THE INTERLOCKING SYSTEM AT THE STOCKHOLM CENTRAL STATION

(CONTD.)

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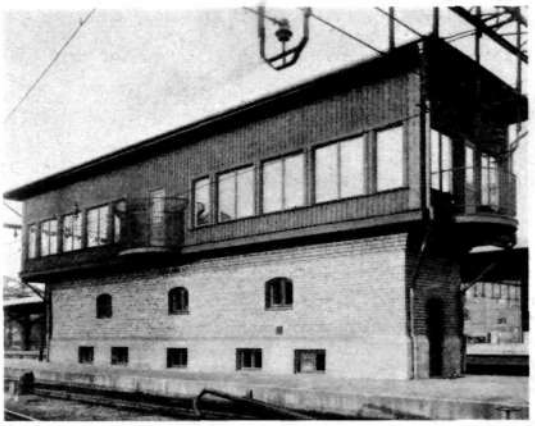


X 1272 **The signal cabin at Stockholm C.**

The Signal Cabin at Stockholm C.

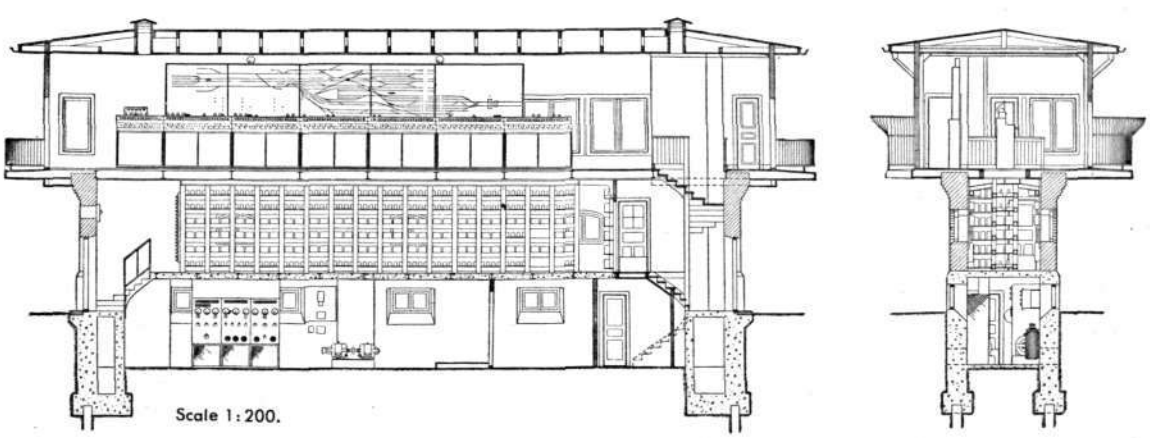
The signal cabin at Stockholm C, Fig. 7, is a three story building. According to the usual practice of the Swedish State Railways the top floor is built of wood and the two others of brick and concrete. The height of the cabin was determined by the requirement that, according to investigation made, the floor level of the top section should be about 4 m above the ground in order that the best possible view under the street bridge immediately north of the signal cabin might be obtained. With a view to making the rooms of the two bottom floors sufficiently high, the floor of the ground floor has been sunk 1.5 m below ground level.

The ground at the site consisted of old filling on sea bottom. In view of the risk of injury to the apparatus in the signal cabin by vibrations from trains passing, special care had to be taken with the foundations and these were made by friction piling.

The width at the bottom was determined by the position of the building on a platform between two train tracks, as free passage for platform trucks is required on either side of the building. The bottom floors are therefore only 2 m wide. The top floor is overhanging and the rooms are, therefore, wider. Lookout balconies have been arranged on all four sides of the signal cabin. The railings of the side balconies have been provided with guards to prevent the staff when on the balconies from touching the high tension trolley wires which run close by.

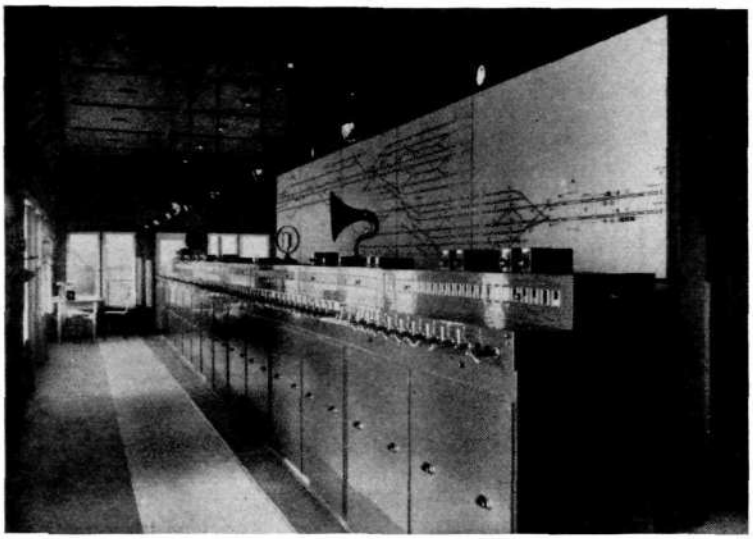
The building is warmed by hot water from the steam central of the station. In addition electric heating elements have been installed in the top floor for use during the periods of the year when the steam central is not in service. In the middle floor there is as a rule a certain surplus of heat from the electric apparatus installed there, and ventilation has been arranged by means of an electric fan placed in the wall.

The top floor, Fig. 8, is built as an operators' room with interlocking machine, illuminated



X 7050 **Fig. 7. Section of the signal cabin at Stockholm C.**

On the top floor: the operators' room; on the middle floor: the apparatus room; on the bottom floor: the power plant.



X 5114

Fig. 8. The operators' room,
with interlocking machine and illuminated track diagram.

track diagram and the necessary telephone equipment. Loudspeakers and microphones for the yard telephone system may be seen on top of the interlocking machine.

Walls and ceilings are made of plywood painted brown. The light is supplied by projector lamps which throw light on the track diagram and on the upper part of the interlocking machine where the switches, indicators and supervisory windows are situated.

On *the middle floor,* Fig. 9, there are the relays mounted on a separate wooden frame along the middle of the room, also the terminal boxes of the incoming underground cables, and finally all transformers etc. connected direct to the outgoing cable circuits. In the relay room there are more than 1 000 relays, 160 transformers and 110 terminal blocks for the cables. On the middle floor there are also the fuses with the exception of those of the AC motors, which are placed below the corresponding switches in the interlocking machine.

On the *bottom floor,* Fig. 10, all equipment for the power supply has been installed. In the northern end there is a small room with a working place for a repairer and shelves and cupboards for various stores. Part of the bottom floor is occupied by a distribution central for the outdoor lighting of the yard and by the heating installation.

Illuminated Track Diagram.

The track diagram is 13 m long and has been made in five parts which are held together by a frame of iron bars. The front is of sheet-iron, with the tracks represented by two narrow parallel black lines on a blueish-grey background, this having proved less tiring to the eye than the white background previously used, and with yellow filling between the lines for the tracks controlled by track circuits.

In this plate there are small windows behind which are lamps for track supervision, supervision of signals, signalling of train arrivals etc., so that by regarding the track diagram the staff may easily follow the movements. The total number of lamps is 748, all of which are easily accessible as behind the track diagram there are easily removable doors of wood.

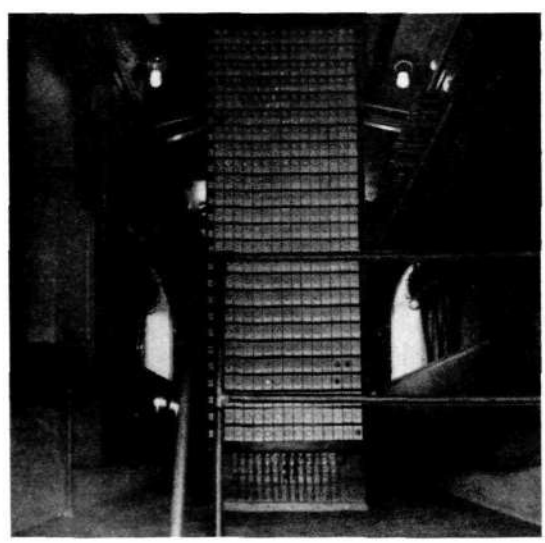


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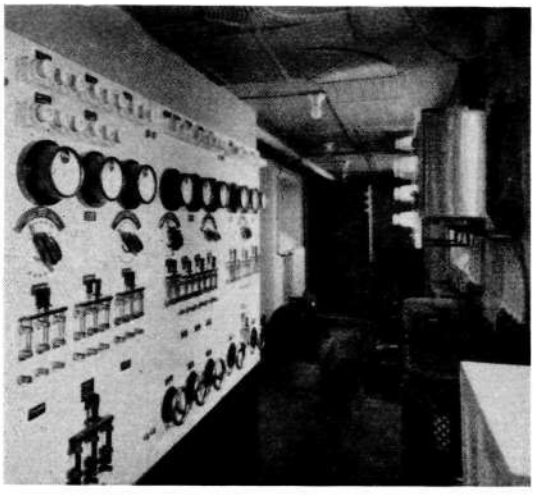
Fig. 9. The relay room,
with relays, cable terminal boxes, transformers and fuses.



X 1274 **Fig. 10. The power plant.**
Left, instrument panel; right, main transformers for the track circuits; in the background, converters.

The oblong light windows to be seen in Fig. 11 cooperate with the track circuits. The lamps light when the corresponding track circuits are occupied by vehicles.

The dwarf signals are indicated in the diagram by circular light openings which show white light for »clear» and yellow light for »caution». For »stop» the openings are unlighted.

The main signals are indicated by red and green lamps, which are connected direct in series with the lamps of the signals.

At the bottom of the track diagram, Fig. 11, there are the train-indicator lamps which indicate whether the block sections of the double track to Tomteboda are occupied by trains of the State Railways or those of the private railway company. Before a train leaves, the kind of the train must be indicated on the diagram, which is done by pressing a button, whereby a lamp (departure lamp) in the diagram lights up. When the train enters the first block section of the line the departure lamp goes out, and the corresponding lamp for the first block section of the line lights up. This lamp goes out and the corresponding lamp for the second block section of the line lights up when the train has left the first block section, and so on until, when the train has left the last block section, the last indication disappears.

The space below the track diagram between the supporting pillars has been utilized as a cupboard for housing such electric resistances, transformers, light relays, etc. as have direct connection with the lamps of the track diagram.

The Interlocking Machine.

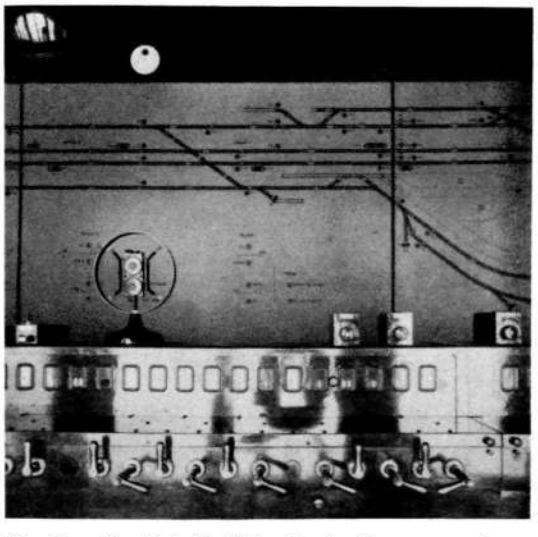
The interlocking machine is placed in front of the track diagram. It has a total length of 13.5 m and contains 70 point switches and 61 signal switches, by means of which more than 100 points and 150 signals with about 380 track combinations are operated. The interlocking machine has place for 30 additional switches to provide for future completions and extensions.

The interlocking machine is built into a cubicle of green enamelled sheet iron. The switch handles are of polished brass.

On the top of the interlocking machine are fitted various apparatus for the management of the traffic, such as switches for changing the traffic direction on the automatic block sections, time contacts for emergency release of track locking, press-buttons for the operation of certain shunting signals and train-indicator lamps.

The switches of the interlocking machine are placed in front of the corresponding points and signals in the track diagram. The handles of the signal switches point upwards and those of the point switches obliquely downwards, Fig. 11. Boards with symbols and information regarding the sequence of operation are placed in horizontal position above the switches (when the picture, Fig. 11, was taken the boards were not yet in position).

Figure symbols are used for both points and signals and these symbols are always the same as the corresponding number on the interlocking machine.



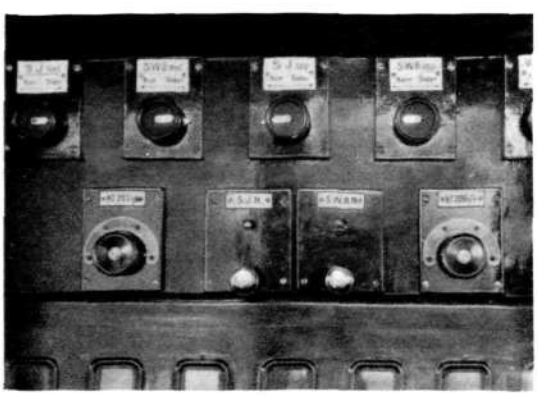
X 1275 **Fig. 11. Detail of the track diagram and the operating switches.**

Above the boards the supervisory windows may be seen, in which indicators of different colours are shown, Fig. 11. The supervisory windows at the signal switches are used for indicating when the switch for the road that corresponds to the switch in question may be thrown. The rule to be followed when throwing over the switches is that the switch should be moved in the same direction as the movement. When the switch has been thrown over the colour in the window will indicate whether the switch may be thrown back or not.

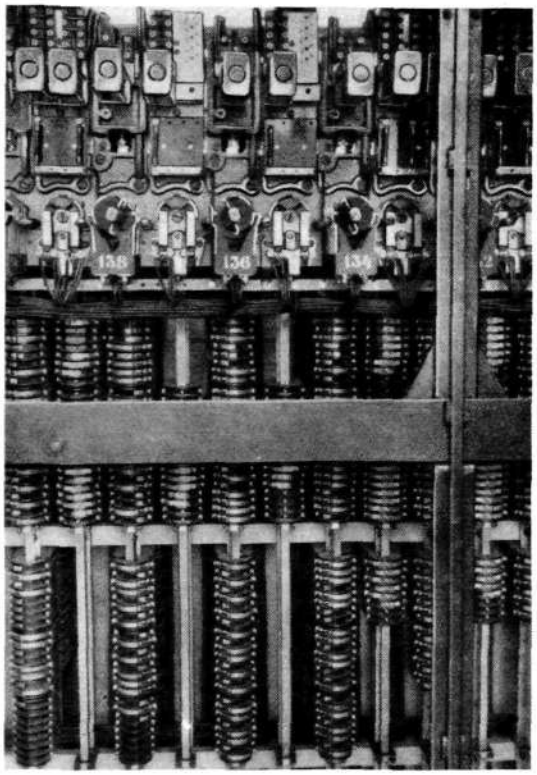
White appears in the supervisory window of the point switches when the position of the switch in question corresponds to the position of the points that are operated by means of the switch. When a switch is thrown over the white indication will consequently disappear, but it will return when the points have also gone over to the other position.

In order to indicate whether a point switch may be operated or not there is a special indicator device consisting of a pointer which appears in the supervisory window when the point switch is locked. The staff need therefore never try a switch but will always know beforehand whether the switch in question may be thrown over or not.

Fig. 12 shows the part of the interlocking machine that cooperates with the block sections of the line. In the top row there are the switches which are used for changing the traffic direction on the automatic line sections between Tomteboda and Huvudsta and Solna respectively. When the traffic direction is to be changed the handle is given half a turn, and a clockwork is then started. This clockwork actuates a contact device, which first sets the signals in stop position. After about 1 minute, during which the signals have indicated »stop» for both traffic directions, the signals will change over to indicate »clear» for the other traffic direction.



X 1276 **Fig. 12. Detail of the switches for operating the line sections.**



X 1277 **Fig. 13. The register of the interlocking machine, seen from the rear.**

At the ends of the bottom row, Fig. 12, there are two time contacts for emergency release of track locking and in the centre two press-buttons for indicating the kind of train (State railways or the private railway company) arriving from the north on the double track between Tomteboda and Stockholm C. By the use of time contacts for emergency release of track locking the sealing of the corresponding apparatus has been rendered unnecessary.

The interlocking machine at Stockholm C, of which a part is shown in Fig. 13 with the sheet-iron plates removed, is of a comparatively new design, used for the first time in 1927 for an interlocking machine manufactured by Signalbolaget for the Hässleholm station. In all previous electric interlocking machines mechanical locking registers have been used, *i.e.* the different switches of the machine are made mechanically dependent on each other by means of rods along the machine.

In the Hässleholm interlocking machine this principle was departed from for the first time, and the mechanical register was replaced by purely electrical connections between the swit-

ches. By application of the experience gained with this interlocking machine, the same design has been used at Lund, Gothenburg and several other stations and has now been installed at Stockholm also.

Each switch with the corresponding contacts and magnets is a separate unit having nothing but electric connections with the other switches. This makes the system extremely flexible for the planning of new installations and for alterations or extensions of existing plants. From a reliability point of view dispensing with the mechanical register has not caused any inconvenience, since it has been replaced by electromagnetic locking devices which are of the same or even of a higher degree of efficiency. A compulsory acting supervision of the functioning of the locking magnets has been arranged, and special steps have been taken so as to render harmless current leakage between different circuits due to faults in the insulation.

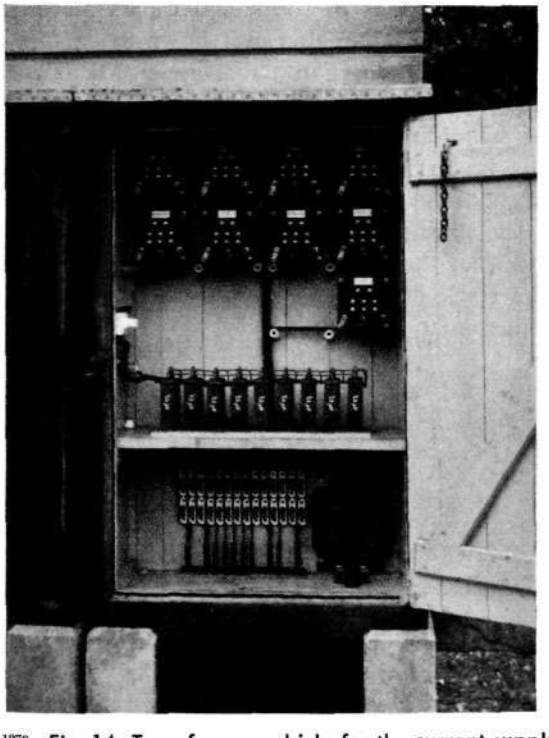
Power Plant and Track Circuits.

The primary power consists of three-phase AC, 50 c/s, which is supplied to the signal cabin at a tension of 220 V between phases. This power is partly used directly, and is partly converted into three-phase AC, 75 c/s, and DC of 220 V and 12 V.

As reserve in the case of breakdown at the mains there is also available in the signal cabin 2 × 220 V from the DC mains of the Stockholm Electricity Works. Equipment has been provided for converting the DC into AC of 50 and 75 c/s.

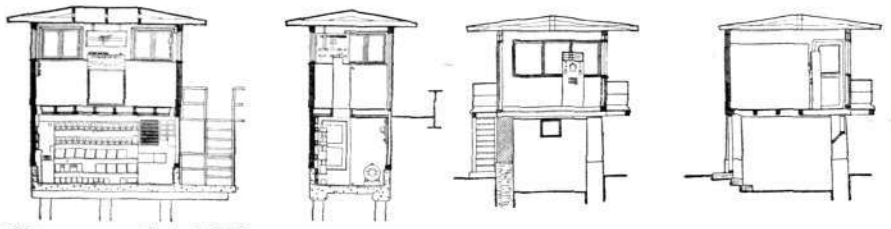
With the exception of a small 12 V storage battery for voltage equalization there are no reserve storage batteries in the plant, operation being based on the assumtion that power should always be available from one of the mains systems. The switch-over from the one system to the other is carried out by hand by means of a switch on the switchboard.

The main transformers, Fig. 10, for the track circuits are of a special design which prevents the voltage differences that might occur in the tracks on account of the electric traction from entering the local phases of the track relays, which might cause dangerous disturbances. The protection against the traction current has previously been arranged by using special frequency selective relays insensitive to the traction current, but in the present system ordinary two-phase track relays for 75 c/s AC have been introduced. The necessary protection has instead



X 1278 **Fig. 14. Transformer cubicle for the current supply of nine track circuits.**
Top, track transformers; middle, on the shelf, condensers; below, terminal strips.

X 1279 **Fig. 15. Relay cubicle at a block station along the track.**
Top and middle, relays and choke coils; below, storage battery with charging equipment.



X 7051 Scale 1:200.

Fig. 16. Section of the signal cabins at Mälarstrand (left) and Jakobsgatan (right).

been arranged by a kind of filter fitted in the feeding transformer which is common for all track circuits and this has rendered possible considerable reduction of both installation cost and power consumption.

Fig. 13 shows a cubicle with equipment for the supply of 9 track circuits. For each track circuit there is a condenser and a track transformer. AC of 75 c/s and 110 V is supplied to the cubicle. The transformers are connected to this supply with the condensers in series with the primary windings. The power for the track circuits is taken from the secondary sides of the transformers. The transformers are of such a design that the voltage supplied at the secondary side varies with the resistance of the track circuit and is adjusted automatically so that the current fed to the track circuit will remain practically constant.

In the case of the arrangement formerly used, with constant voltage over the track transformer and series resistances on the secondary side, an overcurrent will occur on account of the shunting when vehicles enter the section; this overcurrent will render the release of the track relay more difficult and makes necessary a more complete short-circuit over the axles than would otherwise be required. The track feeding with constant current therefore involves an increase in the sensitivity of the track circuit to shunting, which is of great importance from a safety point of view. The arrangement at the same time provides better economy on account of the reduced power consumption.

The power supply to the track circuits of the line north of Tomteboda, which are situated at a comparatively great distance from the signal cabin, is carried out by means of DC from storage batteries which are continuously charged from cuproxide rectifiers, Fig. 15. In order to protect the relays from the traction AC, choke coils with high reactance and low DC resistance have been inserted in series with the relays.

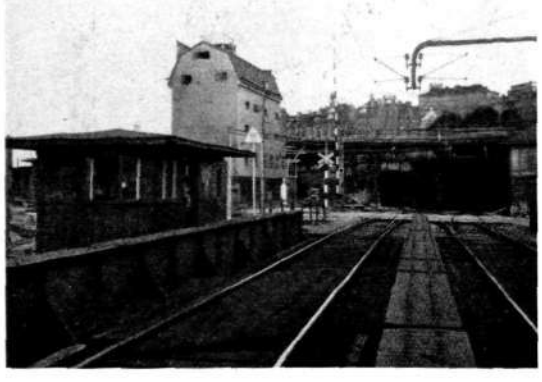
Track circuits of this type have been in use for several years to a great extent on the electrified lines of the Swedish State Railways. The principle of the design, however, in spite of its simpleness is rather unique.

Arrangements at Mälarstrand and Jakobsgatan.

Cross sections of the signal cabins at Mälarstrand and Jakobsgatan are shown in Fig. 16.

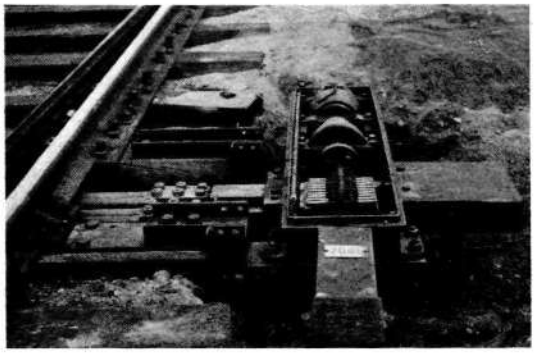
The greater part of the work at Mälarstrand consists of the operation of the street barriers and the swing-bridge, since the operation of the signals is carried out automatically for all trains except those to and from the harbour.

The interlocking machine has 8 switches only and is of the same type as that of Stockholm C. The track diagram is of wood and is provided with miniature lamps.



X 1281 Fig. 17. The signal cabin at Mälarstrand.

X 1280 Fig. 18. The level crossing at Jakobsgatan, between the tram line (600 V) and the railway line (16 000 V).



X 1282 **Fig. 19. Electric point drive.**

X 1284 **Fig. 21. Double crossing points, with double drive.**

The primary power for the signal cabin at Mälarstrand is taken direct from the DC mains of the Stockholm Electricity Works, which also supply the power for the operation of the swing-bridge. Reserve supply has not been considered necessary as there are practically never any breakdowns in the power supply.

A picture from Mälarstrand is shown in Fig. 17. The left tunnel opening leads to the Stadsgården harbour and the right one, to which the points are thrown on the illustration, forms the entrance of the tunnel under the southern part of Stockholm.

The driving machine for the street barriers, which is common for the two 12 m long barriers, may be seen to the right on the illustration near the base of the old signal cabin, which has now been removed.

The street barriers of the level crossing at Jakobsgatan are operated from the signal cabin situated near this crossing; it carries the heaviest traffic of all the leval crossings of the Swedish State Railways in respect of both railway and street traffic.

The barriers are operated by means of two motors, one for each pair of barriers, and are combined with light signals, which stop the traffic of the street before the barriers begin to close.

The power to the barrier system at Jakobsgatan is supplied from the power plant in the signal cabin at Stockholm C. The operating instruments consist of switches mounted on a switchboard in the upper part of which there is a small track diagram with lamps for the signalling of the arrivals of trains etc.

The barrier watchman has to follow the traffic by means of the track diagram and to decide for himself when the barriers must be closed.

When the barriers are operated a motor-driven contact device is automatically actuated, by means of which the trolley wires above the street will be connected either to the 16 000 V line of the railway or to the 600 V line of the tramway, according as the barriers are open or closed to the street traffic.

Arrangements for the Throwing-over and Locking of Points.

Fig. 19 shows how the driving machine of a point is mounted on a bracket of U-irons which are fixed to the ends of the sleepers and to the irons of the point fundament. The driving ma-

X 1283 **Fig. 20. Point rollers.**

X 1295 **Fig. 22. Mechanical switchman.**

X 1285 **Fig. 23. North view of the points at Tomteboda.**

chine will consequently follow variations in the height of the track. The cable from the signal cabin is terminated in a separate box connected to the driving machine by a flexible tube through which the conductors have been drawn.

Four rods leave the driving machine, *viz.*, two point rods for the operation of the tongues and two supervisory rods which serve for controlling the position of the tongues, independent of the position of the point rods.

The locking of the tongues is carried out by means of a device built into the driving machine. Point locks are therefore not required, which makes the cleaning of the points from snow and ice much easier. The driving machine may be forced open and is provided with an enclosed gear which runs in oil. For all other sliding surfaces and bearings the lubrication is by means of grease forced into the driving machine by means of a syringe through lubricators with ball valves.

The cleaning of the points from snow and ice is facilitated by notches made in the point plates, so that the channel between the tongue and the guard rail will be open at the bottom, Fig. 20. Roller bearings have been provided below the tongues so as to support them during the switch-over. The slide plates have only to support the tongues in their resting positions. It is therefore not necessary to lubricate them, and the switch-over will always be easy.

Fig. 21 shows double crossing points. Two driving machines are required for such points, each machine operating two pairs of tongues.

Fig. 22 shows points provided with a mechanical switchman which returns the points to home position after they have been forced open. This arrangement has been provided at some points at the inner end of the platform tracks of the Eastern Yard. The switches are generally trailed and need then not be thrown over but may be forced open if the points should not be in the right position.

Signals.

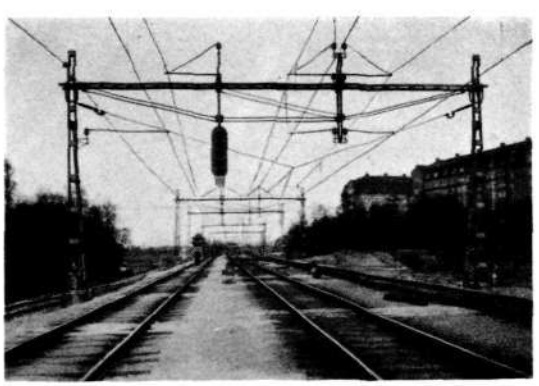
Fig. 23 to 32 show signal arrangements at various places in the yard and on the lines.

Fig. 23 shows the signals for the points at Tomteboda Övre, situated at a distance of 2.5 km from the signal cabin. Main signals have been provided for the two left tracks only. For the other tracks the signalling is carried out by means of the dwarf signals. The main signals are fitted on poles of reinforced concrete and the dwarf signals on low bases of the same material. A signal telephone to the signal cabin is mounted on the pole of one of the main signals.

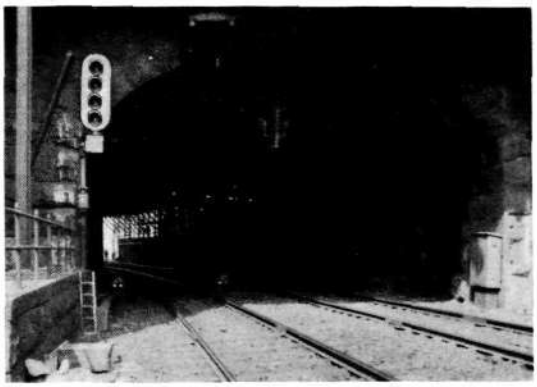
The rectangular shape of the number plates indicates that the signals are operated from the signal cabin. The number plates have a coating of enamel, which reflects the light from the headlights of the engine, so that the number may be seen clearly from the engine even in the dark.

Fig. 24 shows automatic signals at the block station about 800 m north of the Tomteboda points. The signals have been fitted with a round

X 1286 **Fig. 24. Block station north of Tomteboda Övre.**



X 1287 **Fig. 25. South view of Tomteboda Övre.**



X 1288 **Fig. 26. Entrance signal at Mälarstrand.**

X 1289 **Fig. 27. Southern entrance of the tunnel.**

plate, which indicates that the signals are operated automatically.

The main signal shown in Fig. 25 belongs to the upward track and indicates »clear» by means of one green light for the trains of the private railway company and two green lights for the trains of the State Railways. The two bottom lights form the distant signal of the next block section and show green light or flashing white light. When passing over the crossing points on to the downward track the signalling is carried out by means of the dwarf signals only.

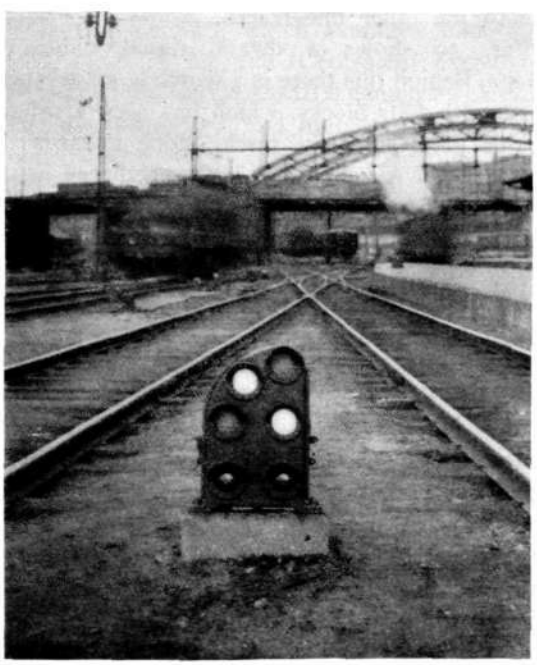
The signal telephone may be seen on the left pole carrying the trolley wire. In this case the main signal has been placed in the catenary bridge and is accessible by means of a ladder raised against a support which is placed on the bottom part of the signal. The old Tomteboda signal cabin may be seen in the background; after the removal of the interlocking machine the building has been used as office for the Tomteboda shunting yard.

Fig. 26 shows the signals south of the points at Mälarstrand, *i.e.*, main and dwarf signals for the upward track and a dwarf signal for the other track.

Fig. 27 shows approach signals at the southern entrance of the tunnel under the southern part of Stockholm. On account of the sharp curve the signals are repeated further along the tunnel. The special painting of the background plates indicates that the signals are distant signals. On main signals these plates are black.

In Fig. 28 »clear» and »stop» is indicated by

X 1290 **Fig. 28. Entrance signal south of Stockholm C.**



X 1291 **Fig. 29. Starting dwarf signal.**

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X 1292 **Fig. 30. Dwarf signal and scotch-block light.**

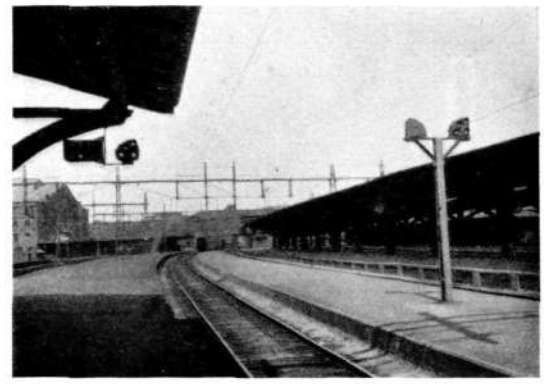
the two top lights of the main signals. The same »clear» signal feature is shown for all five train tracks. The lower lights of the signal are used as distant signal for the starting signals at the other end of the yard.

A home dwarf-signal with similar signalling but without main signal has been provided for the downward track also, for use on single-track traffic on this track.

Fig. 29 shows a starting dwarf signal indicating »caution». The bottom lights are used for indicating when the whole starting road is clear, and such signals may consequently replace the main signals of starting roads. Flashing light is shown when the starting signal at the station limit indicates »stop» and fix light when this signal indicates »clear». The light to the right corresponds to the upward double track and the left one to the other line tracks.

Fig. 30 shows a dwarf signal indicating »stop». Behind this there is a scotch block arrangement with four blocks, which has been arranged in this place since the tracks slope towards the train tracks. A guard rail has been placed in the track so as to prevent the carriages on running off the rails from striking against the adjacent trolley-wire pole.

About 10 m behind the main signal the home dwarf signal may be seen; this signal is provided with a special light at the bottom for green light. Fix green light is shown when the whole entrance road is clear. When only half the train track is clear flashing green light is shown by the dwarf signal while the main signal shows red light. If not even half the track is clear the train will proceed by clear from the dwarf signals only, but the engine driver must then have special permission to do so. This may be obtained from the staff of the signal cabin by means of the signal telephone at the main signal.

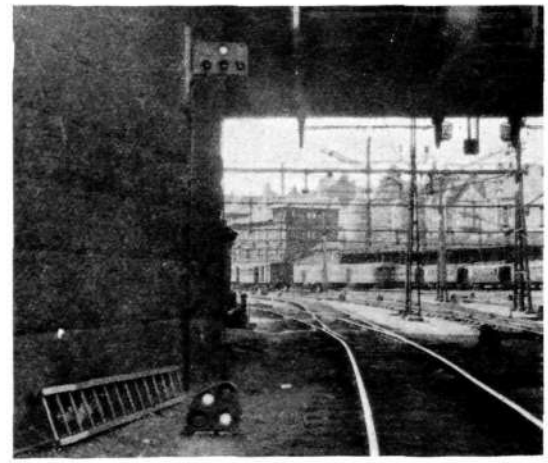


X 1293 **Fig. 31. Platform signal.**

The scotch blocks must be turned down before »clear» can be indicated on the dwarf signals of the track circuits where the scotch blocks are placed. In addition the scotch blocks are combined with a separate scotch-block light which shows a black bar on a white background. The slope of the bar indicates that the signal refers only to the track towards which the bar is directed.

Fig. 31 shows a platform signal with indication lights, and some of the dwarf signals which divide the platform tracks of the Western Yard in two parts. With regard to their position on the platforms these dwarf signals have been mounted on poles.

Fig. 32 shows a special signalling device, which shows to which track of the storing groups the points are thrown; this device is necessary as the view is screened by the left abutment of the bridge. The signal shows a white light permanently as well as a yellow light, the position of which in relation to the white light indicates to which track the road leads. Yellow light can be shown only when the dwarf signal further along the track indicates »clear» for shunting.



X 1294 **Fig. 32. Shunting signal.**