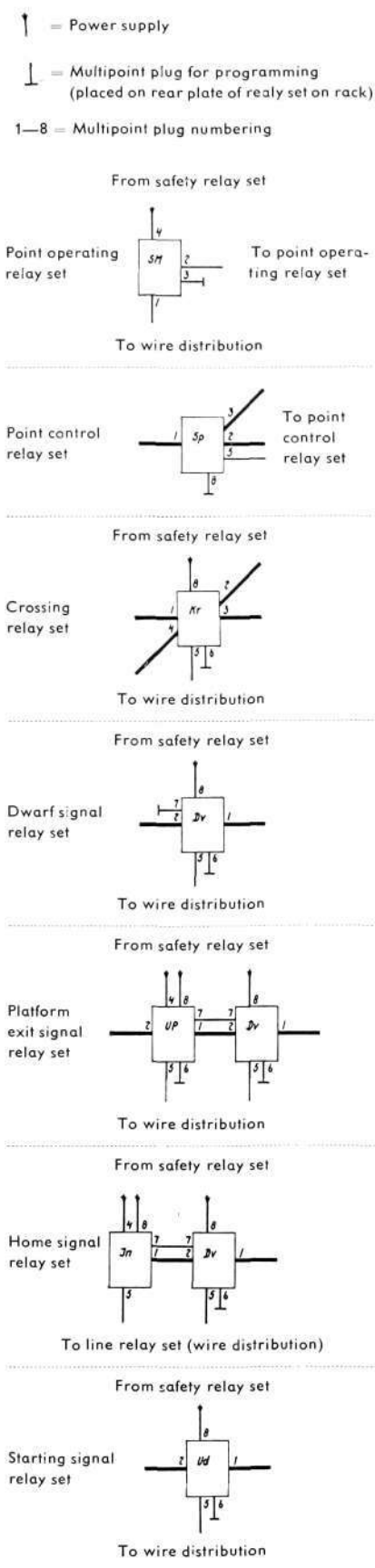


Fig. 4
Function of the 7 most used of the altogether 17 relay sets in the new type of plant. Thick lines mark track cables. Each type of relay set has code pins which fit into corresponding holes in the sealed rear plate which is fixed to the rack and contains the multipoint plug connections.



By performing fully automatic tests of relay sets, track cables and the like, DSI can guarantee to DSB that the products are free from fault.

The tests are divided into functional and safety tests.

The object of the *functional test* is to decide whether all relay and contact functions exist. The relay timing conditions and the like are also checked. The test is made at three voltages, maximum, normal and minimum. The entire series of tests takes two minutes for the largest relay set.

The object of the *safety test* is to reveal whether the wiring is correct between the individual relay contacts and between them and the soldering tags of the multipoint plugs. The test reveals both too many, too few, and wrong wiring connections. The entire test comprises about 658,000 individual tests and takes about 30 minutes.

The control panel (fig. 9) is built up on a mechanically stable iron rack covered with a species of wood which fits in with the other furniture in the control room.

The basic elements are DSI's panel components described in Ericsson Review No. 1, 1960.

The control panel for Copenhagen Main Station, which measures 330 × 68 cm², contains:

582 push-buttons

406 lamp-holders for one lamp each

954 lamp-holders for two lamps each

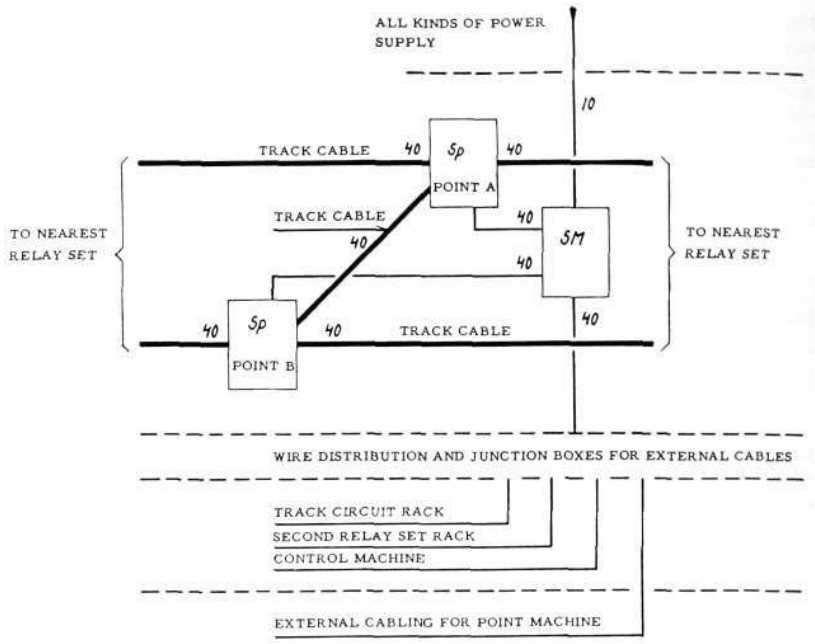
At the top of the control machine there is a special panel for a train annunciator system which advises by means of two code lamps which trains and maintenance cars are approaching Copenhagen Main Station and which are about to depart from the platforms.

Characteristic Operational Features

Centrally controlled points. Since the establishment of the first electrical interlocking plant (around the turn of the century) DSB has used "coupled" points, i.e. both ends of a crossover are operated from the same lever.

This principle has led not only to satisfactory economy through the saving of space in the control machines and cheaper cabling, but is also has advantages from the safety aspect through the easily attainable "compulsory" flank protection of the train route. In the new type of plant the actual switching and control of "coupled" points is effected by a common control relay set, so preserving the advantage of flank protection as well as the not inconsiderable saving of cabling. For the automatic control one relay set is required per point.

Fig. 5
Relay sets and rack cabling associated with a pair of coupled points in a crossover. Thick lines mark the track cable. Sp is the point operation relay set, SM the point control relay set.



Each point can be *latched manually*, which is used for example for shunting movements. The manual latching is cancelled automatically on a regular train or shunting movement.

Each point can also be *locked* in any desired position, so that a route can be established only in that position; this form of locking is used, among other purposes, for preventing entry onto a track on which work is being done, and the locking can be both established and cancelled *manually*.

If the track is arranged so that shunting between two points can be done on several routes, particular points can be given preference.

On depression of the *start button* for the signal from which the shunting movement is to *start*, the control machine itself shows which routes are available.

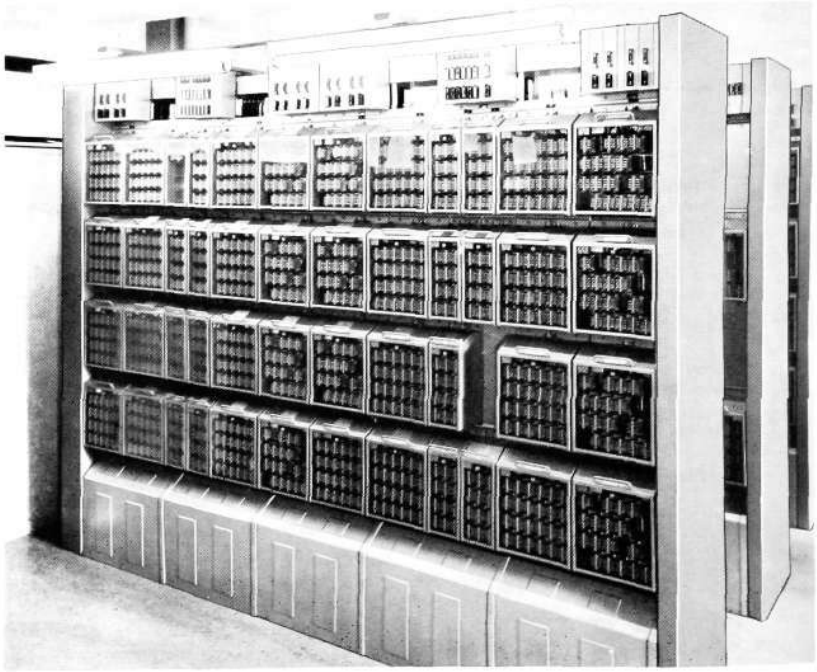


Fig. 6
Racks at Copenhagen Central Station with relay sets mounted on both sides.

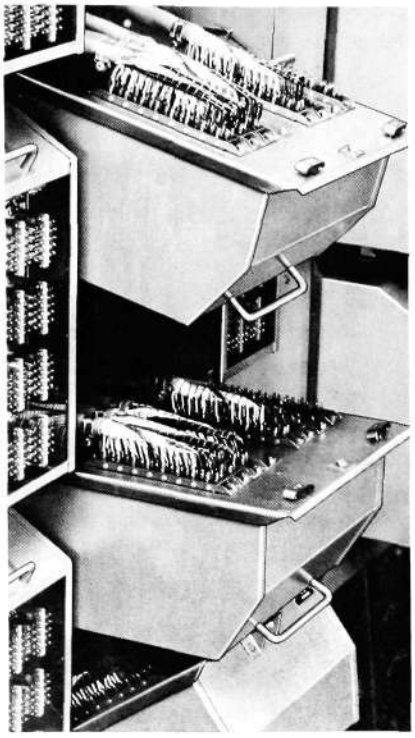


Fig. 7
The photograph shows how the cabling to a relay set can be made accessible for tests by tilting the relay set forwards.

The end points of the main routes accessible to a start button are shown by yellow flashing light on the track diagram; and if the button is pressed at the end point for the shunting movement, all other shunting routes are immediately excluded.

Provided that there is no danger in establishing the desired shunting route, including the situation of the track concerned is free, the following events automatically take place:

Switching of the points to be traversed and which are not already correctly positioned.

Establishment of the route.

Locking of protective points in protective position and of protective signals in "No entry" position.

When these functions have been completed, all dwarf signals to be passed by the cut are switched to "Proceed".

If the conditions for "Proceed" are not completely fulfilled, the dwarf signal remains on "No entry". If the operating personnel thereafter–for example through the use of shunting radio–make sure that there is no risk in setting "Caution" for the cut, the control button of the dwarf signal is pressed once again in acknowledgement.

If a shunting route is used at a time when it conflicts with an already established shunting route, the control is *stored* and the route will not be established until the previously mentioned conditions exist. The points to be switched before the stored route is established are shown on flashing position-lamps.

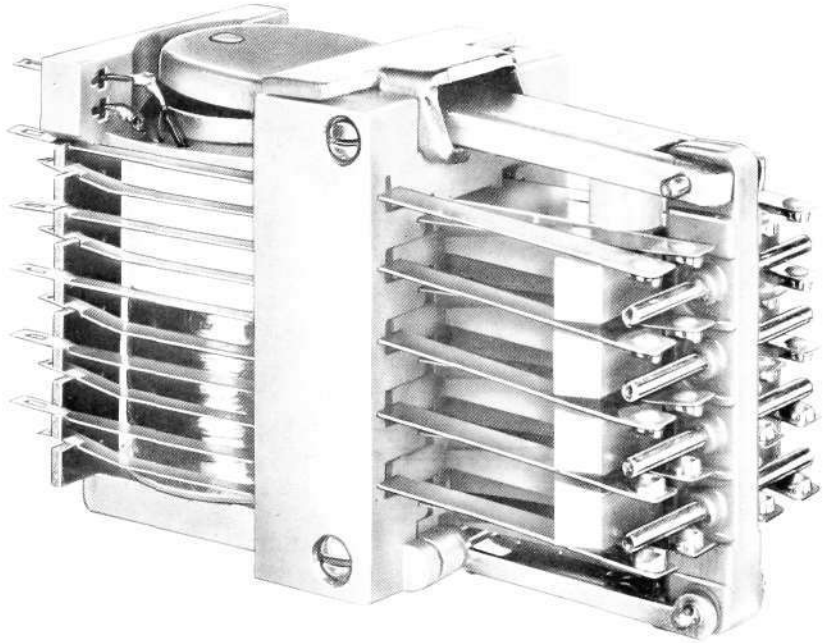


Fig. 8
Dansk Signal Industri's safety relay which is designed to ORE specifications

External dimensions:	width × height × length
40 × 55 × 90 mm	
Number of contacts:	10
Contact pressure:	20—25 g
Contact load:	0.5 A at 220 V AC and DC
	3 A at 30 V
Contact resistance:	less than 0.04 ohm
Power consumption:	1.2—3.5 W
Test voltage:	2 000 V AC

The establishment of points for passage or protection, locking of signals on "No entry" etc., is automatically cancelled as the cut successively passes the track circuits on the shunting route.

"Free shunting". "Signal cancelled" can be displayed from each dwarf signal provided that the signal is not established or used as protective signal.

If a dwarf signal showing "Signal cancelled" is to be used for protection of a route, the signal is automatically switched to "No entry" until the route is released. A flashing light is then shown on the control panel for "No entry" as a sign that "Signal cancelled" has been stored. But despite the fact that the dwarf signal already displays "No entry", the signalling for the shunting route will not be established until the personnel have "acknowledged" by switching the signal to "No entry". The aim of this operation is that the personnel shall obtain assurance (probability) that a shunting movement towards the dwarf signal really respects "No entry".

In areas where free shunting is appropriate, there are local-operation buttons beside the points. As long as a point is released for local operation, automatic switching is prevented; individual central operation on the other hand is possible. Both with individual central operation and with local operation a check is made that the track circuit of the point is unoccupied.

Main route. The establishment of main routes takes place essentially on the same principles as stated above, with the exception that the track circuits after the end point of a route–corresponding at least to the safety distance for the route–must be unoccupied.

The routes are released automatically on the same principle as for shunting, but the emergency release has been made more restrictive through the use of timing relays among other means.

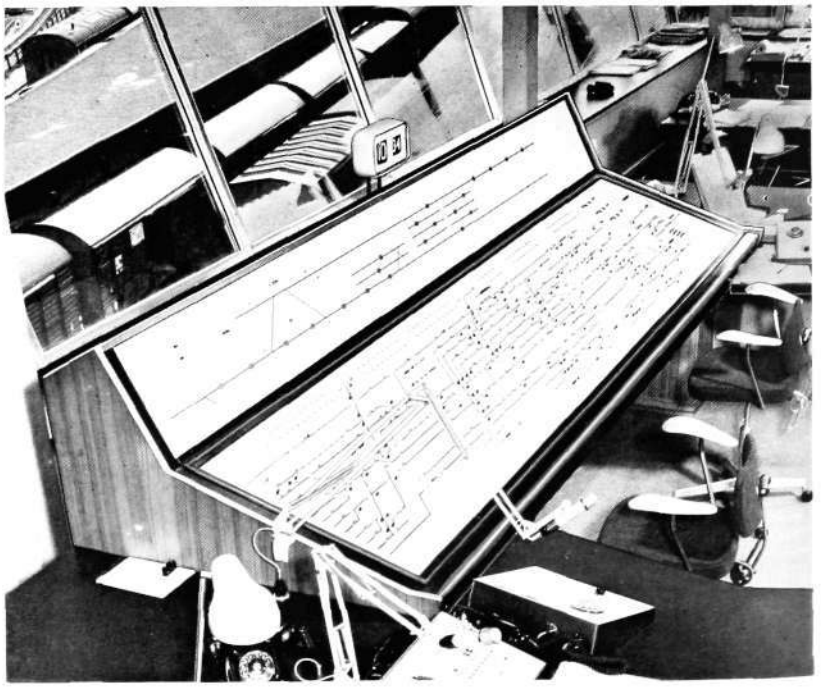


Fig. 9
Control machine at Copenhagen Main Station.

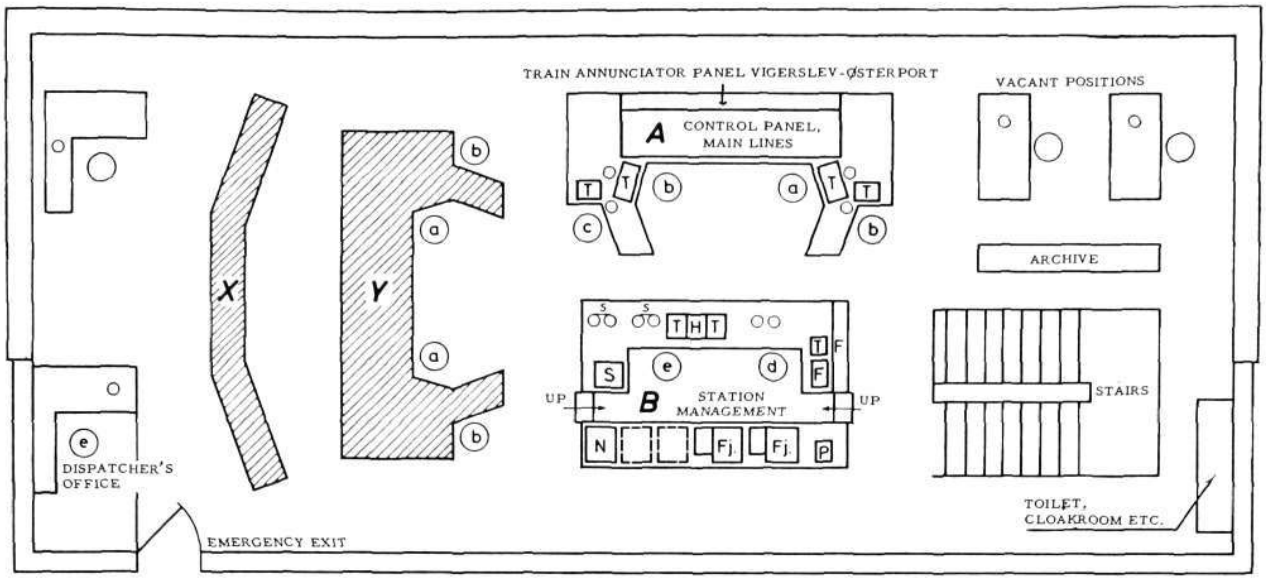


Fig. 10

Furnishing plan for control room at Copenhagen Main Station. The shaded items belong to the suburban line area and their design has not yet been decided on.

A: Track diagram, main lines
B: Train dispatching
Y: Control panel for the entire suburban area
X: Panel for indication of train movements in suburban yard area
T: Telephone switchboard
H: Selection of announcements for public address system
S: Operation of train destination board
F: Operation of train delay panel
N: Train describer printer
Fj: Teleprinter
P: Recording of time of track occupation
a: Responsible stationmasters
b: Assistant to stationmaster
c: Shunting master
d: Train dispatcher for movements to and from Copenhagen Main Station
e: Assistant to train dispatcher

Copenhagen Main Station—Signal Box Functions

The signal box in which the new type of plant is installed is planned for the takeover in due course of the supervision of the entire passenger railway traffic of the Greater Copenhagen area, both suburban and main lines.

The control room (fig. 10) is therefore arranged for this centralization, but for the time being the only equipment installed is that for main lines operation at Copenhagen Main Station; a number of future functions are, however, provided for.

The central part of the room is taken up by the control machine A, which is normally served by a *stationmaster* (a) and an *assistant* (b), who are responsible essentially for the shunting work at the western end of the station. The *shunting master* (c) directs the shunting engines by radio and works chiefly in collaboration with b, who is also in radio communication with the engines.

During periods of heavy traffic one position can be occupied by an additional assistant to the stationmaster.

The control machine can also be operated by the stationmaster alone, which is necessary during certain hours of the night.

In front of the control machine the floor is raised about 0.5 m and on the platform there is space for the duty superintendent (d) during heavy traffic hours. He is responsible for communication with the stations etc. with which Copenhagen Main Station has main contact. For the assistance of the duty superintendent and stationmaster there is an assistant at position (e) who is responsible for the automatic traingraph, teleprinter, train destination board, train delay panel, public address system etc.

The shaded items are intended for control of the entire Copenhagen suburban line plant. X is the indication panel on which the locations of individual trains on the roughly 160 km of track are registered by lamps. Y is the control panel on which the descriptions of individual trains are keyed by the stationmaster (a), after which the trains are automatically routed from the departure station to the terminal station.

It should be noted, however, that the final arrangements for the suburban line equipment have not yet been decided on.

Operational experience with plant type DSB 1964

In the presence of representatives from DSB and DSI the plant was commissioned on August 23, 1967, and the following weeks were used for connecting up and checking of the entire plant as regards both the interworking of individual relay sets and the communications with the control machine, track circuits, point machines, external signals and much else. The time was also used for training of the operating personnel.

It can now be established

that it is an invaluable advantage that all relay sets and internal cabling are mechanically tested before connection,

that is is an invaluable advantage that relays simulating point machines are used so that an interlocking plant can be tested in its entirety before it is connected to the actual point machines on the track. The external signals can usually all be connected up, but with covered lights.

The final cut-over of the plant took place on November 6, 1967, and the operational experience has been satisfactory.

The technical experience of the new type of plant may be summarized as follows.

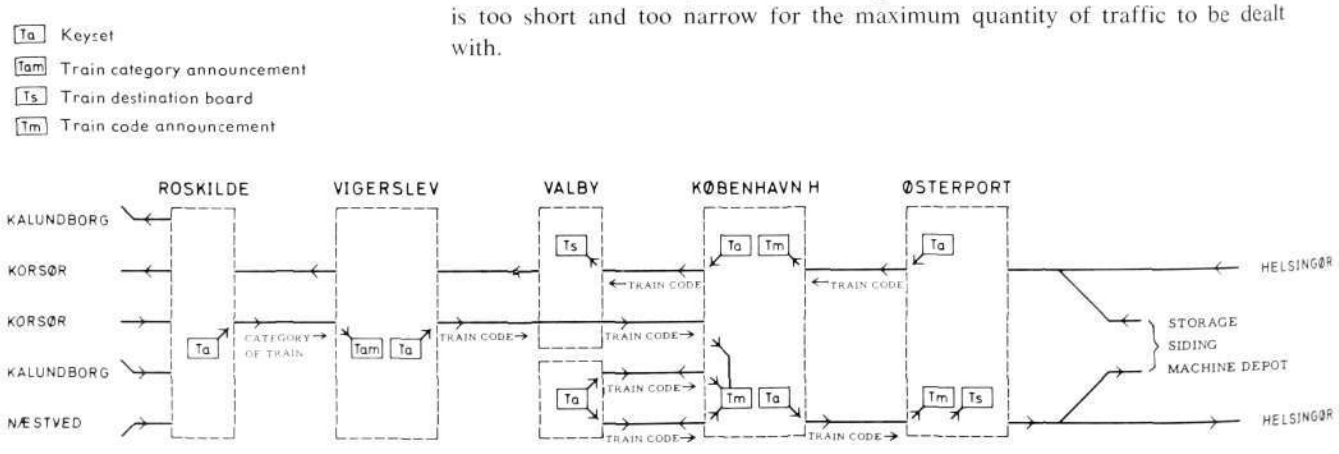
It is *easier*, and it takes a much shorter time, to test and supervise the new type of plant than earlier plant on a corresponding scale. The reason for this is that one can fully rely on the automatic testing of relay sets, track cables and the like. If the new plant had been tested by the traditional methods, the internal dependencies of the relay sets alone would have required some 10 men working for 5 months.

The earlier troubles in maintaining the standardized minimum length of a track circuit *in advance of a point* have been overcome; this is to some extent unnecessary, as the new plant can be satisfactorily adapted to all existing track conditions, provided naturally that shunting always takes place on established routes. At Copenhagen Main Station there are several occasions when such track circuits at points have a length of 7 m, as the station track layout is too short and too narrow for the maximum quantity of traffic to be dealt with.

Fig. 11

Annunciator system Roskilde - Vigerslev-Copenhagen Main Station and Osterport.

By means of differently coloured lights Roskilde announces the category of train (passenger or goods) dispatched to Vigerslev.
By means of two-digit train codes Vigerslev–Osterport announce a train approaching Copenhagen Main Station.
By means of a two-digit code Copenhagen Main Station announces a train to Valby or Osterport and the code is used, among other purposes, for control of the train destination boards at the stations.



The *few operational requirements* which were overlooked before the plant was installed could be easily fulfilled without interfering with the handling of traffic.

Contact faults play an extremely small role. In all there were only about 20 contact failures out of 100,000 or more operating contacts. The establishment of main and shunting routes requires 1 million contact operations daily.

The extended use of factory-tested solder connections–in all some 100,000–proved efficient. Only one soldering fault has been discovered.

It is now also considered profitable to use the new type of plant for medium-sized installations despite the extra equipment required in conjunction with geographical circuitry. This is compensated by a saving on the very considerable drawing and supervisory work that has been necessary hitherto.

The new type of plant is expected also to be used for relatively small installations on the suburban lines.