

Interlocking Plant at Aarhus Railway Station

H. SCHMEDES, SIGNAL INSPECTOR, DANISH STATE RAILWAYS, AARHUS

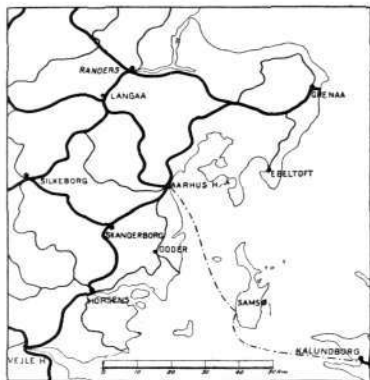


Fig. 1
Map showing railway lines meeting
at Aarhus

In connection with the establishment of a railway goods station at Mølleengen, Aarhus, and the reconstruction and extension of Aarhus H passenger station, the station has been provided with a new interlocking plant, supplied by L. M. Ericssons Signalaktiebolag. The new plant is noteworthy on account of its size and a number of special devices which are employed for the first time in Denmark.

Aarhus H constitutes a shunting station for the East Jutland main lines, i. e., the line from Fredericia to Frederikshavn, see Fig. 1, seeing that the double track from Skanderborg (Fredericia) arrives at the same side as the line from Langaa (Frederikshavn), which latter line is also at the present time being made into a double track. Side by side with the double line from Skanderborg, the Odder line runs into Aarhus H, while the Grenaa line arrives by way of the eastern end of the station towards the harbour, proceeding thence to Aarhus Ø and Grenaa.

Planning

When studying and designing the new interlocking plant it was considered whether it was advisable to depart from the usual type of safety devices hitherto used in Denmark and introduce the system employed in America and England which, with modifications suited to the existing conditions, has been adopted at a number of Swedish stations, including Malmö, Gothenburg and Stockholm. This system not only handles train movements but also shunting operations within a considerable section of the signal-protected field, the shunting being controlled by dwarf signals.

A prior condition was that the new plant should be operated electrically, seeing that the numerous points and signals would involve an extremely complicated and costly installation as well as expensive upkeep of the wire system and moreover the great distances to several of the points and signals — the distance from Cabin I to the furthest point at Kongsvang is about 1 100 m and to the furthestmost signal about 2 100 m — did not allow or could not be served by wire lines.

Since Aarhus main station, as mentioned above, is principally a reversing station, every through train whether single motorcoach or train consisting of motorcoach with attached coaches, but with controls at either end must reverse the motors, and moreover there is frequent coupling and uncoupling of coaches, as the lengths of trains are reduced or increased for the remainder of their run. In addition there are numbers of trains which terminate or start at the station. Besides arrivals and departures of trains there is considerable shunting from and to the passenger-coach depot and of locomotive traffic from and to the locomotive sheds. As a great deal of this shunting is regular, a plant with shunting tracks is consequently advisable, particularly as such a plant allows of light engines and motorcoaches running without conductors, for instance, from and to the sheds. It was therefore decided to use dwarf signals at the western end of the station.

At the eastern end of the station, towards the harbour, conditions are on the other hand somewhat different, as the space is considerably restricted and moreover shunting to and from the harbour is quite irregular so that it is not suited to a system in which the shunting is controlled from the signal-cabin. At this end of the station therefore the plant is made without dwarf signals.

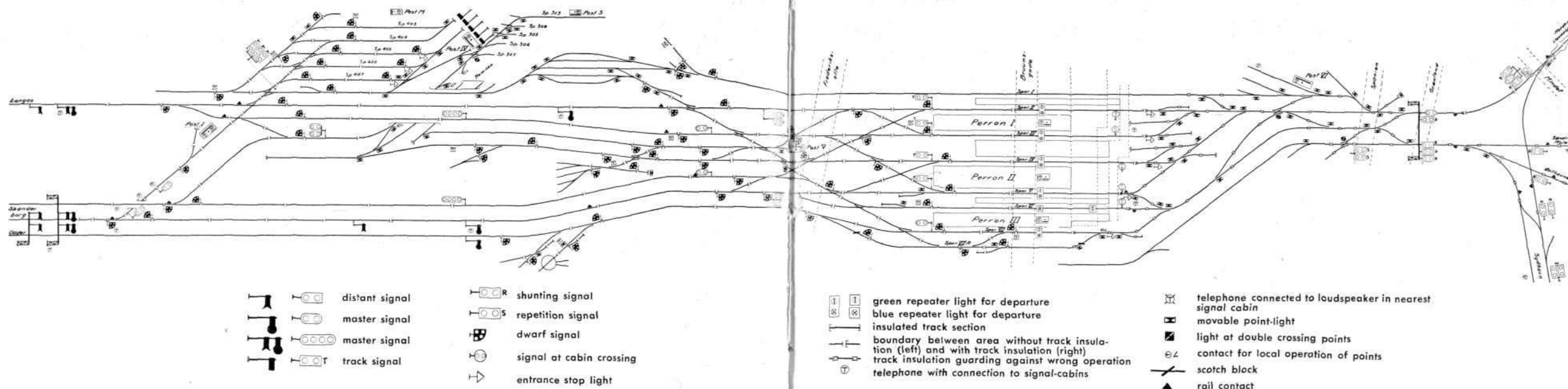


Fig. 2
Track signalling plan of Aarhus station

Fig. 2 shows a diagram of the new plant. There are 3 signal-cabins, namely: Cabin I, about 2 km to the west of the station buildings, where the lines from Skanderborg and Langaa run side by side, Cabin V, which is the master cabin, Cabin VI, at the eastern end of the station. Further, there is connection with Cabin IV, at the departure grid for goods trains, and on the platforms there are entrance contacts for incoming trains. The following tracks are operated: from Skanderborg to tracks IV and V, and thence to Langaa; from Langaa to tracks II and III, and thence to Skanderborg; from Grenaa and the harbour to tracks V and VI, and from track VI to Grenaa and the harbour; from Odder to tracks VII and VIIa, and from track VII to Odder; from Skanderborg to goods-arrival track at Cabin I and reverse, and from Langaa (goods trains) to tracks 405, 406 and 407; to Skanderborg and to Langaa (goods trains) from tracks 303, 304, 305, 306 and 307.

Section blocking has been arranged between Aarhus and Hasselager, with intermediate block Cabin at Viby for south-going trains, and further section blocking between Aarhus and Brabrand has been arranged.

For running to and from the harbour, shunting signals have been put up, to allow of operation from Aarhus H to the north Harbour track, Søndre Mole, Østhavnen and Sydhavnen and reverse as well as from the north harbour track to Sydhavnen and reverse.

Arrangement of Signals

The main entrance signals are made as semaphores, while the other signals are daylight signals. There are two kinds of the latter, namely *daylight signals* and *dwarf signals*. The daylight signals show red, green, yellow or blue light, while the dwarf signals are seen as pattern signals, the signal indications being formed by the positions of several white lights, Fig. 6.

In respect of signalling Mølleengen goods station is made a station in itself, seeing that passenger trains, both outgoing and incoming are shown »run through». Mølleengen is provided with the following pole signals operated

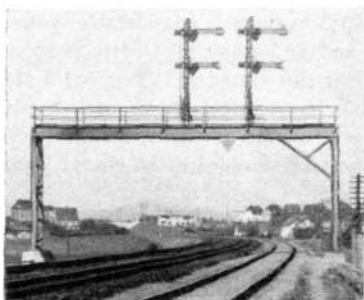


Fig. 3
Signal-bridge with signals for trains from Skanderborg

- green repeater light for departure
- blue repeater light for departure
- insulated track section
- boundary between area without track insulation (left) and with track insulation (right)
- track insulation guarding against wrong operation
- telephone with connection to signal-cabins
- telephone connected to loudspeaker in nearest signal cabin
- movable point-light
- light at double crossing points
- contact for local operation of points
- scotch block
- rail contact

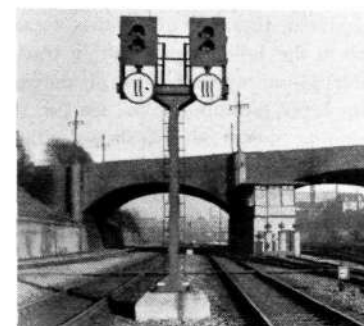


Fig. 4
Daylight track signals for entrance on tracks II and III
In front of the bridge may be seen Cabin V (master cabin)

from Cabin I: for trains from Skanderborg over track on signal bridge seen in Fig. 3: two incoming semaphores with »run through» arms and daylight signal with requisite distant daylight signal for incoming from the goods track to the goods grid, and three daylight signals for entrance to the goods tracks;

for trains from Langaa: one entrance semaphore with »run through» arm, and three daylight signals for entrance to the goods tracks (the same three as mentioned above);

for outgoing goods trains: five track semaphores located at and operated from Cabin IV for outgoing to Skanderborg and Langaa, and two daylight signals for outgoing goods trains to Skanderborg and Langaa respectively; for trains from the passenger station to Skanderborg and Langaa: two daylight signals for »run through» to Skanderborg and Langaa respectively.

The passenger station has the following pole signals operated from Cabin V: for trains from Odder: one entrance semaphore;

for trains from Skanderborg: one entrance semaphore and two daylight track signals for entrance to tracks IV and V;

for trains from Langaa: one entrance semaphore and two daylight track signals for incoming to tracks II and III, see Fig. 4;

for outgoing trains: at the ends of the platforms 5 daylight signals: for trains to Odder from track VII, to Langaa from tracks IV and V and to Skanderborg from tracks II and III, with further out two starting signals for trains to Skanderborg and Langaa respectively.

Operated from Cabin VI are a number of daylight signals, viz:

for incoming from Aarhus Ø and Harbour: one entrance signal at the swing bridge over Aarhus river;

for trains to Aarhus Ø (Grenaa) and Harbour: one starting signal from track VI and several shunting signals with blue and yellow light for running from and to the various parts of the harbour.

The signals for traffic with Aarhus Ø and the harbour are erected on the signal bridge shown in Fig. 5. The crossing at the east of the main building is protected with 5 small daylight signals with yellow and blue light. The starting signals are repeated in the platform hall with a green light for »clear», and the signals for incoming with a blue light in »clear» position. All the pole signals are automatically set at stop by trains passing them.



Fig. 5
Signal-bridge with signals for traffic with harbour

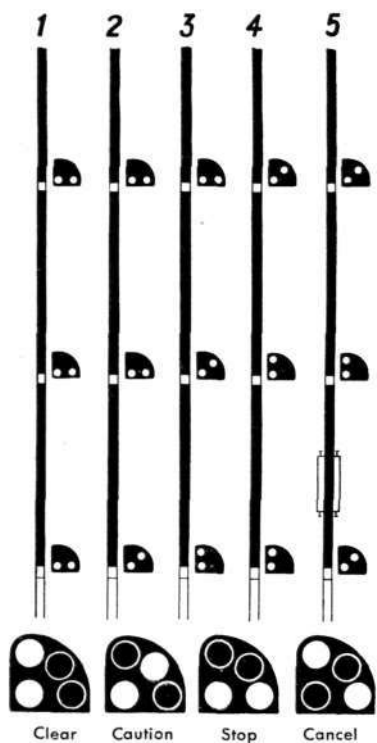


Fig. 6
Cooperation of dwarf signals X 3420

Insulated Tracks, Dwarf Signals, Shunting Tracks

The train roads at the western end of the station (Cabins I and V) are provided with insulated track sections with track current. The track system is divided up into a fixed number of insulated sections and each section receives AC which operates a relay. When a coach, locomotive or the like is in a section the current leaks through the wheel axles and the relay armature falls. The signals are connected with contacts on these track relays so that clear signal cannot be shown while there is a coach, locomotive or the like in the train road. Thus there is automatic check whether a track is free before signal can be given.

Besides the above-mentioned principal train roads the field under Cabins I and V is also provided with shunting tracks which are equipped in similar way to the train roads. These require special signals in considerable numbers, as all movements allowed by the track system must be directed and controlled from the interlocking apparatus concerned. These signals are small low dwarf signals. The operation of the signals is by two white lights taking up different positions, see Fig. 6, which shows four signal patterns, *viz.* »stop», »caution», »clear» and »cancel», the last-named being utilisable to only a limited extent. The dwarf signals are set in connection with the points, hereunder covering points, and insulated track sections lying behind the signal. The train road from a dwarf signal to a following dwarf signal, the area of another signal cabin, a siding or the free line are indicated in the following: shunting track. When a shunting signal lever at the interlocking apparatus is at normal position the signal or signals belonging to the lever indicate »stop», see Fig. 1. If the lever is pulled down the corresponding dwarf signal shows either »clear» or »caution», as described below. If the lever operates more than one dwarf signal, the signal covering the track required shows one of the two »clear» signals, while the other signals indicate »stop».

If there be coaches, locomotives or the like on one or more of the insulated track sections (occupied tracks) behind a dwarf signal, that signal cannot give »clear» but only »stop» or »caution», no matter what may be the position of the next signal.

If the insulated track section behind a dwarf signal is free for coaches or the like (unoccupied track), the dwarf signal can show »clear», provided a following signal shows »clear» or »caution», and it cannot show »clear» but »caution» if the following signal indicates »stop». Where there is no following signal and vehicles enter a section which is not provided with dwarf signals, it is determined for each case according to the local circumstances whether such a dwarf signal with unoccupied or possibly uninsulated track behind may show »clear» or »caution».

When the lever of a shunting signal is thrown over, the points in the shunting track are locked. The connections between shunting signal lever and point lever, points, opposite shunting signal lever and train track lever are operated wholly electrically.

In those track sections which are divided into shunting tracks a number of these will come into the main train roads, and the shunting signals for these are so arranged that they indicate »clear» when the main track is required. The signal »clear» is shown until the front axle enters the first track section behind the dwarf signal.

The shunting signal levers are provided with lock for the position they are set at, though as a rule the lock operates only when the front axle enters the first insulated section behind the dwarf signal. So long as the section has not been entered the shunting signal lever — contrary to a main-track signal lever — can freely be returned to normal position, a facility which is made use of naturally in very few instances. Still for single shunting tracks



Fig. 7
Dwarf signal X 3416

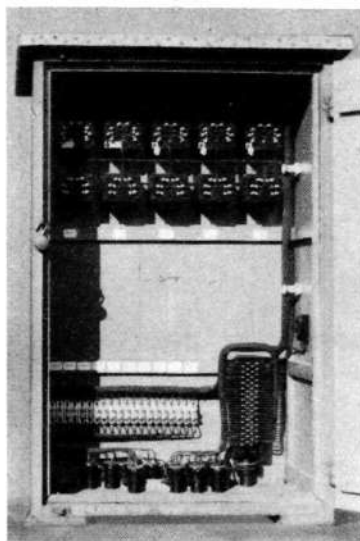


Fig. 8
Transformer cubicle for five track sections

showing track transformers above and reactance coils below

it has been considered advisable to allow locking to take place immediately the lever is thrown over. The unblocking of shunting tracks takes place according to the circumstances at the spot, either when the whole track section is cleared or when a part of it has been passed by the last axle. In the latter case the remaining points in the track remain locked against changing, no matter whether the shunting signal lever is restored or not. These points can only be changed after the last rear-axle has left the insulated section of track belonging to them or, provided passage has not taken place, when the whole track is cleared.

The dwarf signals are in general similarly arranged for automatic change from »clear» or »caution» to »stop». If »clear» is showing this changes automatically to »caution» when the leading axle comes into the insulation behind the signal, and changes back to »clear» when the track is completely cleared, provided the lever is still in thrown position. If it shows »caution» no change occurs as a rule in the signal indication on entering the track.

A dwarf signal is placed immediately to the right of the track it refers to, and does not give indication backwards. A dwarf signal at »clear» or »caution» does not indicate which track is concerned, so that it is not possible to see from the signal which track is operated; there are in dwarf signals areas no point lights indicating this either. But since a signal cannot be set at »clear» for less than the track section to which it applies and at the same time the corresponding shunting track (or mutually dangerous shunting track) cannot be changed, all movements are protected, even the possibility of a wrong lever being pulled and causing an operated shunting track to lead in a different direction than was intended by the operating staff. A number of dwarf signals one behind the other work together as already described and as shown in Fig. 6.

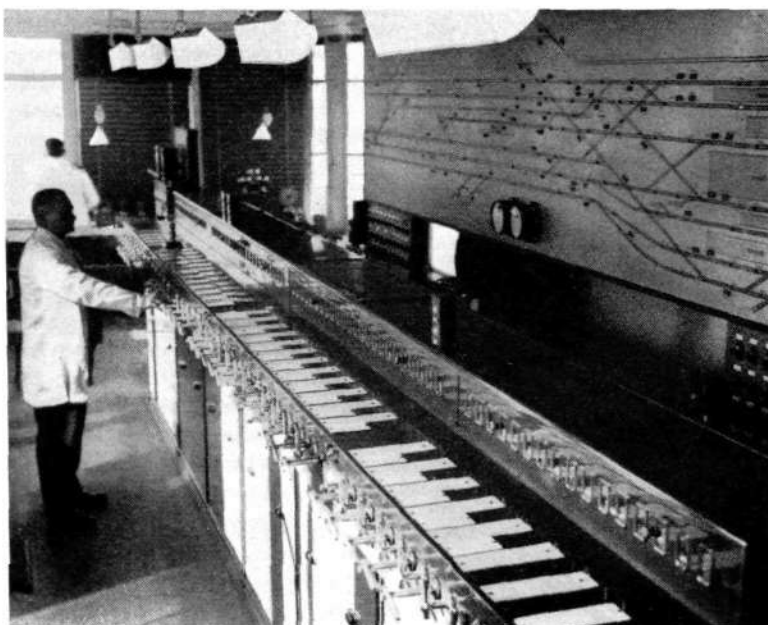
While the track section under Cabins I and V are divided into insulated track sections, in the area under Cabin VI there is a single section beyond, which can be insulated for safety against untimely reversal of the central-operated points and locking of the track.

The insulation of the fish-plates and the intermediate plates is by layers of American fibre. The insulated rails are provided with insulation in both rail-ties with the exception of the rails insulated against untimely reversal and locking of the tracks under Cabin VI and of fairly simple sections under the other Cabins where insulation at one side is sufficient. Connection within the individual insulations is provided by double 5 mm copper wire attached to the insulation by conical spikes.

The insulated rails under Cabin VI are fed with 34 V DC while a single insulated section under Cabin VI and all the rest of the insulation are fed with 110 V AC in conjunction with the track transformers and reactance poles. Thus the open track circuits are arranged for condenser feeding for continuous track current. Two-phase induction relays are used here. The current feed to the track-relay local phase is taken from the 110 V side of a $3 \times 220/3 \times 110$ V transformer placed in each signal-cabin, while the current supply over the insulated rails to the track phase of the relays is taken from the same transformers over a special track transformer for each single section. The track transformers and the reactance coils as well as the condensers are located in cubicles at the station, Fig. 8, and from these current is fed at low tension to the one end of the track section concerned. The two insulated railties then lead the current from and to the track relays (one relay for each section) introduced between the rail ties at the other end of the track section. The track relays and the greater part of the other relays are located in the under part of the signal cabin. The connecting wires are laid in armoured underground cables.

Fig. 9
Interlocking apparatus and illuminated
track diagram in Master Cabin

X 5207



Operation of Points and Signals

The point drives are of Signalbolaget's newest type, some with and some without built-in lock according to whether the points have hook-lock or not. They are arranged for 220 V DC. The control of the position of the points is carried out in the Cabin I and Cabin V areas by means of three-way disc relays housed in the relay rooms, with local and indication phases for 110 V AC, 50 c/s.

In the field of Cabin VI the supervisory current is 34 V DC used in the ordinary way without special relays.

All the corresponding points in the tracks are control-locked and in addition the furthest points at Kongsvang, some 100 m from the signal-cabin are provided with special locking.

The insulation in all the individual operating locks is provided with double joints and in the control-locks with single joints.

The semaphores are operated with devices furnished by Signalbolaget arranged for 220 V DC and 34 V DC.

The daylight signals and the respective dwarf signals are operated by means of special DC relays located in the underpart of the signal cabins.



Fig. 10
Cabin VI

X 3418

Interlocking Apparatus, Relays, Signal-Boxes etc.

The interlocking apparatus in Cabins I and V are of Signalbolaget's latest type. The point levers each serve one or two points and in normal position lie over to the right, being over to the left when thrown. The angle traversed is 140° . The signal levers normally slope upwards and can be changed 70° to either side. Each lever can thus serve two train tracks, one at either side, while — as stated above — it can serve many shunting tracks, provided all the shunting tracks on the same lever are mutually opposed.

As concerns the main train roads there is also mechanical connection between the point levers and the signal levers, while for the shunting tracks there may be purely electrical connection, obtained partly at the lever magnet armatures and at contacts on the levers and partly by a considerable number of relays

installed in the underpart of the cabin. The relays, of which there are both AC and DC, are for the most part provided with contacts enclosed in glass cases.

Fig. 9 shows the interlocking apparatus and the illuminated track diagram in Cabin V, the main cabin. Fig. 10 shows Cabin VI and Fig. 11 the view from Cabin I towards the main station. The illustration shows the double-track harbour line which runs under the main track at bridges.

The arrangement of the interlocking apparatus in Cabins V and I is substantially the same as described in Ericsson Review No 1—3, 1931. The interlocking apparatus in Cabin VI is of the Signalbolaget's normal type. An occupied track is locked automatically and cleared, also automatically, on the passage of the train. The traction track is protected, from Cabin V, by 5 daylight signals with 10 lights. The swing bridge over Aarhus river is blocked from Cabin VI in conjunction with the track section.

The table below gives for each central apparatus an idea of the levers, numbers of tracks, numbers of points operated, signals, dwarf signals, track insulations etc.

	Cabin I	Cabin V	Cabin VI	total
fields in the central apparatus	40	80	48	168
point levers	18	32	20	70
signal or clearing levers	7	16	13	36
dwarf signal levers	11	25	—	36
spare sections	4	7	15	26
train roads	13	26	14	53
shunting tracks	51	147	—	198
centrally operated points	22	56	32	110
centrally operated scotch-blocks	—	1	1	2
semaphores	6	4	—	10
distant daylight signals	9	22	17	48
distant daylight signals on tractor track	—	5	—	5
dwarf signals	21	44	—	65
insulated track sections with lamp at track level	45	69	2	116
track insulation as precaution against wrong operation of points	—	—	28	28

Fig. 11
View from Cabin I looking towards
station buildings

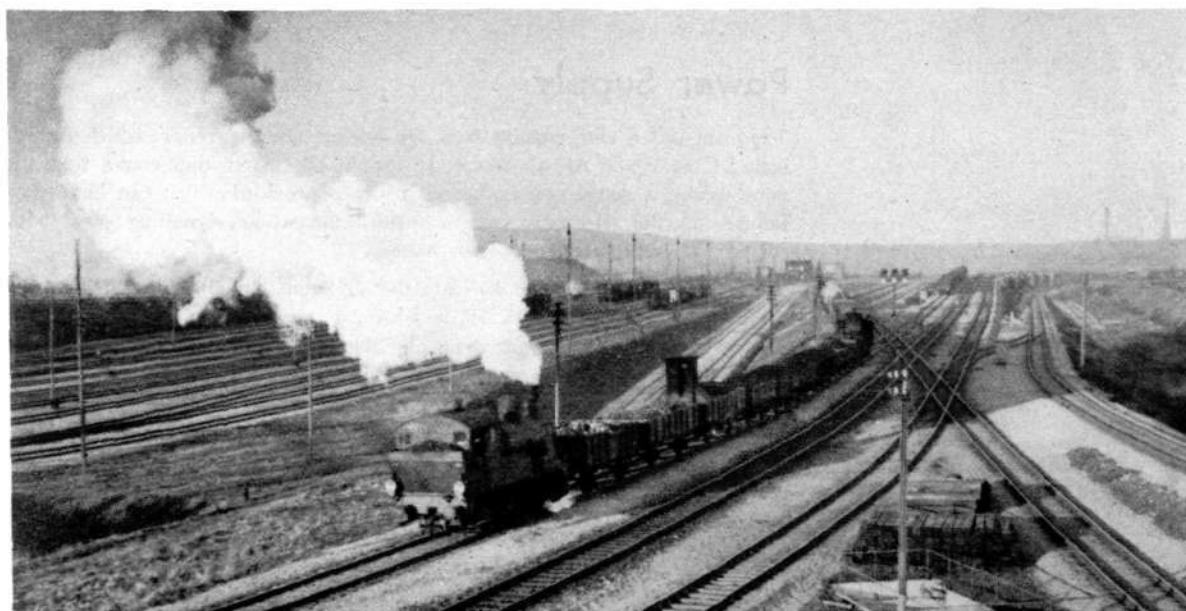




Fig. 12
Instrument board in Cabin VI

X 3419

Illuminated Track Diagram

As the shunting in the fields of Cabins I and V is to be controlled by and directed from the signal cabins it is necessary that the operating staff should be able easily to supervise and follow the individual movements and for that reason each of these cabins is provided with an illuminated track diagram for the track system concerned.

On these track diagrams, which are set up separately behind the interlocking apparatus, there are indicated, in addition to the tracks, the main signals (pole signals) and dwarf signals as well as the individual insulated track sections into which the track field is divided. The positions of the signals are repeated on the track diagram by separate coloured lights which show up as coloured lamps set behind windows and which indicate the signals. There is on the diagram one lamp for each insulated track section. The presence of a vehicle on a track section is marked by the corresponding lamp, set behind a window inserted in the track line, lighting up, and when the track is cleared the lamp is extinguished. Thus the lamps are out when a track is unoccupied and in this way very few of the lamps are lit up at one time. Momentary movements are thus noticeable earlier than with the contrary system: lamp out when occupied, lamp lit when unoccupied track. As a rule also the life of the lamps is longer and the changing of burnt out lamps more seldom necessary. All movements on the track system can be followed on the track diagram.

»Stop» at a dwarf signal is not repeated on the track diagram while »caution» is shown by a flame-yellow light and »clear» by a white light. »Cancelled» is indicated by flame-yellow light with a black cross. The various main signal positions are shown by red light for »stop» and green light for »clear», while the shunting signals are indicated by flame-yellow light for »shunting permitted» and blue light for »shunting forbidden».

The tractor line signals can be lit at the time of the trains and they are repeated with yellow or blue light on the track diagrams of Cabin V. Cabin VI has no track diagram of its own but there is a smaller diagram which by means of a couple of track insulations can show the position of main signals on much the same principle as described for Cabins I and V. The arrangement of the track diagram in the main cabin may be seen from Fig. 9.

In the direction of Skanderborg manual AC current line blocking has been installed while the same is intended for the Langaa direction and will be taken into service at the same time as the double track.

Power Supply

The plant is fed with current from the Aarhus Electric Works which furnish both DC 22 V and AC 3×380 V, 50 c/s. As all current thus comes from the same works, a petrol generating set has been provided which can in case of failure at the electricity works furnish the whole signalling plant with current. There is no accumulator battery.

The 220 V DC current is led into the different signal cabins direct from the mains, while the 380 V AC is taken by a special cable direct from the electricity works to the lower room of Cabin VI, which cabin is situated close to the electricity works. A petrol motor generating set is installed at Cabin VI. In normal conditions the current supply is utilised as follows:

220 V direct current is used in each of the cabins for: operating current for points and arm signals, lighting of arm signals, distant open-work signals etc., dwarf signals and point lights.

3×380 V alternating current is delivered to a transformer for $3 \times 380/3 \times 220$ V at cabin VI, from which each of the cabins is fed with 3×220 AC, which through transformers and rectifiers supplies 34 V DC for the supervisory

current etc., and further through transformers supplies $3 \times 220/3 \times 110$ V, 50 c/s, to track insulations and track relays (3×110 V, which at the track transformers gives 12—24 AC) and to the point relays local phase 110 V, and through transformers 110/110 V to the relays' indicating phases, and finally through transformers 110/14, 12, 11, 10 V for the lamps of the track diagrams.

Whenever DC in a cabin fails, 220 V DC can be obtained from the 220 V AC mains through a rotary converter. Should the AC supply fail or both AC and DC fail then the required current can be obtained for the whole plant from the petrol generating set referred to above.

Telephone Installation

The signalling plant is provided with a comprehensive telephone installation, since besides the customary connections between telegraph office, signal cabins, platform boxes etc. there is a considerable number of instruments at various spots, providing convenient communication with the signal cabin concerned, which is necessary in cases where shunting is controlled and directed from the signal cabins. The communication is carried out either with ordinary instruments or with loud-speaking instruments.

Under Cabin I there are 6 ordinary instruments at different places, two being at the incoming signals, and in addition 3 telephones connected to loud-speakers in the signal cabin. Under Cabin V there are 2 ordinary instruments at incoming signals, 3 at the platforms and 8 instruments at other spots connected to loud-speakers in the cabin. Under Cabin VI are 6 outside telephones.

As Aarhus H during the reconstruction period has for a part of a year been worked with purely provisional safety arrangements at Mølleengen — substantially the area under the present Cabin I — and for the areas now under Cabins V and VI without any safety arrangements, it is difficult to arrive at any estimate of the saving in staff due to the new installation, as there is no basis of comparison. It can however be stated that for safety and shunting service there are now employed 12 fewer men at Aarhus H than formerly. The new installation has thus, in addition to providing greater rapidity and safety in handling the trains at Aarhus H, also caused an economy of 12 men in comparison with formerly. A further saving of 1 or 2 men may be expected with some slight modifications in the plant.