

Relay Interlocking Plant at Copenhagen Main Station

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The Danish State Railways (DSB) have recently installed a relay interlocking plant for the suburban lines terminating at the main Copenhagen railway station. The plant is designed on the most modern principles with relay groups for control of shunting movements. The shunting route circuits were designed by DSB, and relay groups, relays, control machine and other equipment were supplied by L M Ericsson's Danish Company, Dansk Signal Industri A/S. The head of the Signalling and Telecommunications Department of the Danish State Railways, Mr. W. Wessel Hansen, describes the new relay interlocking plant, starting with a few words about modern signalling techniques as employed by DSB.

The New Interlocking Technique

The introduction of track circuits, track diagrams and automatic block systems has provided the basis for all-relay-controlled signalling systems. Railway companies all over the world have shown a great interest in relay systems in preference to the earlier mechanical and electromechanical interlockings. An important factor was the saving in operating costs expected with relay operation for, since the outbreak of the last war, practically all railways have run at a loss.

But the prices of relays were still too high to warrant a general change-over to relay interlockings. It was only in the USA that such systems had been installed in fairly large numbers before the war. Efforts to reduce the cost of relays were essential; and so successful were they that the first three relay interlocking plants, the components of which were designed by Dansk Signal Industri A/S, Copenhagen, could be introduced on trial around 1950.

Fig. 1
X 7769
The new control machine and the telephone switchboard, Copenhagen



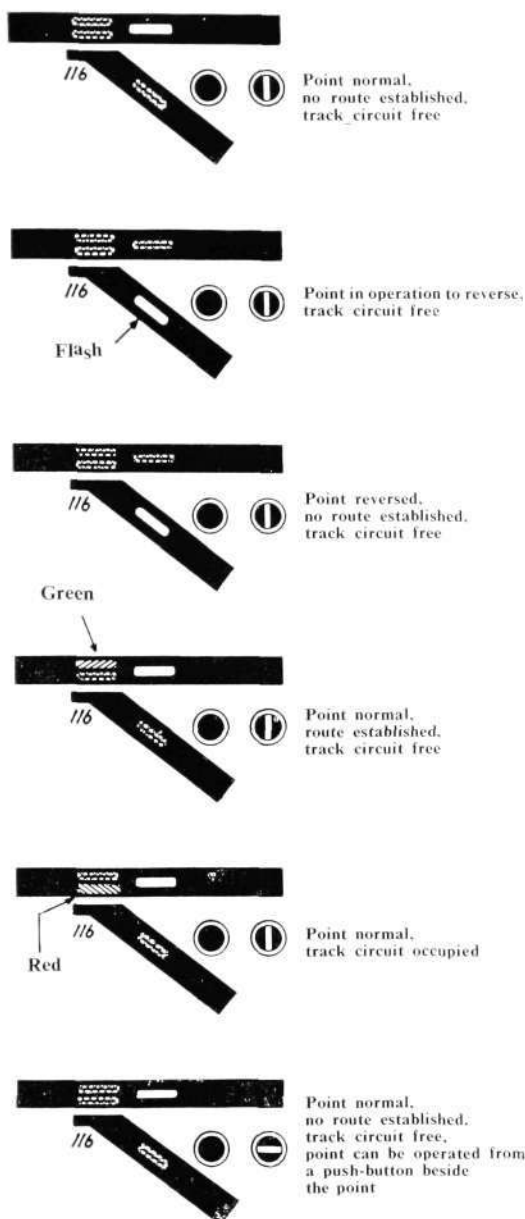


Fig. 2

X 2485

Indication lamps and control buttons for centrally controlled points with local switching facilities

The three trial installations proved satisfactory, and a number of both small and, by Danish standards, large relay interlocking plants were installed in the following years at Esbjerg, Glostrup, Odense, Hobro, Kolding, Lunderskov, Nyborg and Helsingør—the two latter on a purely provisional basis during reconstruction of the track layout; for investigations showed that the installation of temporary relay interlockings was preferable to the costly and hazardous practice previously employed of cutting out the signalling while reconstruction was in progress. The basic principles of these relay interlockings are as follows.

The *centralized switching of points* is effected by brief depression of an individual button beside the point symbol (fig. 2) and of a common button. This two-button operation eliminates the risk of points being switched by accidental pressing of a button. The start of point operation is indicated by darkening of the lamp marking the initial position of the point and by ringing of a bell. In addition, the lamp for the new position of the point flashes white during the switch-over. The completion of switching is indicated by a new bell signal, and the lamp for the new position of the point now shows a steady white light. The same button is used for the two directions of operation of the point.

Should the common button be kept depressed by mistake for more than about 10 seconds, a bell rings.

Each point on the track diagram has its own lamp combination which can show red or green. The lamps are normally dark, but red light is shown when the track circuit at the point is occupied. The green light is shown when the track circuit forms part of an established route; the light indicates that the point cannot be switched but that the track circuit at the point is unoccupied.

To facilitate lubrication of the points, snow clearance etc., the points can be equipped with control buttons for local operation (fig. 3). All points are now provided with roller bearings which are fitted direct to the stock rail (fig. 4).

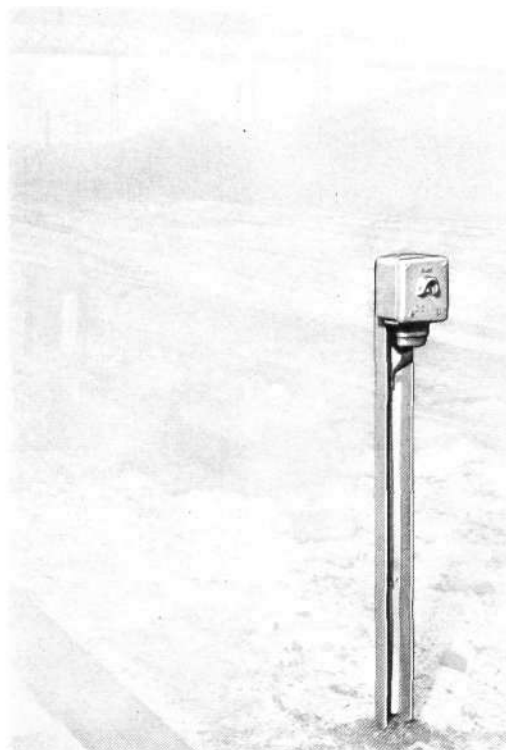
At large installations the staff are unlikely to notice a failure of point operation owing to a *fault*. Every point is therefore provided with a time relay which automatically stops the switching operation, if not completed within 15—20 seconds, and issues an alarm.

At the plants installed hitherto there has been no need for automatic switching of points simultaneously with the establishment of routes (except at C.T.C. installations).

Routes are established and signals operated by the simultaneous depression of a signal button and a route button on the track diagram. The establishment of a route is indicated by the lamps for the track circuits in the route showing green if the track is unoccupied (occupied track circuits show red). The relay system associated with the keys checks that the track is unoccupied and, if so, operates the signals. The establishment of a route is also indicated by the lighting of two arrow-shaped lamps on the track diagram; white light beside the route button and yellow light beside the signal button.

The system has now been developed a step further in that relay-controlled shunting routes have been introduced at Copenhagen, i.e. routes which are intended for normal shunting movements. The economic prerequisite for the

Fig. 3 X 2499
Control button for local point operation



introduction of this system was the design of a small, cheap and reliable relay (fig. 5), since shunting routes require a comparatively large number of relays. A considerable amount of additional development work was necessary, for DSB required that the relays for shunting routes should be assembled in the form of relay groups (fig. 6).

Fig. 7 gives an idea of the *control of shunting routes*. The release of a shunting route is effected sectionally. The points at the approach end of the route are released first, so that they may be used for other shunting movements. The points at the exit end of the route are released when the cut has passed the entire route. No manual operation is required for release of a route. A dwarf signal can be set to "No entry" by simultaneous operation of the signal key and of a common key. A dwarf signal can be set to "Signal cancelled" by simultaneous operation of the signal key and another common key.

Fig. 4 X 8186
Roller bearings attached to the stock rails reduce the likelihood of faults in point operation

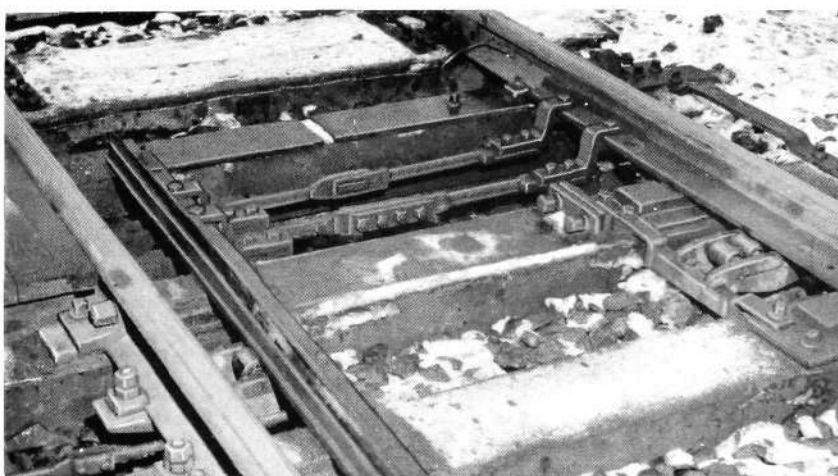


Fig. 5

X 8194

Relays for relay group

8-contact size: 59 × 40 × 81 mm

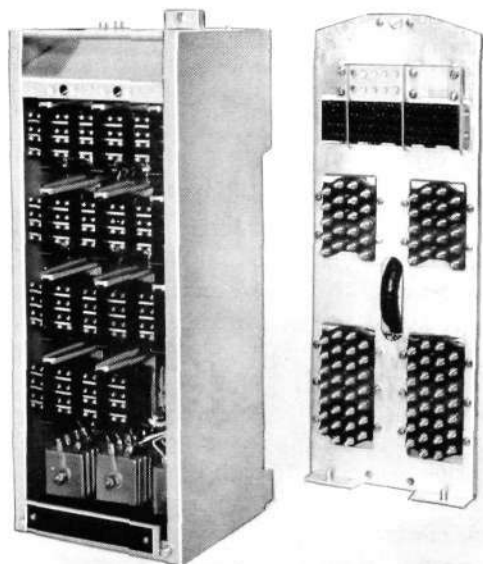
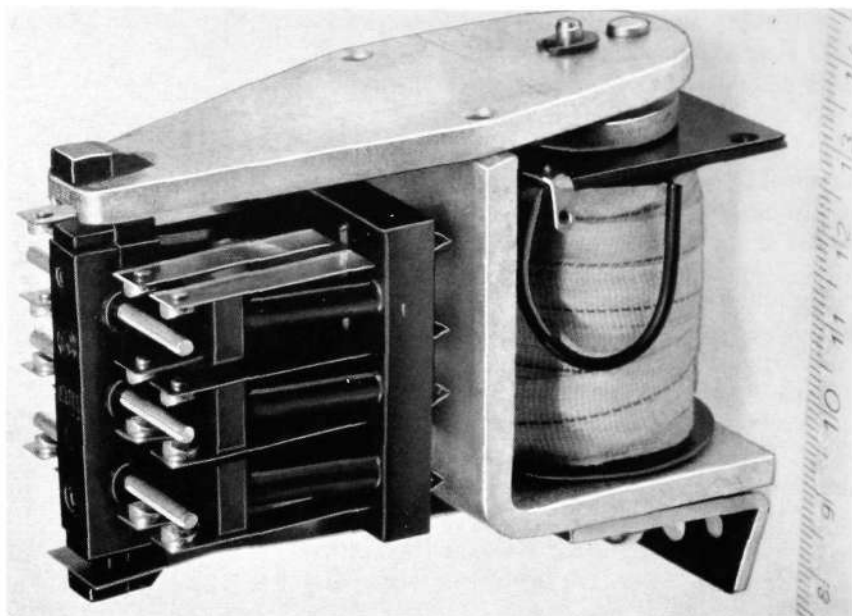


Fig. 6

X 2488

Relay group containing relays and rectifiers.
Max. 15 relays type RF.

On the right is the mounting plate which is attached to the relay rack and on which the wiring terminates.

Dimensions 140 × 160 × 370 mm

Fig. 7

X 8187
X 9149

Control of shunting route

If a route is to be established, say, from dwarf 129 to dwarf 125, the points must first be operated, after which the yellow button at 129 and green button at 125 are depressed simultaneously. "Cancellation" of a signal is effected by simultaneous operation of the yellow signal button and the A button. The "No entry" aspect is set by simultaneous operation of the yellow signal button and the F button. Manual release of a route from, say, dwarf 129 to dwarf 125, is effected by simultaneous operation of the F button and (successively) of the green button at 129 and green button at 125.

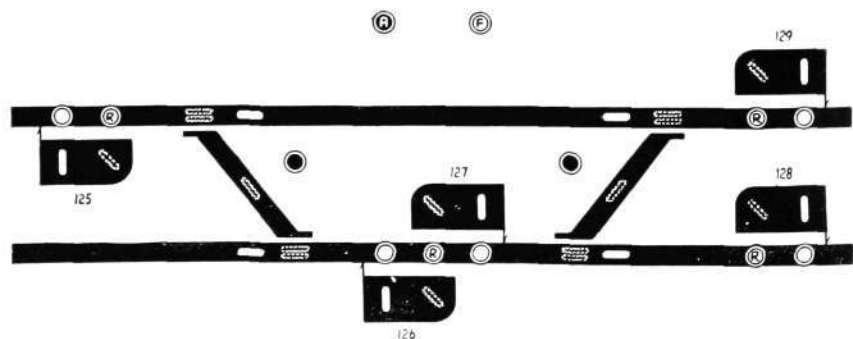
Interlocking Plant for Copenhagen Main Station

When the railways were electrified in 1933, there was considerable doubt whether the electrical interlocking at Copenhagen could be used in conjunction with an electrified railway in view of the risk of faulty point operation due to heavy "stray" currents. Investigations showed, however, that the plant could be retained provided that the equipment and the cables were kept in the best possible condition.

It was nevertheless decided that the interlocking plant, which had been installed in 1911 and was already approaching the end of its life, should be replaced by a new one. This proved no easy task, however. Not only was interlocking technique still in the melting pot, but it was difficult to design an efficient new plant which would comply with the signalling regulations.

The main features of the new plant are the following.

The basic element of the control panel is a perforated plate (fig. 8) on which buttons and lamps are mounted. The buttons, with their dust-tight con-

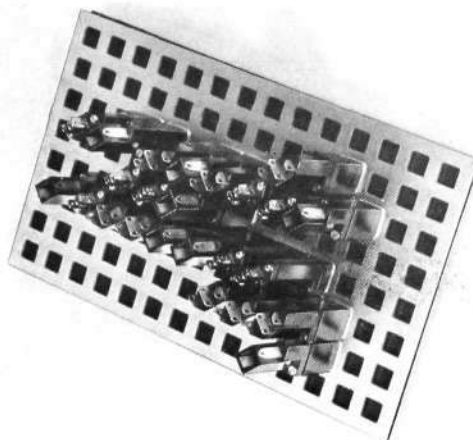


Colours of buttons

- (R) green
- (F) red
- (O) yellow

Fig. 8
Perforated plate

X 2489



tact system, have one transfer contact (fig. 10). Some buttons are of the locking and others of the non-locking type, and they are differently coloured and engraved according to their usage.

One type of panel socket has two lamps (fig. 9), each with its colour filter or lamp profile corresponding to the function it is to indicate.

For indication of digits 01-99, which are used, among other purposes, for indicating the positions of route signs, there is a separate panel system with 20 lamps which project their light through a lens system on to a matt glass plate (fig. 11).

Fig. 9
Twin-lamp panel socket
Dimensions: 16 · 16 · 58 mm

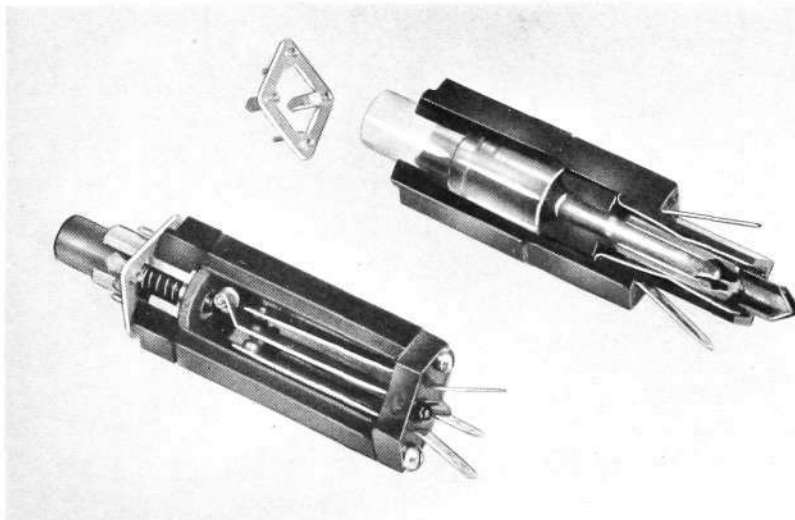
X 2490

The perforated plate is covered by a plastic plate on which are engraved the schematic track system, signals etc., the tracks being white against a dark background.

The cabling of the control machine is divided into separate sections, each of which accommodates a maximum of about 200 wires. The individual wires are taken to a distribution frame and to cable sealing ends at the bottom of the control machine and thence to the relay racks.

Fig. 10
Control button and single-lamp panel socket
Dimensions: 16 · 16 · 65 mm

X 8188



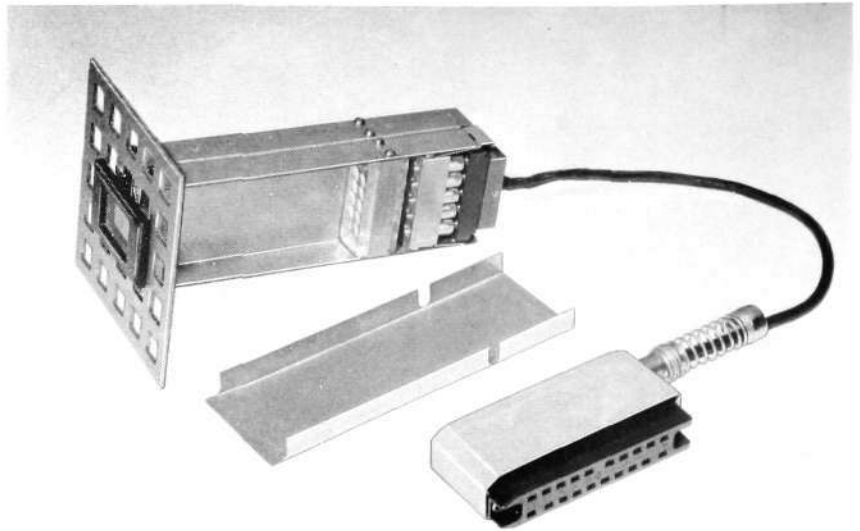


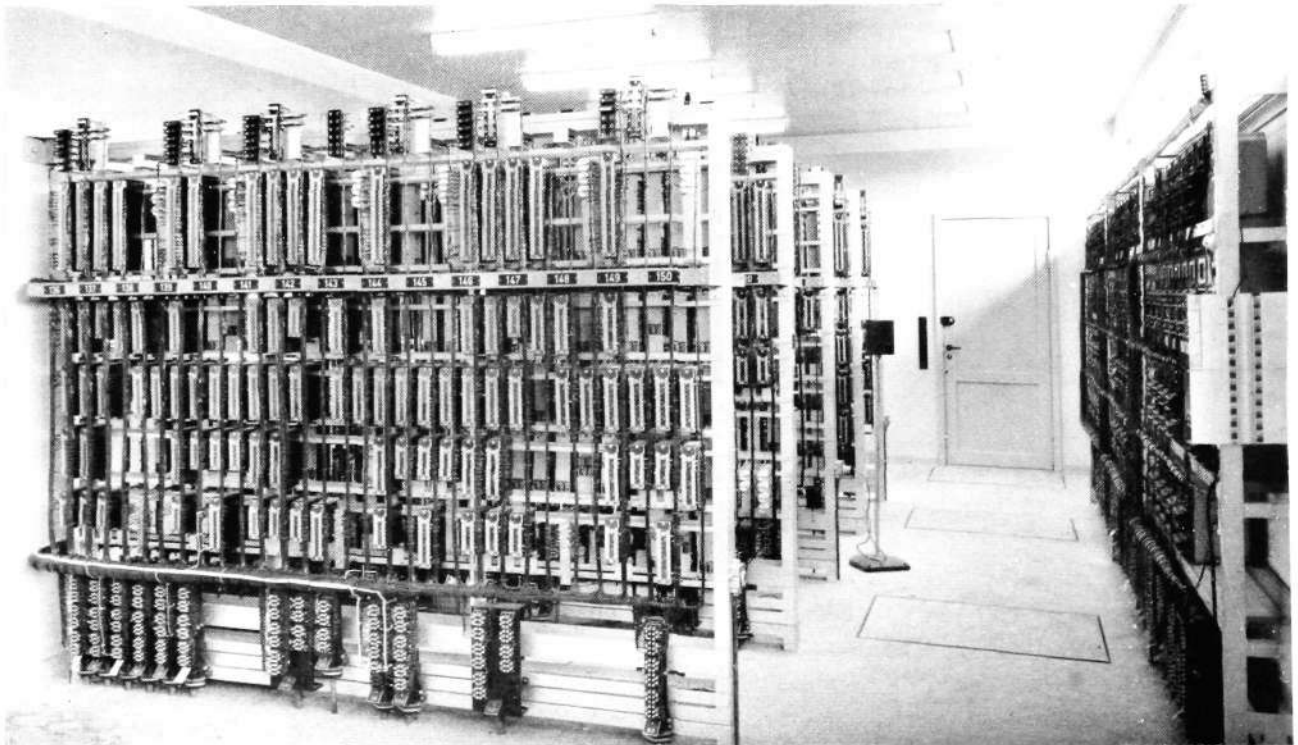
Fig. 11 X.8189
Panel units for 2×10 digits or letters
Dimensions: 32 - 48 - 155 mm

The relays are placed on racks which are divided into sections. Thus all relays involved in the operation and control of a point are placed in the same section (fig. 12). Fig. 13 shows the circuit diagram for point operation. Fig. 14 shows an example of how a station area is divided into signalling areas for shunting movements. There are 22 routes solely for the track area delimited by signals *D 133*, *134a*, *134b*, *D 135*, *D 146*, *D 147* and *D 148*. The circuits for the shunting routes are made up on the geographical circuit principle (fig. 15). By this means the number of relays and contacts can be greatly reduced.

The new interlocking plant covers:

- 20 main routes
- 102 shunting routes
- 53 signals
- 64 points
- 85 track circuits

Fig. 12 X.7770
Relay racks for interlocking plant



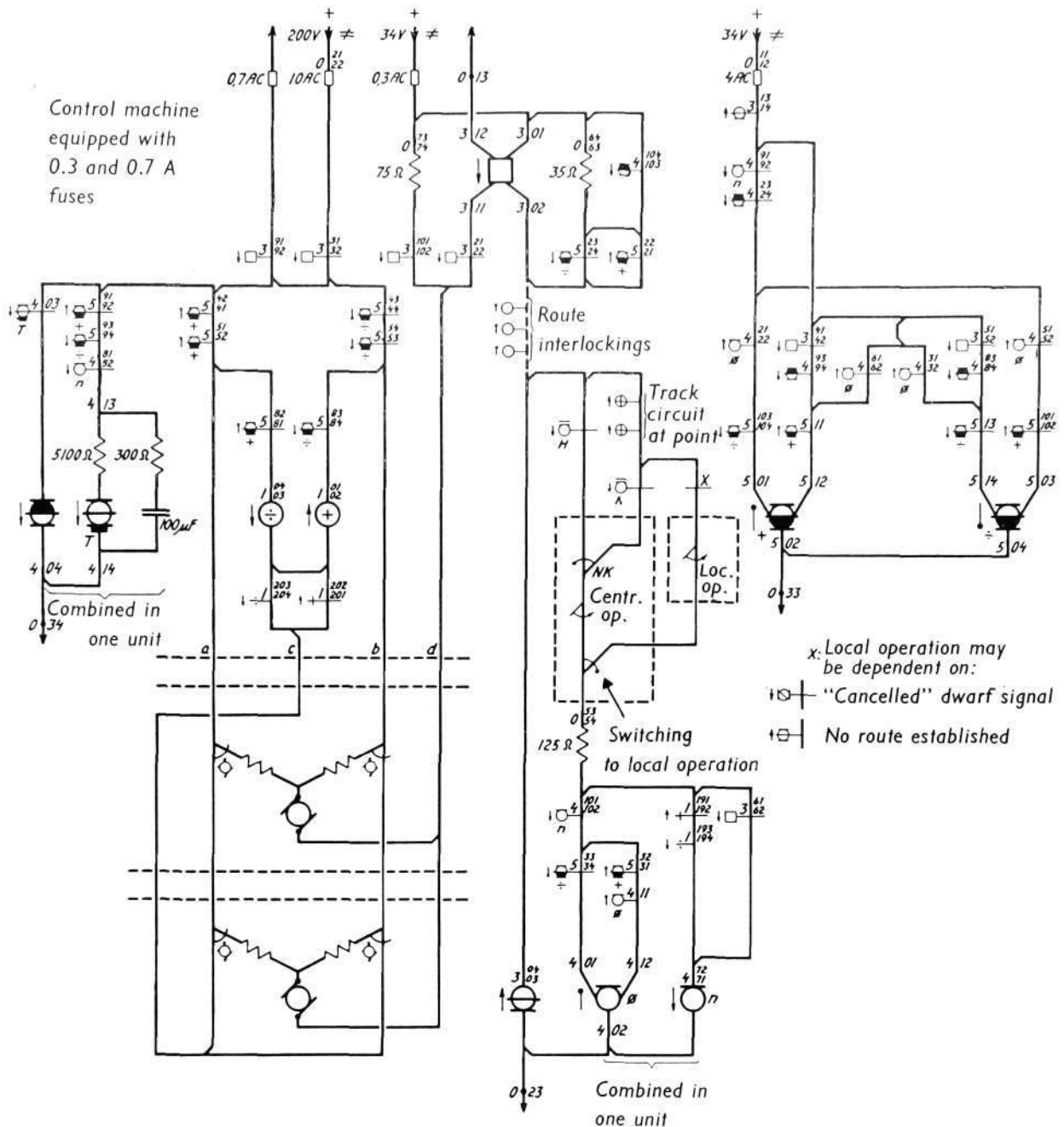


Fig. 13

X 7775

Circuit diagram for point operation

Silver contacts only are employed. The points are operated by a 220 volt d.c. motor.

1368 relays, of which 451 in 41 relay groups
approx. 33 miles of cable with overall conductor length of 400 miles
approx. 20 miles of wiring between relays, cables etc.
34000 terminals
17 call stations, with 23 loudspeakers
47 electrically heated points

The control machine has 260 push buttons and 354 lamps.

An interesting new feature is the automatic self-regulating emergency power plant. This consists of an air-cooled diesel engine, which, through a centrifugal coupling, can be connected to a shaft carrying a heavy flywheel. The other end of the shaft is coupled both to a self-regulating, self-magnetizing a.c. generator and, via an elastic coupling, to an electric motor.

Under normal supply conditions the electric motor is coupled to the shaft, so that the generator and flywheel are rotated at about 1,500 r.p.m. while the diesel is at a standstill.

If the supply fails, the load is automatically switched over to the generator and flywheel, and at the same time the diesel is started. It takes about 15 seconds, however, for the diesel to attain the speed at which it can take over the production of alternating current of the required frequency and voltage. In the meantime the supply is maintained by means of the flywheel which can deliver 5 kW. As soon as the diesel has attained the necessary revolutions, the centrifugal coupling connects the diesel to the flywheel shaft (and to the generator).

When the main supply returns to normal, a relay system "senses" whether the supply is stable and, if so, the load is switched back to the mains and the diesel stops.

The relay system also contains a frequency-sensitive element which starts the diesel if the mains frequency drops below a given limit. This brings the flywheel up to normal revolutions so that its full energy is available to meet any fluctuations from the mains. The load thus remains on the mains. The relay system likewise contains a voltage-sensitive element which starts the standby unit if the mains voltage falls below 25 % of normal.

The diesel engine has an all-automatic lubricating system and stops if the oil pressure sinks or the oil temperature rises above a given level.

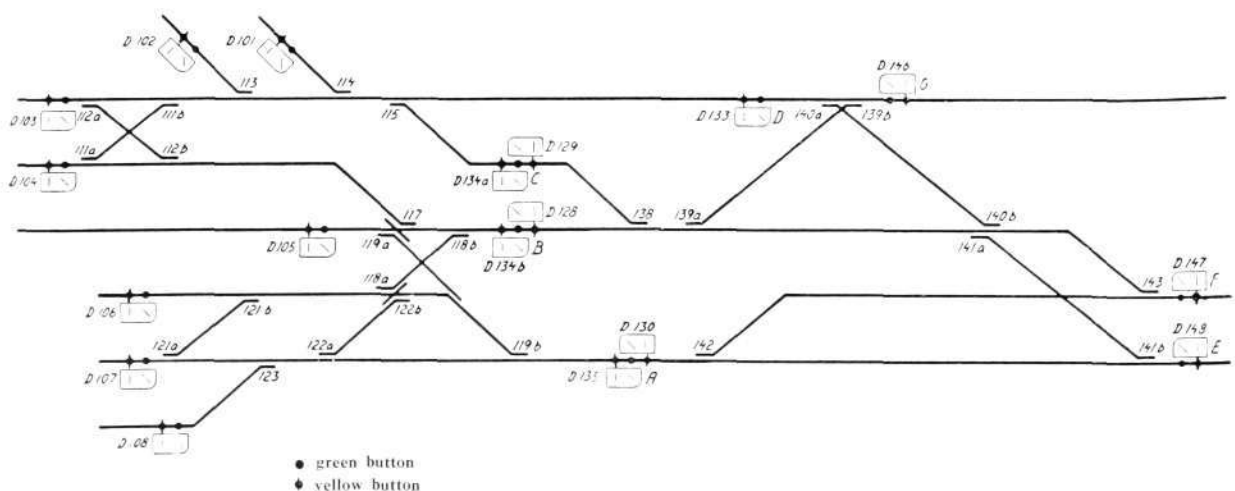
The diesel engine has built-in thermostat-controlled heaters in the sump which keep the lubricating oil at the proper starting temperature.

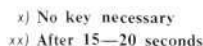
Traffic Conditions at Copenhagen Main Station

The area served by the new interlocking plant covers 4 platform tracks, 13 storage tracks, 9 shunting tracks and 6 dead-end tracks. Adjoining the area is a machine depot equipped with 5 overhaul tracks for suburban trains and 7 depot tracks on the west of the depot. The fourth main track connects the station area with the goods yard (where the machine depot is situated). Over the third main track there are two crossing tracks leading to the long-distance tracks.

Fig. 14
Shunting area

X 7772





Functional diagram for figs. 13 and 15

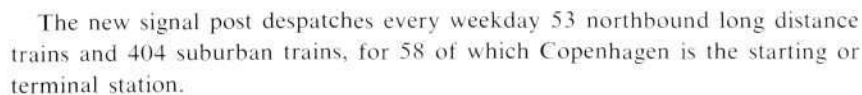
The diagram should be read from the top downwards. \uparrow signifies that the relays in that column are energized, \downarrow signifies that the relays in that column are de-energized. \bullet signifies that the last position of the relay (push-button) gives rise to the function shown in that row.

— signifies that the last position of the relay (push-button) is checked by the function in that row.

Fig. 15

X 8195

Circuit diagram for shunting tracks

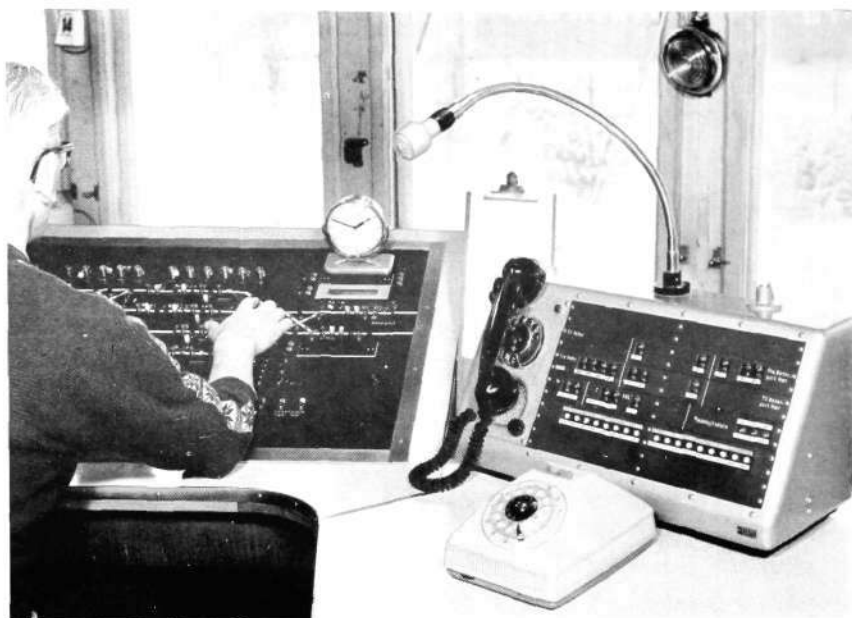


As already stated, the plant is designed to eliminate shunting operators as far as possible. Engine-drivers can now act as shunting operators for all suburban shunting movements to and from the machine depot, for shunting of departing trains from storage tracks to platforms and of arrivals from platform to storage tracks. It is reckoned that the work in the signal post can be done by one man. If this expectation holds good, the new interlocking plant should result in a reduction of station staff by altogether 16 men. This figure includes reliefs for off-days, leave and illness.

Fig. 16

X 8190

Control machine and telephone equipment including L M Ericsson's loudspeaking telephone, Ericovox



Cut-over of Plant

The cut-over was started on November 10, 1959, when 32 points were connected up to the new plant. Connection to main and platform tracks was done on Sunday, November 15, and by 5.15 a.m. the entire installation was in operation—with certain minor exceptions—without any interruption to service.