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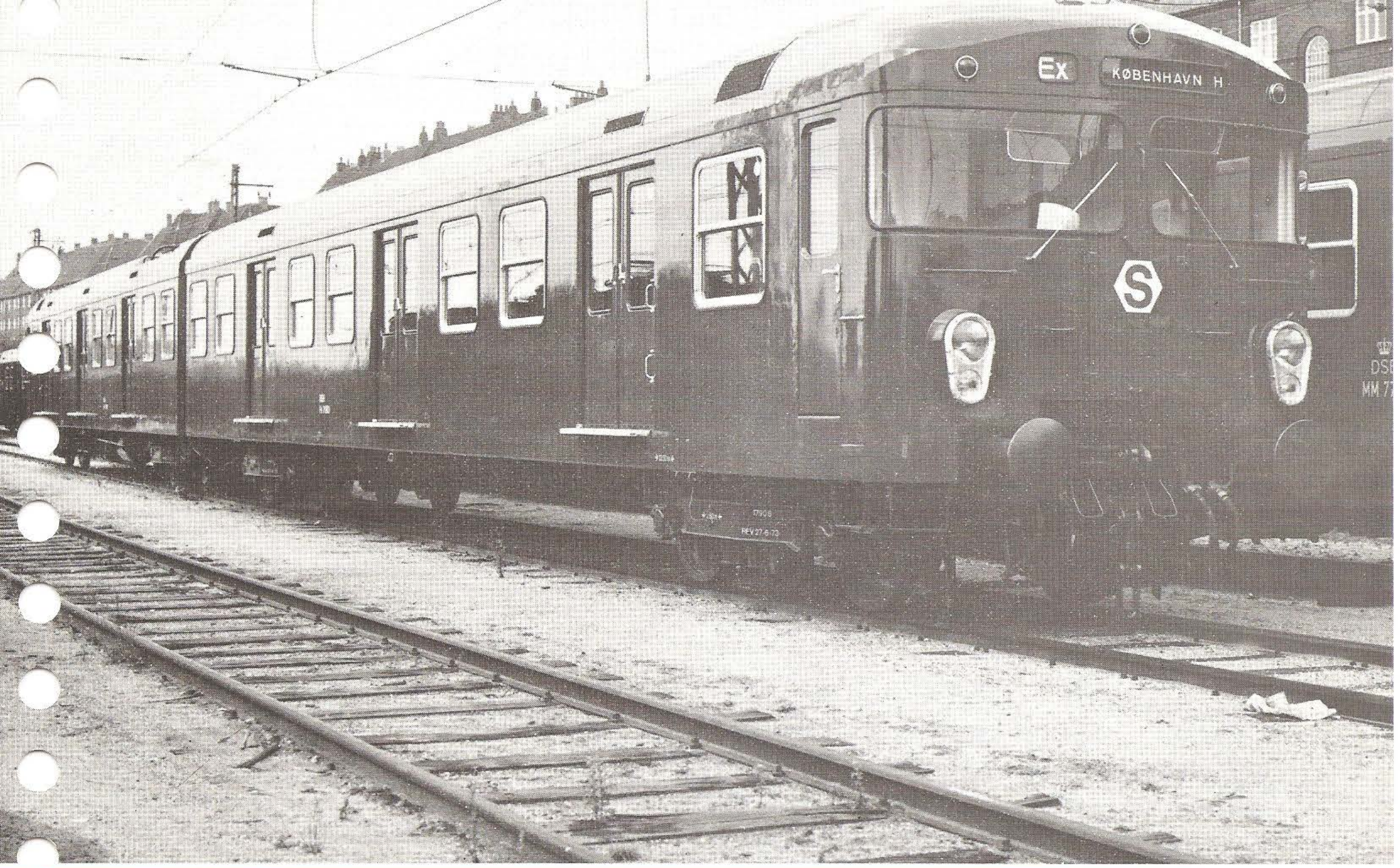
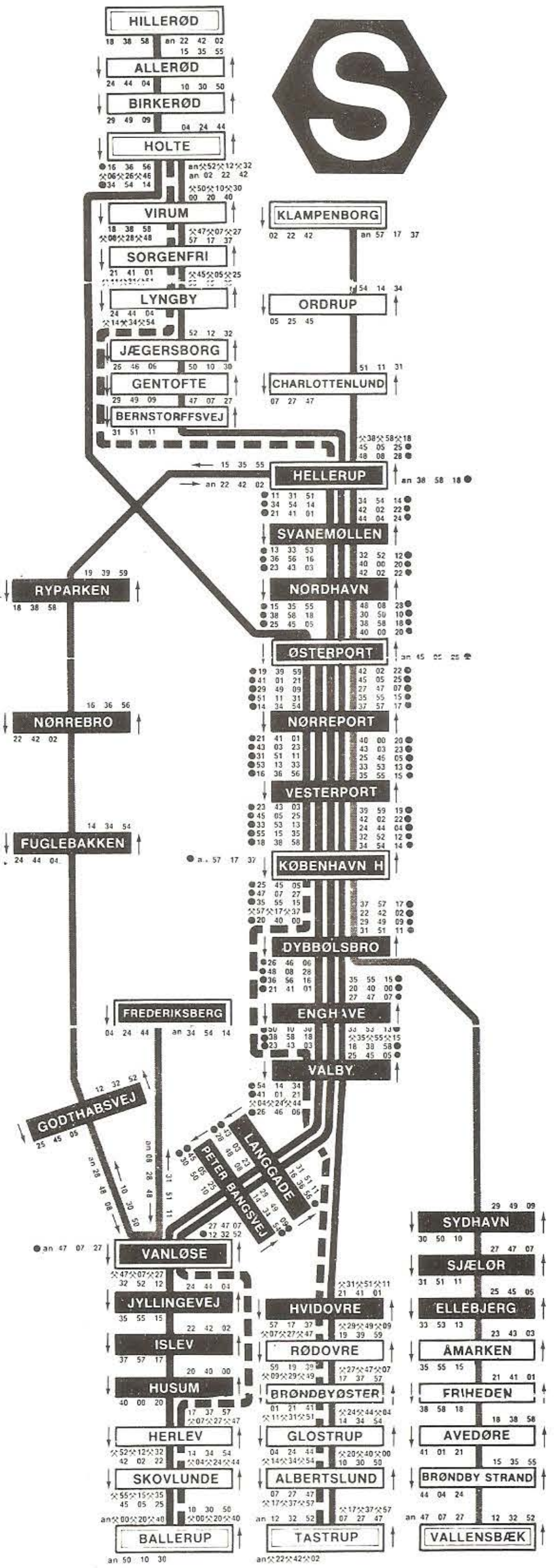


EQUIPMENTS for COPENHAGEN S TRAINS

GEC Traction Limited

ENGLISH ELECTRIC | AEI

Length of 2 car set	40.54m
Overall Height	3.865m
Width	3.024m
Weight tare	70 tonne
Normal laden	90.3 tonne with 290 passengers
Crush laden	100.7 tonne with 438 passengers
Access 3 double doors per coach side, each opening to	2.22m
Nominal voltage	1650v dc
Maximum speed	100 km/h



Part of the pocket time table issued free to Copenhagen Commuters. Each line has its own colour so that travellers can easily identify their own train.

Copenhagen prepares for more commuters

STEADY EXPANSION of Copenhagen's suburbs has made it essential to increase both the extent and the frequency of 'S-trains' operated by the Danish State Railways (DSB). The most ambitious project is the new line along the coast to the south-west, of which the first 14 km to Vallensbaek were opened on September 30, 1972; ultimately this service will rejoin the main line to the south at Koge.

Future plans envisaged by the DSB include the extension of the Koge Bugt line from Hundie to Solrod (the Vallensbaek–Hundie section is due for completion in 1976), the extension of the suburban line from Tastrup to Roskilde, further extension of the Koge line from Solrod to Koge, and the electrification from Ballerup to Frederikssund. When all these works are completed, the S-trains will serve a total of 158 route-km electrified at 1 500 V dc compared with 96 route-km at present.

Clearly, expansion of the suburban network will require more staff and more trains, as well as throwing a greater strain on the already well-loaded tracks through Copenhagen.

To improve performance and thus line capacity through the central area, DSB is to try out a multiple-unit train on which all axles are motored. The present services are operated by some 250 two-car sets with 50 per cent motored axles supplied by Frichs and Scandia with electrical equipment by GEC Traction and its predecessor, English Electric, since 1933. At the same time, a number of other innovations are being tried for which equipment design has also been entrusted to GEC. These include conversion of the second-generation S-train prototype set produced in 1963 to electronic logic control, and provision for operation of trains by one man only.

Electronic logic is not being pursued at the present time because the camshaft control gear proved very economical to maintain and is lower in first cost, but trials with one-man operation have been completed and equipment for converting the fleet is now being delivered.

Current designs

All S-trains are currently made up of two-car units comprising a driving motor coach and a driving trailer. Up to four units may be coupled, eight coaches being the limit set by the station platforms. This arrangement gives considerable flexibility, although DSB is investigating whether four-car units might not be a more economical proposition, since elimination of half the driving cabs would allow passenger capacity to be increased.

Nominal line voltage is actually 1 650 V dc, and the emphasis in the equipment design has been on simplicity, robustness and minimum maintenance.

The power circuit on the most recent stock is of bridge transition type with the traction motors arranged in permanent-series pairs. The camshaft is driven by an air/oil vane type motor, and it has an integral current limit relay which is arranged to allow different current settings to be used for series and parallel connections.

Main power contacts are arranged

RIGHT: *Driver's desk in the cab of a DSB S-Train; pushbuttons beside the door on each side permit the train to be started while the driver is looking back along the platform, thus eliminating the need for a second crew member on the train*

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in two banks, each pair of contacts being cam-opened and spring-closed by profiles on the same cam. There are 18 power contacts, 12 of which progressively short out the resistance, the other six being arranged to tap the motor field-weakening in two stages for each pair of motors.

From standstill, the camshaft notches up the resistor with the motor pairs connected in series in eight steps until full series is reached. Intermediate weak field is then brought in, after which transition to parallel full field takes place with part of the resistor reinserted into the circuit. The camshaft then notches back down the resistor in five steps until full parallel is reached. Two further notches are provided by the intermediate and weak field tapping contacts.

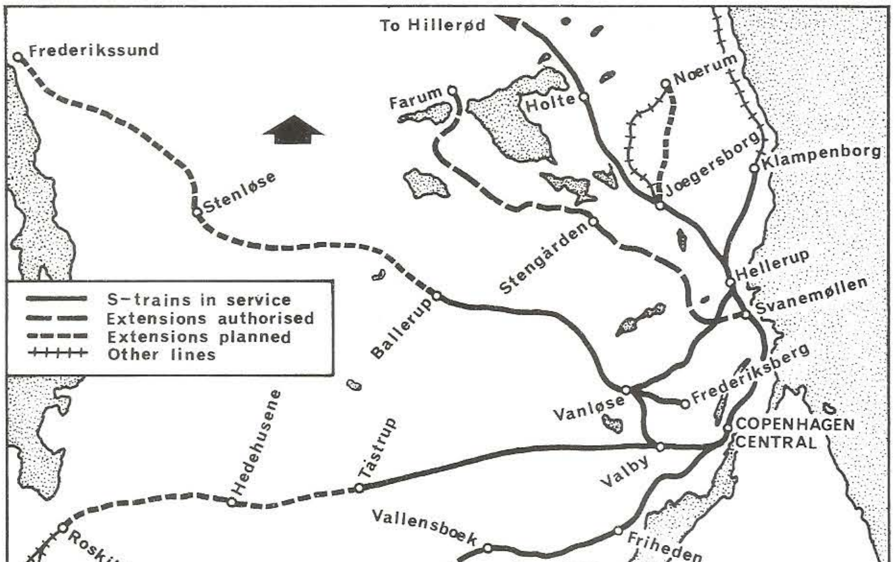
Notching back of the camshaft is not used before shut-off, and this feature allows a simpler notching sequence and simpler power contact design since the camshaft contacts are never called upon to break current. Power shut-off and fault clearance is carried out entirely by a group of three line breaking contactors; the first one of these to operate has a damping resistor across its contacts, and the other two complete the isolation of the equipment from the line.

The EE539 traction motors are rated at 140 kW self-ventilated. They are four-pole wavewound machines, nose-suspended on plain bearings. Originally, they were designed to run totally enclosed in winter to avoid problems of snow ingress and to run self ventilated in the summer. However, service experience has shown that with the schedules in use the motors can be enclosed permanently, thus avoiding ducting between motors and coach bodies, or the risk of debris entering the motors if ducts or filters were not used.

All axles motored

Improvement in station-to-station times has been the subject of intensive investigation by the DSB because, as already mentioned, all trains to and from the various suburban lines must pass through the six stations situated in the centre of Copenhagen, and these central stations are in danger of becoming a bottleneck.

This has led to the design and manu-



LEFT: *Considerable expansion of the S-Train network into and beyond the outskirts of Copenhagen is planned by DSB* facture of a prototype single control equipment to power all eight axles on a two-car unit, using the same EE539 traction motors. Design emphasis once again is on simplicity and ease of maintenance, but a further constraint is that the minimum of new components are to be incorporated in the design. This is to minimise disruption to stores and maintenance procedures.

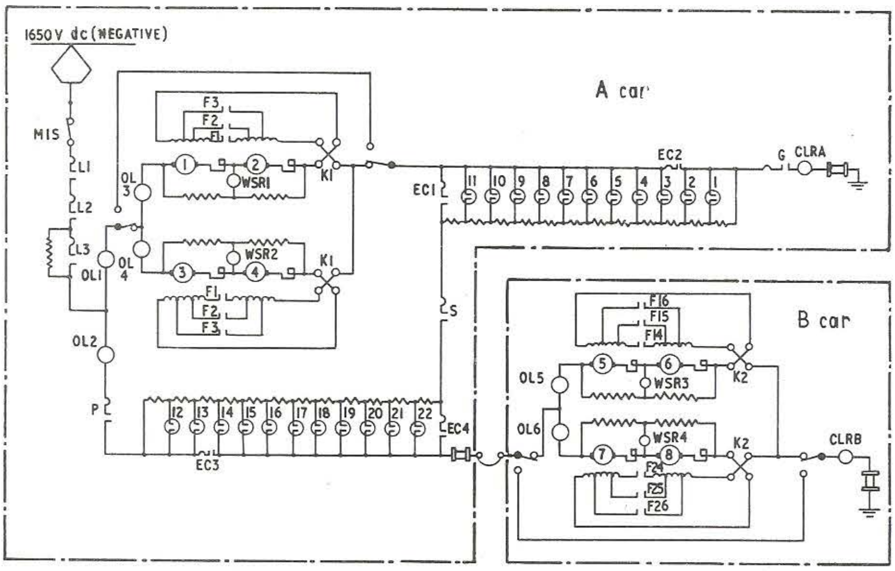
In point of fact, the opportunity is being taken to introduce a new camshaft which will provide more than twice the number of notching steps possible with the present camshaft, thus further reducing peak notching currents. With the exception of the new camshaft, the traction motor field tap contactors and the reversers, no new components will be used.

As can be seen from the power diagram (Fig. 1), the single camshaft controls the voltage applied to all eight traction motors which are arranged in two groups. One group comprises the four motors on what was the motor coach (car A), the other being the four new motors on what was the driving trailer (car B). Acceleration from rest follows broadly the same sequence as before, except that 17 resistance notches are now available and field tapping is carried out by separate contactors instead of camshaft contacts in order to avoid a multiplicity of inter-coach connections.

The scheme is also arranged so that an all-axles motored unit can run coupled to an existing half-axles motored unit, giving a 75 per cent motored axles combination. Thus an eight-car formation could consist of any combination with 50 to 100 per cent motored axles.

A further benefit is that the existing trailer coaches can be retained in standard train make-ups, thus avoiding premature coaching stock redundancy caused by the existing units being unable to maintain the same performance as the all-axles motored units. This could allow a gradual improvement in station-to-station times if all-axles motored units are introduced progressively.

BELOW: *Fig. 1. Single-camshaft control of eight motors on the prototype set equipped by GEC Traction to run with all axles motored*



One man operation

DSB's attitude to ATO is that if a man is necessary on a train he may as well drive it rather than do nothing in between starts from stations. This philosophy also removes the need for precision station stops, always a problem with completely automatic driving. The DSB's one-man operation is thus a combination of in-cab signalling and a supervisory scheme rather than automatic driving. A track-to-train communication system causes the speedometer to present information to the driver concerning permitted speed as well as actual. The instrument consists of a conventional speed indicator with small windows situated around the scale at intervals of 10 km/h from zero to maximum speed. Illumination of one of these windows indicates the maximum speed at which the train should be travelling, and a change in speed requirement is also indicated by an audible warning. Should the driver fail to initiate a brake application when a speed reduction or stop is called for, the train is automatically brought to a halt.

As the driver must now operate the doors at stations, it is necessary to ensure that he can look back down the platform which can be on either side of the train to check that passengers are clear. A set of pushbuttons is provided on either side of the cab to allow him to control the train to a certain extent while he is performing this function.

Each set of pushbuttons comprises a red button, a green button, a button which operates the train whistle and an emergency door release button. The operating procedure is that the driver stops the train in the station in the normal manner, which on the S-trains means that he will have pressed the door-release button on the platform side of the train. This allows passengers to open individual doors by operating the handles provided on each door, once the train speed has dropped below 12 km/h. Movement of the door handle operates a microswitch which in turn causes the pneumatic door engine to operate.

Starting sequence

Having stopped the train, the driver presses the red button which causes the on-train signalling/supervisory system to apply the air brakes, thus allowing the driver to release his electro-pneumatic brake and leave his normal driving position. When he is satisfied that the train is ready to depart, he presses and holds the green button. This causes whistles to blow for 3 sec, after which the doors close and brake release is initiated. Failure of any door to close is indicated by a lamp, and a longer time delay is introduced in the starting sequence so that the driver has time to take the appropriate action, although he still has the option of starting the train. Assuming that no untoward incidents occur, the train will start after a short delay provided brake release has occurred.

While the driver continues to hold the green button, acceleration takes place under control of the current limit relay as if the driver had selected series on his master controller. He can, however, stop the train at any time by pressing the red button, which re-applies the air brakes via the signalling/supervisory system and shuts off power.

However, assuming that everything is still functioning normally, the driver can release the green button and return to his driving position to use the master controller and brake controller in the normal manner. He must do this within a short time of releasing the green button; otherwise a deadman's brake application will be initiated. The sequencing and timing relays which control this operation are mounted on a small panel located under the driver's desk.

I would like to thank the DSB for assistance is preparing this article. ■

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