Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Tuesday, November 5th, 1963

The President (Mr. J. S. S. DAVIS) in the chair

The minutes of the Technical Meeting held on October 8th, 1963 were read and approved.

The President introduced and welcomed to the meeting Mr. R. W. Penny (Student) and Mr. S. D. Smith (Technician Member) who were present for the first time since their election to membership.

The President referred to a decision of the Council to present a medallion to Past Presidents of the Institution who were still in membership as a token of thanks for their past services to the Institution. It was stated that these medallions, which were in the form of a replica of the Crest of the Institution, had been presented at the Annual Dinner and Dance to those Past Presidents who were present and the remainder had been sent by post. The President stated that any member wishing to see one of the medallions could do so by approaching the Hon. General Secretary after the meeting.

The President then requested Mr. H. A. E. de Vos tot Nederveen Cappel of the Netherlands Railways to read his paper entitled "The Latest Signalling Developments and the Modernisation of the Signalling on the Netherlands Railways".

The Latest Signalling Developments and the Modernisation of Signalling on the Netherlands Railways

By H. A. E. de VOS tot NEDERVEEN CAPPEL (Member)*

1. INTRODUCTION

For a proper understanding of signalling on the Netherlands Railways I think it desirable to tell you first something about its network.

In our watery and flat country the railways never held a monopoly in transport. The share of the railways in the entire freight transport in 1961 was 18.1 per cent, that of road transport 40.3 per cent. and that of inland navigation 41.6 per cent To operate the network in the most efficient way the Government consented to the closing down of various unremunerative lines and to discontinuing passenger transport on other lines.

The length of the network, amounting to 3 705 km in 1929, was consequently curtailed to 3 250 km, 765 km of which were used only for running freight trains at a maximum speed of 30 km/hr.

Of the remaining 2 485 km for passenger transport, 65 per cent has been electrified at 1 500 volts direct current.

The replacement of the entire steam locomotive fleet by electric and diesel-electric locomotives and multiple-unit train sets was a considerable contribution towards efficiency.

In the Netherlands the era of steam

* *Chief Signal and Telecommunications Engineer, Netherlands Railways*

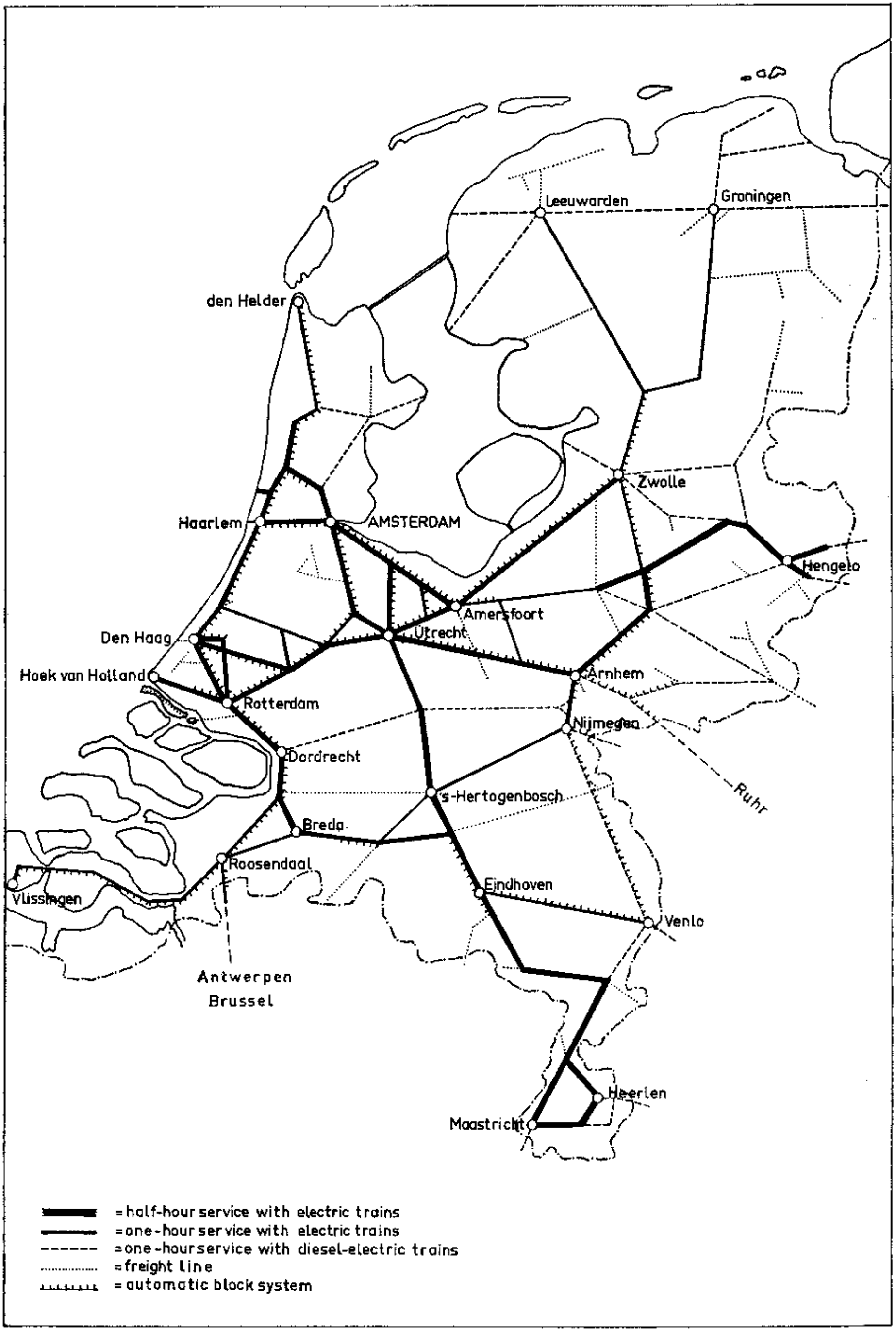

Fig. 1 Network of the Netherlands Railways

traction came to an end in 1957 and on January 7th, 1958 the last steam engine made its final run to the railway museum in Utrecht. Consequently on the non-electrified lines diesel-electric trains are running exclusively. Their maximum speed is 125 km/hr.

In 1961 the volume of passenger transport was 7.99 milliard passenger-km and of freight transport 3.39 milliard ton-km, viz. 2.16 milliard ton-km in inland traffic and 1.22 milliard ton-km in traffic to and from abroad.

The passenger train services run at very regular intervals. On sections with heavy traffic a half-hourly service is run and on sections with light traffic an hourly service (Fig. 1). Passenger trains to Belgium and Germany are run with the same clock-like regularity; besides T.E.E.-trains and other international trains an hourly service with Antwerp and a two-hourly service with the Ruhr district is run.

The number of Netherlands Railways employees amounts to approximately 30 000 against 43 700 in 1953.

2. SIGNALLING—GENERAL

There is a large difference between safeguarding a network on which freight trains only will run and a network on which passenger trains will run as well. The protection of the lines on which exclusively freight trains run at a maximum speed of 30 km/hr. is very simple. The number of trains on these lines is very small, at the most a few trains a day. There is no block system and the protection only consists of key locks on manually operated points and home signals for movable bridges and some large yards. The public telephone service is used as the only means of telecommunication.

913 km of the passenger service network are equipped with automatic block installations having colour-light signals, while the remainder is equipped with the Siemens-type manually operated block installations.

Not until after World War II were colour-light signals installed on a larger scale.

3. COLOUR-LIGHT SIGNAL ASPECTS 1947-1955

In 1952, my predecessor Mr. Verstegen read a paper on the signalling of the Netherlands Railways at that time. For the sake of brevity I would like to refer to

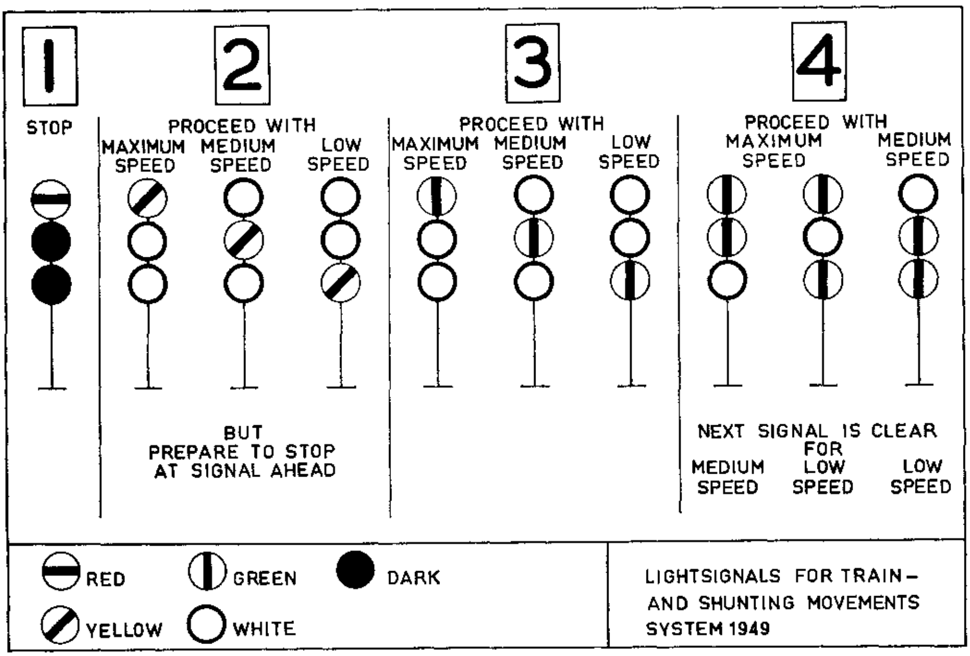

Fig. 2.

pages 149/170 of the Proceedings for that year and to Fig. 2.

(1) I would ask you to give your special attention to the two different ways in which an order for slowing down was given in those days:
An order to slow down to a stop was indicated by an yellow aspect, but an order to slow down to a lower speed by a double green aspect. The top green light meant "high speed allowed here" and the bottom green light "slow down because the next signal will be clear for a lower speed only".

When discussing the signalling system in use in 1955, I shall return to this matter.

(2) At the end of 1952, 250 km of double track were equipped with automatic block installations.

4. SIGNALLING SYSTEM IN 1955

In December 1952 Dr. F. Q. den Hollander, at that time President of Netherlands Railways, requested me to draw up a plan in order to equip as soon as possible the entire electrified network with automatic block installations having colour-light signals.

As we now had to elaborate a large plan it was desirable to give all our attention to making the right choice as to the type of signalling system to be introduced.

We realised that if millions of guilders should be invested in a modern signalling system it would not be possible to modify it in the next ten years. Therefore a committee of signalling engineers was set up in order to study all the facets of modernising signalling. One of the most important elements was the study of the signalling system itself, viz. whether the system in use should be maintained or whether there were grounds for modifying it.

If ever a suitable opportunity to modify the system had presented itself this was the right moment. So far as the signalling system in use was concerned some objections had already emerged from practice, e.g.:

(1) The order to the engine driver to slow down to a lower speed was indicated by a colour-light signal consisting of a top green light, a centre white light and a bottom green light. It appeared, however, that this signal did not impress the engine driver sufficiently. In his subconscious mind the engine driver attached to this signal the significance of a green light aspect, i.e. a safety aspect and consequently permission to travel at full speed. In some cases like this accidents occurred, because the engine driver wrongly travelled too fast.

(2) The circuits in this type of signal system were very complicated and were thus unnecessarily expensive.

(3) When this signal was introduced we had the impression that three speed levels would suffice. Practice proved, however, more and more, that a larger number of speed levels were necessary on account of the greater variety of points.

When discussing the requirements a modern signalling system should meet, I would make the following comments:

4.1. *Meaning of signals*

We may say that signals should in the first place refer to the permissible speed. In a signalling system the following three aspects are of primary importance:

(*a*) an order to stop

(*b*) an order to slow down

(*c*) an order to run at a certain speed

The order "slow down" and the order "travel at a certain speed" require a number of signal aspects which number is determined by the number of speed levels which must be indicated.

4.2. *Speed levels*

On Netherlands Railways network the following speeds are permissible with relation to points and curves: 30, 40, 60, 70, 80, 90 km/hr etc. When introducing the signals with the top, centre and bottom lights we had hoped that speed levels of 40, 90 and 120 km/hr would suffice. It appeared, however, that in particular we could not do without the speed levels of 30 and 60 km/hr. If we now could use figures to indicate the speed a smoother adaptation to the layout of points was possible. Besides, it is sometimes necessary to restrict the speed on account of the braking distance available In this connection two possibilities present themselves:

(*a*) the braking distance is so short that it is necessary to travel at a sight (e.g. because the arrival track is occupied) restricted speed that means proceed prepared to stop short of any train or other obstruction.

(*b*) the braking distance available is but a part (e.g. 2/3) of the normal braking distance. This case presents itself when on account of the frequency of the trains it is necessary to make the length of the blocks shorter than the braking distance; this often occurs in yards, where the locations of signals depends on local conditions. If for both cases signals are introduced it is not possible to assign a certain speed to these signals on account of the braking distance. So on the other hand, a speed indication is considered to be a better aid than a braking distance indication. In order to overcome this objection as much as possible, besides the above speed levels yet another two speed aspects may be introduced, which are not determined by the layout of the points but by the braking distance, viz.:

a. "restricted speed" which means "travel at sight at a maximum speed of up to 30 km/hr". In practically all countries this speed is permissible for travelling at restricted speed.

b. "slow down to half the schedule speed".

4.3. *Colour-light signal aspects*

We get a simple signalling system when assigning to the colours green, yellow and red the following significance:

green: travel at permissible speed

yellow: slow down

red: stop

If we indicate the permissible travelling speed by means of figures, it is the most simple system we can think of, as the train driver need not remember anything. Diagram figure 3 will give you an idea of the new signalling system.

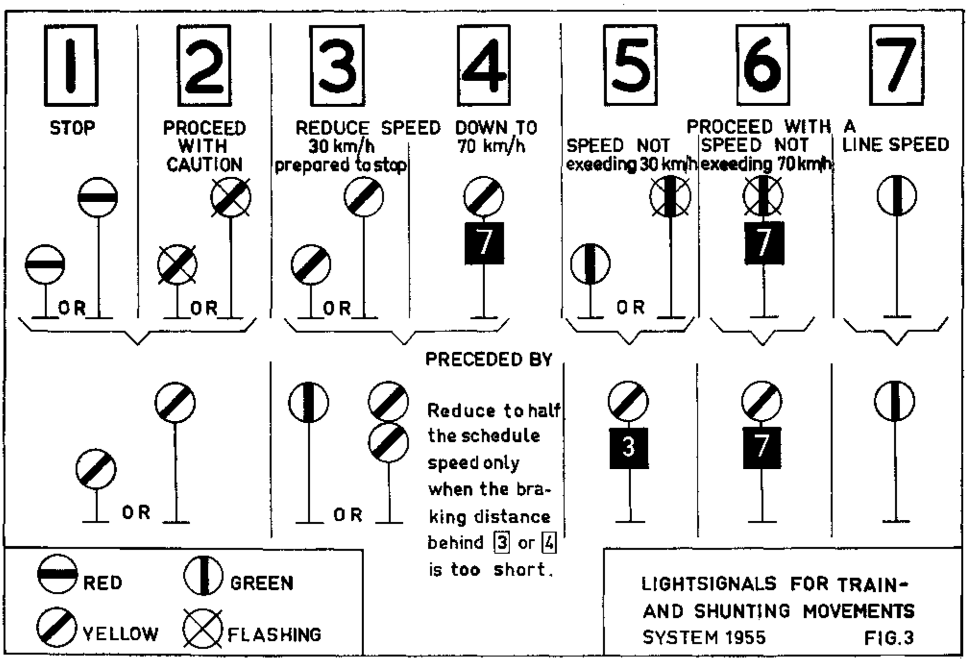

Fig. 3.

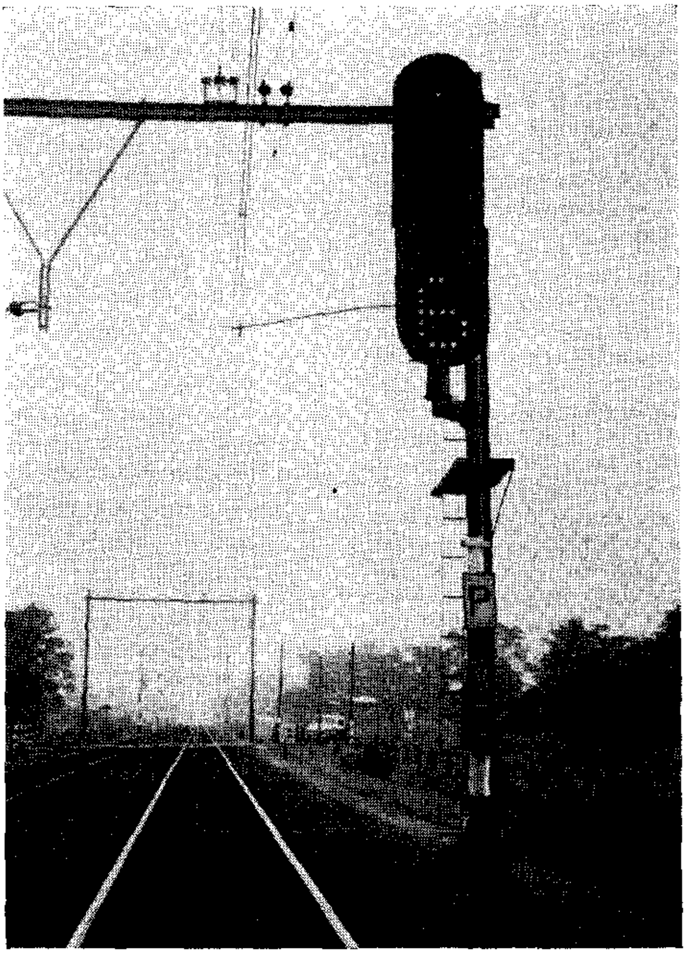

Fig. 4 Colour-light signal with speed indication 60 km/hr.

The advantages of this system (Fig. 4) are as follows:

(*a*) speed levels may be smoothly adapted
(*b*) installing cab signals at a future time does not offer any difficulty
(*c*) speed reduction is always indicated by means of a yellow light
(*d*) circuits are not complicated
(*e*) there is no confusion with this former signalling system so that both systems may be applied at the same time.

5. INTRODUCTION OF THE MODERNISATION PLAN 1955

The modernisation plan comprises the following components:

1. automatic block system on the free track
2. relay interlocking at the stations: at large stations, the NX-type at small stations, formerly the AR type, at present C.T.C.
3. automatic protection of level crossings (automatic flashing lights with or without automatic half-barriers)
4. centralised remote control of substations and of catenary switches (resulting from 1, 2 and 3).

5.1. *Automatic block system on the free track*

Before this modernisation plan was

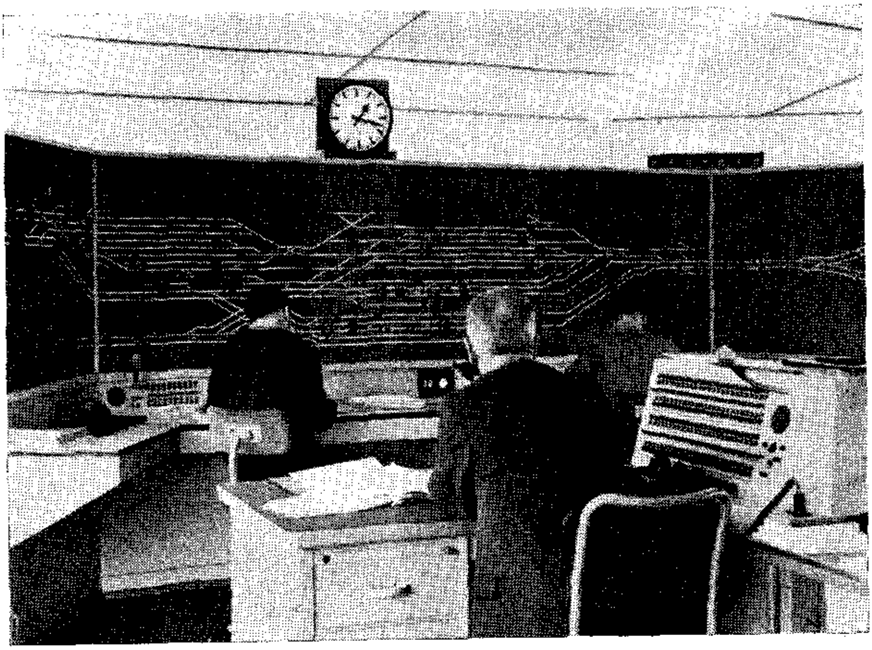

Fig. 5 NX control panel station Amersfoort

taken in hand the automatic block system had only been introduced on some sections, the stations retaining their mechanical interlocking. Where necessary, the mechanical interlocking had been adapted to the automatic block system. Also some of the larger stations were equipped with the GRS N.X.-type of relay interlocking.

Now that we had taken in hand one large modernisation plan it became necessary to reconsider the lay-out of the track, yards and level crossings. For this purpose working parties, consisting of traffic engineers, operating engineers and permanent way engineers, regularly met under the chairmanship of a signalling engineer.

Starting from the future passenger and freight train services it was determined which sidings, points etc. would still be necessary and which could be taken up. Level crossings were examined and if necessary equipped with an automatic protection installation. The underlying principle was that the booking clerks should no longer be made responsible for attending to safety devices and level crossings, but that it should be seen to that a minimum number of staff would be required for the operation of the safety devices.

5.2.1. *Relay interlockings at the stations*

Large stations were equipped with the NX (GRS) type interlocking (Fig. 5) and small stations with the AR-type of relay interlocking. The difference between the NX-type and the AR-type of relay interlocking (Fig. 6) is that in the latter the points are separately worked by means of switches on the panel. After the points have been put into the right position by means of these switches, a route is set up by simultaneously pressing the entrance and exit buttons. In the same way as with the NX-type modernisation this change resulted in a considerable economy in the number of staff. The closing down of signal boxes and level crossing posts had another effect as well, for from these posts the switches of the catenary were operated. This became no longer possible on account of the closing down of these posts and therefore we had to change over to remote control of the catenary switches also.

5.2.2. *C.T.C.*

5.2.2.1. *General*

The first C.T.C. installation in the

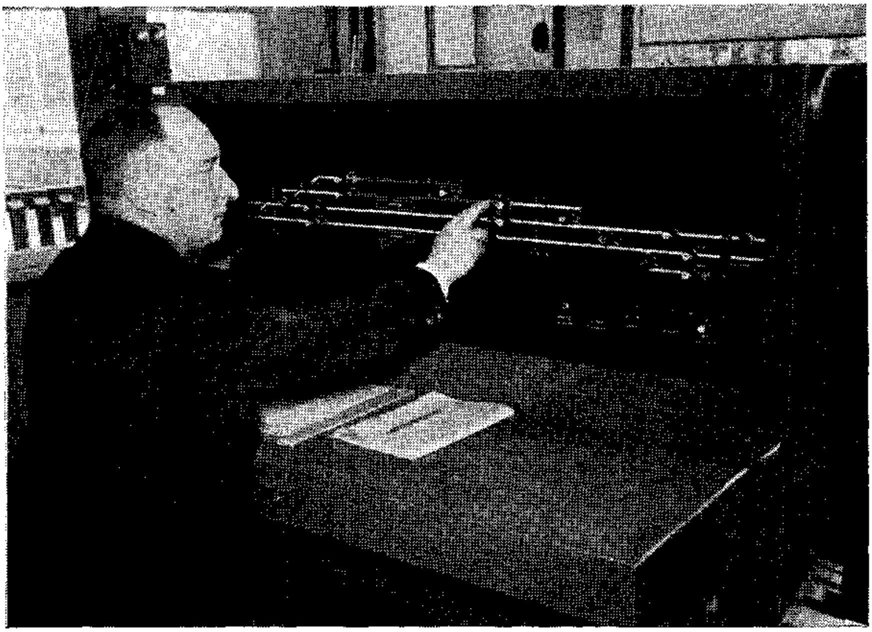

Fig. 6 AR control panel station Oudenbosch

Netherlands was put into service in 1960 on the Nijmegen-Blerick line.

The control office is located at Nijmegen and controls a 60 km long line consisting of 50 km of single track and 10 km of double track; there are eight stations, four of them having passenger facilities.

Traffic on this single track was so heavy that a second track was considered necessary. The introduction of C.T.C. and the reconstruction of the sidings, however, meant that the question of a second track could be left in abeyance. The experience gained by this first installation surpassed all expectations and the installation of C.T.C. continues to increase traffic capacity and save manpower.

The second C.T.C. installation was put into service in 1962 on the Utrecht-Amersfoort line. The control machine of this installation is located temporarily at Blauwkapel junction but it will be relocated in Utrecht when the mechanical interlocking of the latter station is replaced by an NX interlocking. There are four stations, three of which have passenger facilities, the other one being a junction Indications of train information are received from the Utrecht-Amersfoort line 20 km long, the Blauwkapel-Hilversum line 13 km long and the single track line from Utrecht to Baarn 8 km long Here the double track is signalled for both directions and thus it is possible for a low speed train between stations to be overtaken by a high speed train without stopping by directing one of the trains so as to run over the left-hand track It is also now possible to block one of the tracks for maintenance purposes and to run the trains over the other track without taking any special measures although naturally this is only possible in periods when traffic is light

The Schiedam-Hook of Holland line (26 km double track, 3 stations) is under construction and will be controlled from Rotterdam; the Utrecht–'s Hertogenbosch line (48 km double track, 4 stations) is also under construction and will be controlled from Utrecht. The Tilburg-Roermond line (82 km double track, 8 stations) is planned for C.T.C. operation and will be controlled from Eindhoven.

5.2.2.2. *The C.T.C. system*

The principle of the C.T.C. system is

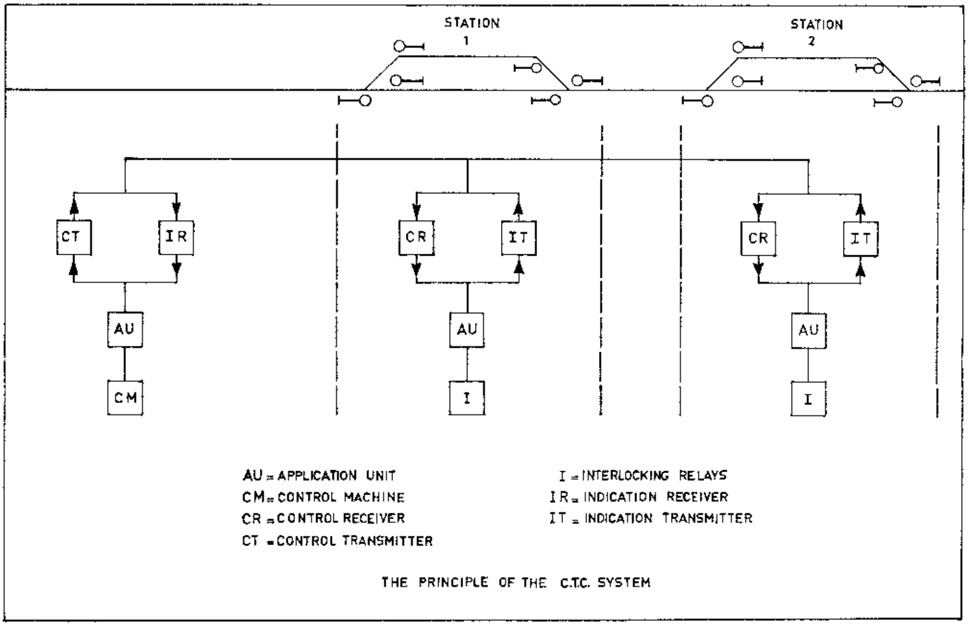

Fig. 7.

shown in fig. 7 and its characteristic features are as follows:

Both controls and indications are sent over a two-wire line. This system has been developed and patented by the General Railway Signal Company and bears the name of "Quiktrol"; it is made up of a control part and an indication part. The control equipment consists of a transmitter in the C.T.C. office and a receiver at each station. The number of functions that may be controlled in a group at a station depends upon the number of code steps used for station selection. Normally a capacity up to 16 stations, each of them having four groups of seven two-position controls, is used. If necessary double-cycle control codes may be used, making 11 additional controls available at any desired group. Other groups may use either single or double cycles.

The indicating equipment consists of a receiver in the C.T.C. office and a transmitter at every station.

Basic capacity of the indication system is 15 stations; fifteen additional stations may be handled by adding an extension at the control office.

Indication capacity at a station depends upon the number of indication groups assigned to the station. Normally seven groups indicating 10 two-position functions each are used.

The system can operate on cable or on an open wire line. For longer distances repeaters may be used. If the line is occupied when a control or indication cycle is to be sent, the control or indication waiting is stored until the line becomes free.

The control and indication systems are completely indepenent in operation, so that controls may be transmitted and indications received at the same time. A control cycle that contains all necessary controls for setting up a route is transmitted in 1.5 seconds. An indication cycle that contains normally 10 indications is transmitted also in 1.5 seconds. The control office indication receiver can handle one indication cycle from each station simultaneously. A typical section of a C.T.C. control machine panel is shown in Fig. 8.

To keep the C.T.C. panel as simple as possible only the most important indications are displayed on it. The track between the two stations is divided into three sections, the outer sections of which represent the block either side of the station with the middle section repre-

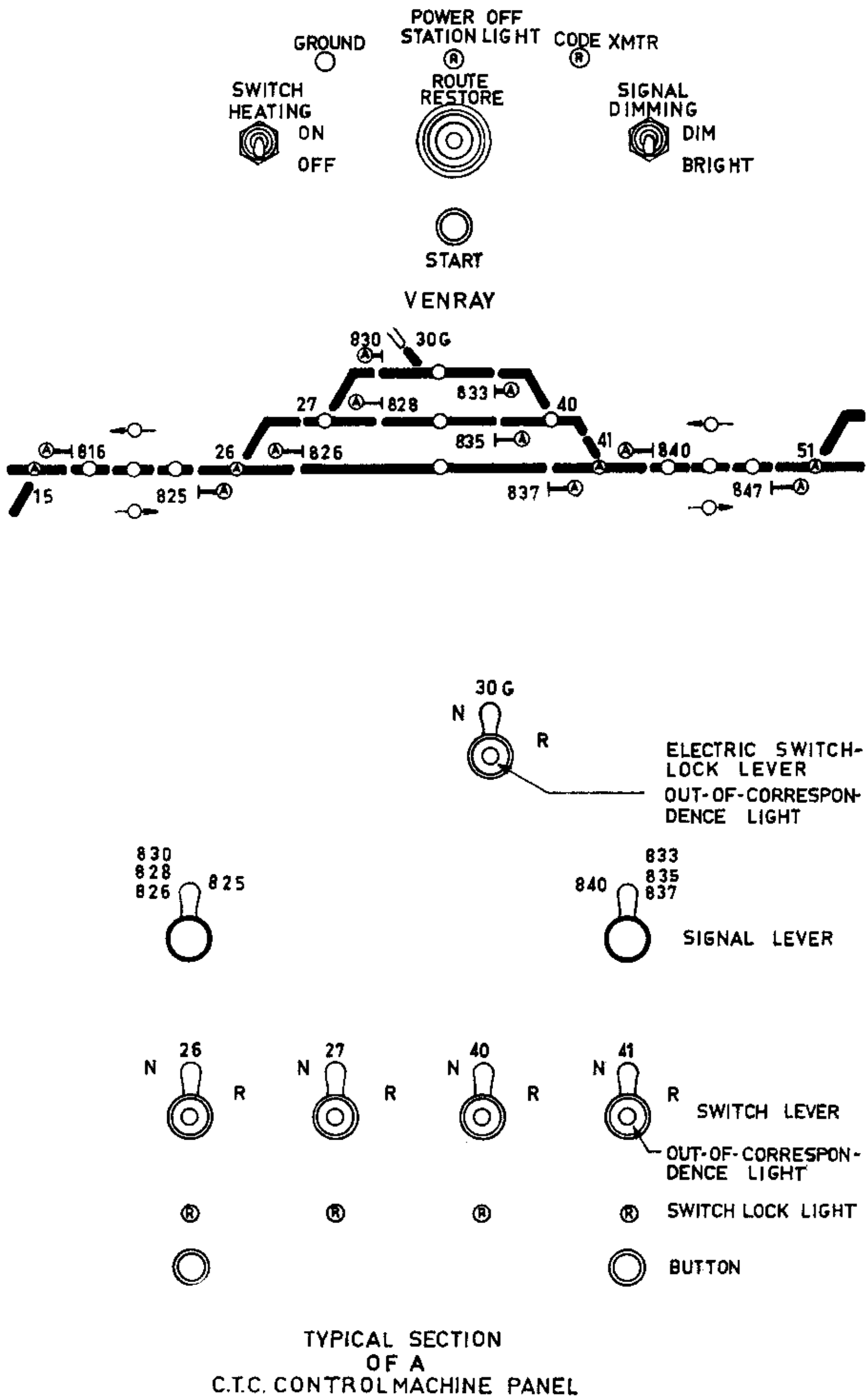
POWER OFF
STATION LIGHT
GROUND
CODE XMTR
SWITCH HEATING
ON
OFF
ROUTE RESTORE
SIGNAL DIMMING
DIM
BRIGHT
START
VENRAY
830
30G
27
828
833
40
835
41
840
816
26
826
51
15
825
837
847
N
R
ELECTRIC SWITCH-LOCK LEVER
OUT-OF-CORRESPONDENCE LIGHT
830
828
826
825
840
833
835
837
SIGNAL LEVER
26
27
40
41
SWITCH LEVER
OUT-OF-CORRESPONDENCE LIGHT
SWITCH LOCK LIGHT
BUTTON
TYPICAL SECTION
OF A
C.T.C. CONTROLMACHINE PANEL

Fig. 8.

senting all other blocks. The lights with the arrow markers indicate in which direction a train is running. In a station the occupation of the signalled tracks is indicated as well as that of the approach sections. Occupied sections are indicated by yellow indication lights. Only the symbols of controlled signals, with "signal clear" indication lights, are engraved on the panel. Using the information provided by the indications the operator can effectively control the movements of trains through the use of the control levers on the panel.

The levers on the control panel are of two kinds, switch levers and signal levers. The switch levers are two-positioned and stand with the lever in the "N" position for switch "normal". A switch lever is set for switch "reverse" by turning the lever clockwise to the "R" position.

The signal levers are three-positioned and are positioned with the lever pointing vertically upwards for signals at "stop". A signal lever is set for "proceed" by turning the lever from its centre position into the direction required for setting up the desired route, i.e. it is moved to the "R" position for a movement to the right and to the "L" position for a movement to the left.

To send a control instruction the control levers are turned to the position desired as described above and the associated start button pressed. Beneath each signal lever a start button is located. Usually there are one or more switch levers and signal levers involved in setting up a route and all of these must be positioned as desired before pressing the start buttons under the levers concerned. This procedure eliminates unnecessary operation of the system. After a signal lever has been moved to call for a clear aspect and the start button has been pushed, the control is transmitted to the field location to move the appropriate points into the desired position and clear the wayside signal, providing conditions permit.

When the return indications arrive at the control office, the out-of-correspondence lights in the point levers, which have been moved to call for a new position of the points, become extinguished, the lock lights located below the point levers concerned will be illuminated to indicate that the points are not now free to be moved and the "signal clear" light will be illuminated. After a train has accepted the signal and has entered the detector track circuit its presence is indicated by the extinguishing of the "signal clear" light and the lighting-up of the "track occupied" light.

Both the control and indication systems use synchronous stepping units at the control office and in the field to generate code steps independently but simultaneously.

The control units at the office and in the field each include a synchronous mechanical oscillator, normally held locked still by steady d.c. on the line. When a control is transmitted, the line polarity is reversed, and all control oscillators begin to swing in unison. Each half-swing establishes a simultaneous code step in each control unit. The polarity of the line for specific steps, as established by the control office, constitutes a code.

Indication codes are transmitted over the same line wires as controls by means of multiple narrow band carriers. There is an indication unit at the control office and at each field location. Like the control unit, each of these has a synchronous mechanical oscillator, in this case used to generate the steps of an indication cycle.

A carrier transmitter at the control office transmits a synchronizing carrier at frequency f_s. Each field location has a carrier receiver responsive to this frequency, and while this frequency is on the line all indication oscillators are held in the locked position. In addition, each field location has a carrier transmitter operating at the frequency assigned to that location such as f_1. Receiver f_1 at the control office is tuned to frequency f_1. Other field locations have transmitters working at different frequencies received respectively by receiver f_2, receiver f_3, etc. at the control office. Thus each field location has its own separate full-time communication channel for transmitting indications to the control office. The relays used in the system are GRS type A plug-in relays. The C.T.C. system has proved to operate reliably and smoothly.

5.3.1. *Protection of level crossings*

5.3.1.1 *Automatic flashing lights:*

The number of unguarded level crossings on the Netherlands Railways network is very large. The amendment of the Railway

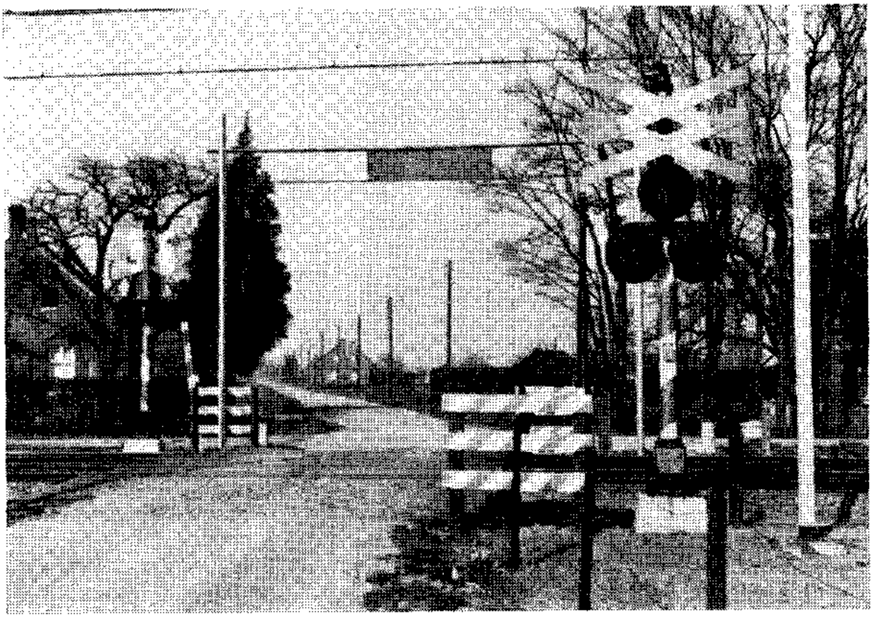

Fig. 9 Automatic flashing light

Act in 1922 offered the possibility of securing exemption from the obligation to install barriers along the main lines providing road traffic was not heavy and if the road offered a satisfactory view of the railway track. On account of this amendment the barriers at more than half of the number of level crossings were removed. After quite a number of accidents had occurred on these level crossings the necessity for finding a solution to the problem of providing a higher degree of safety on these level crossings became very important. Therefore in 1936 a trial was made with automatic flashing lights (Fig. 9). This trial turned out to be very successful, resulting in the Minister of Transport giving his approval to the installation of this type of protection on a larger scale. The working of automatic flashing lights is as follows:

When no train is approaching a green light is shown to road users, flashing at 45 flashes per minute. 25 seconds before a train will pass over the level crossing a red light, giving 90 flashes per minute, gives a "stop" indication to road traffic until the whole train has completely cleared the level crossing. During this procedure a warning bell will be ringing as well. Both lights are also fitted on the reverse side of the signal post. If the signal shows a yellow light, this means "signal out of order". In that case the public must use the crossing with caution, as the approach of a train will not be indicated by the usual red signal.

As the Government has consented to making the above level crossing unprotected, the Government pays for the installation of these automatic flashing lights.

According to Government Estimates 53 sets of automatic flashing lights will be installed this year. It is expected that in the next eight years all unprotected crossings on metalled roads will be furnished with automatic flashing lights.

5.3.1.2. *Automatic half-barriers*

In 1952 the first automatic half-barriers were installed (Fig. 10 and 11). As traffic in our country runs on the right-hand side, the right half of the road is closed by these barriers. The barriers are operated by the trains themselves and the sequence of operation is as follows:

(1) red lights begin to flash alternately and a warning bell starts ringing;

(2) after 5 seconds, the operation of

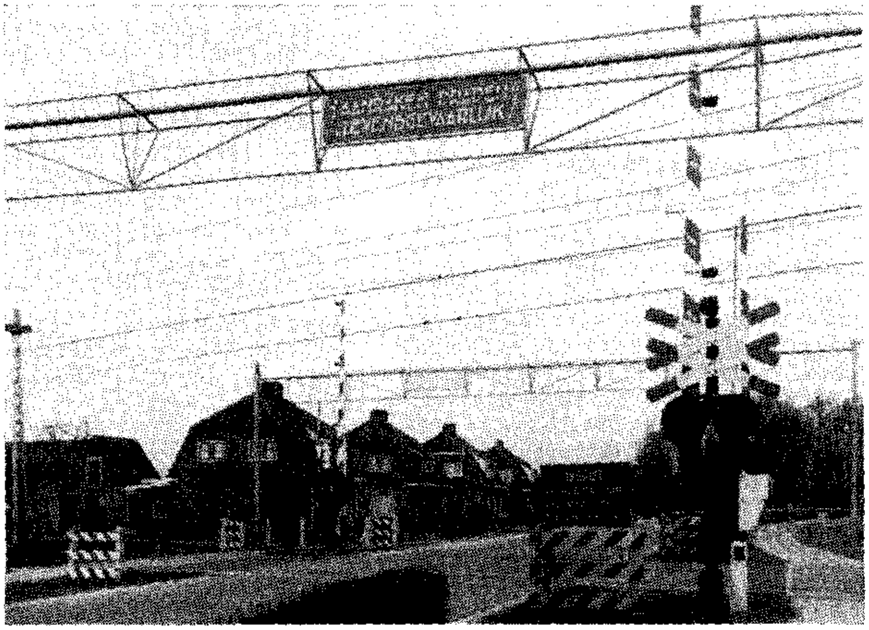

Fig. 10 Automatic half barrier (in open position)

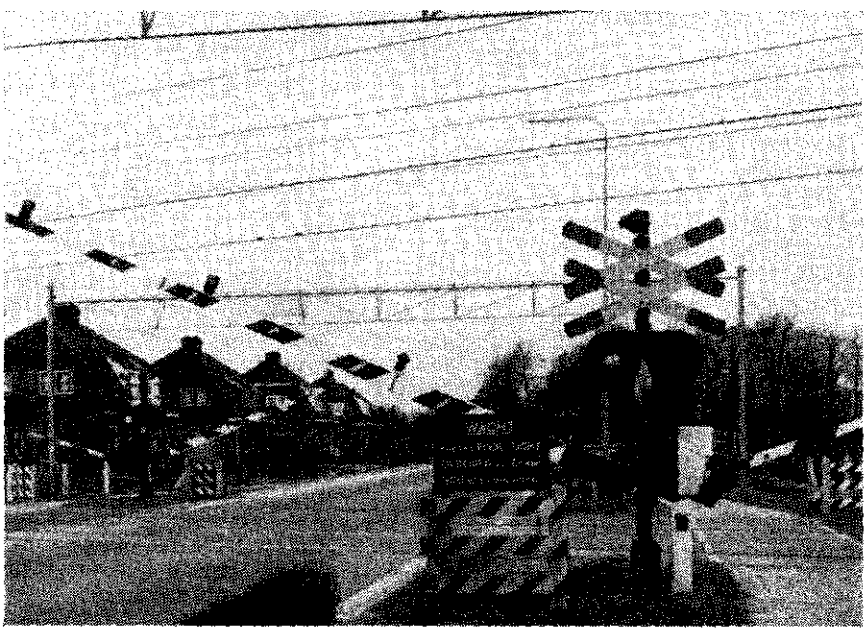

Fig. 11 Automatic half barrier (shown closing)

lowering the barriers starts and takes 12 seconds;

(3) when the barriers are lowered, the bell ceases ringing, but the red lights continue flashing;

(4) 10 seconds later the train passes the level crossing.

When the train has cleared the level crossing, the barriers are raised and the warning lights are extinguished. If another train approaches, the bells start ringing again and the barriers are lowered.

The application of automatic half-barriers was so successful that the Minister of Transport consented to the installation of automatic half-barriers on guarded level crossings as well. At the moment public opinion is so much in favour of this type of safeguarding that requests for installing these automatic half-barriers on a large scale are being made. As regards the installation work itself the only hindrance is the insufficiency of signal engineering staff and the impossibility of installing these automatic half-barriers in the neighbourhood of stations which have mechanical interlocking.

When running on the wrong track, the train is only allowed to pass level crossings at the rate of 5 km/hr if the latter have been equipped with automatic safety devices.

Now that a large number of automatic safety devices have been installed on level crossings, this has often resulted in heavy delays when running on the wrong track became necessary. In consequence level crossing safety devices have now been made suitable for traffic in both directions so that in the case of running on the wrong track the safety device is also operated as normally. As automatic half-barriers are considered to be the ideal solution to the level crossing problem on roads with heavy traffic, the safety devices have to be constantly be adapted to the local situation, e.g.

(1) In some cases the half-barriers must remain lowered if on account of the approach of another train they cannot be held in the raised position for at least 5 seconds.

(2) In the centres of towns safety devices are often coupled with road traffic lights so that a few seconds before a train brings the level crossing safety device into operation the traffic lights at the approaches to the level crossing change to show a red light.

(3) If there is a level crossing close to a station the signalman may press certain buttons which enable him to choose whether a slow train or a through train will pass the level crossing. The result is that in both cases the waiting time is the same.

(4) When there is much cyclist traffic, the half-barriers are equipped with small barriers at the rear end, closing the cycle track as well.

(5) In towns where the pedestrian-tracks are on the left hand side of the road, these are not closed by half-barriers but red flashing lights with warning bells have been installed. As opposed to the warning bells of the level crossing safety device these bells keep ringing until the train has passed the level crossing.

The number of level crossings on the N.S. network may be classified as follows:

(1)	lifting barriers operated at the site	390
(2)	lifting barriers operated at a distance	285
(3)	automatic half-barriers	212
(4)	automatic flashing lights	382
(5)	unprotected level crossings	1 728

5.3.2. *Indication of failures in automatic half-barrier and automatic flashing light installations*

At places where automatic safety devices are installed at level crossings, facilities for indicating failures to the nearest station are necessary in order to provide rapid information for the maintenance crew. (Diagram 12). In the case of half-barriers, an indication is given if the barriers remain closed for a time exceeding five minutes. When an automatic flashing light installation has continued to give a red aspect for fully five minutes it changes to a yellow aspect (meaning that the installation is out of order), and at the same time transmits an indication to the station. The same occurs immediately when the electric current through the red

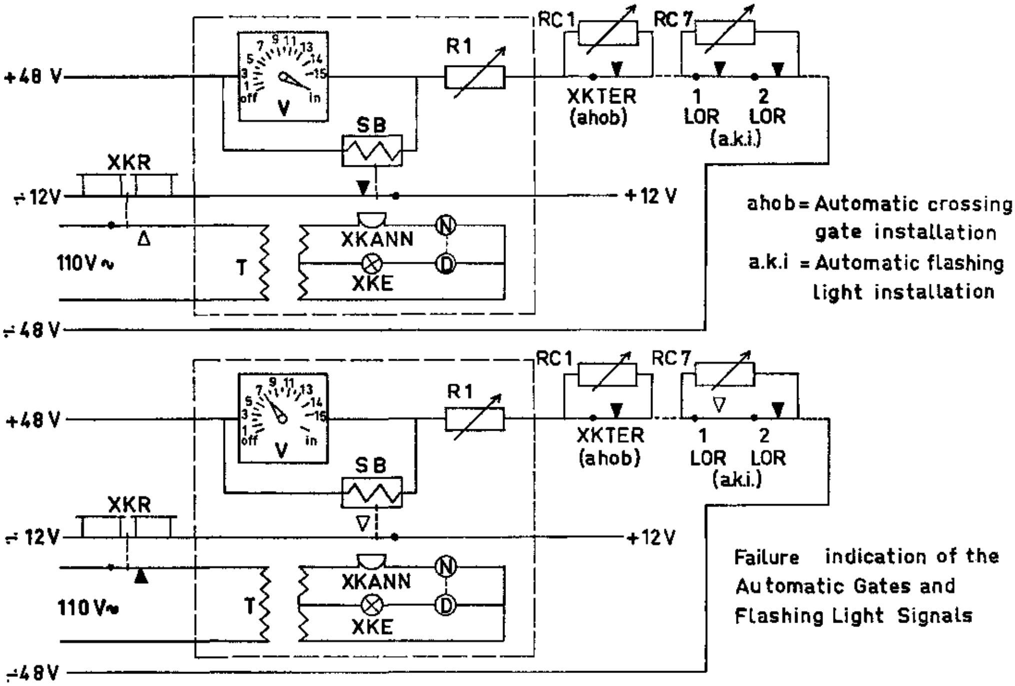

Fig. 12

lamp, being fed continuously, is interrupted by a failure in the circuit or simply by a breakdown of the lamp. In order to provide the above mentioned facilities on a section where a great number of level crossings are equipped with automatic installations, we tried to find a solution requiring a minimum number of line wires. A satisfactory method has been found by measuring the line resistance of one pair of wires along the section. Normally an 80 mA current is fed into the line; thus a voltmeter with a range of 10 volts, applied across a resistance in series with the line has in this case a full-scale deflection (the feed voltage being 48 volts d.c.).

As soon as an installation fails, a predetermined resistance, which is normally short-circuited by a contact of the guarding relay of the installation concerned, is inserted into the line. This causes a current fall in the line, resulting in a change of measured voltage across the series resistance. This change in voltage is different for each installation and in this way the crossing where something is out of order is indicated.

Where track circuits are in common use for more than one installation, a failed track affects all those crossings. In that case the time delay (normally 5 minutes) before the resistance is inserted into the line is different for each installation and in this way a distinctive indication is assured.

In addition to the indication on the voltmeter an audible warning is given to the signalman as soon as the line current decreases. It is possible to connect 15 crossings on one such installation using only 2 line wires.

5.4. *Remote Control of Power Distribution*

5.4.1. *Introduction*

Power for the electric trains is supplied by the central power plants (provincial and municipal) that also provide the public electricity supply. At Netherlands Railways sub-stations the delivered three phase alternating current at 10 000 or 25 000 volts is transformed and rectified to 1 500 volts direct current.

In order to ensure a continuous supply

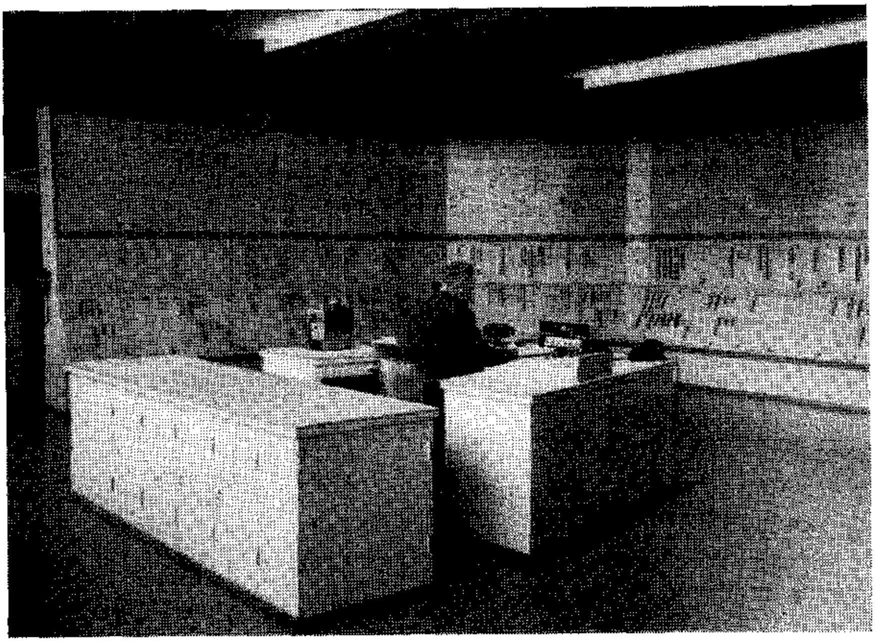

Fig. 13 Remote control panel

of power to the catenary the country has been divided into five Electric Control Areas, each of them having its own central switching-centre.

Actually the greater part of the necessary switching operations are performed by the electric control operator by centralised remote control.

5.4.2. *Brief description*

The switching centre comprises a Control Room, a Relay Room and a Battery Room.

In the Control Room there is a control panel consisting of a number of glass panels on which a mimic diagram of the Electric Control Area network is painted. (Figs. 13 and 14). The items of apparatus to be controlled are represented by two-position switches mounted under the glass panels. The lamps mounted in the buttons are illuminated when the position of the controlled apparatus does not correspond with the position of the buttons. Handsets mounted at various places on the panel and incorporated in the remote control system make it possible to communicate with maintenance personnel stationed in the various substations.

The transmission of controls and indications is effected over one pair of line wires in both directions, i.e. from Control Stations to the feeder stations and vice versa. Up to 28 remote control stations can be connected in parallel on one pair of line wires. An additional pair of line wires is provided for telephone circuits.

For the transmission of information d.c. coded pulses are used both for the identification of the remote control stations and the apparatus to be controlled or indicated.

The d.c. pulses are obtained from a battery. The polarity can be made either "positive" or "negative" by applying $\pm$ or $\mp$ to the line. For the indentification of the remote control stations eight pulses are used of which six pulses are "positive" and two "negative". In this way 28 remote control stations can be identified. The apparatus concerned is identified with one negative pulse in a train of n positive pulses (n indicating the number of items of apparatus that can be controlled or indicated).

The control takes place in two steps; the preparation and the execution. During the preparation a pulse train is sent from

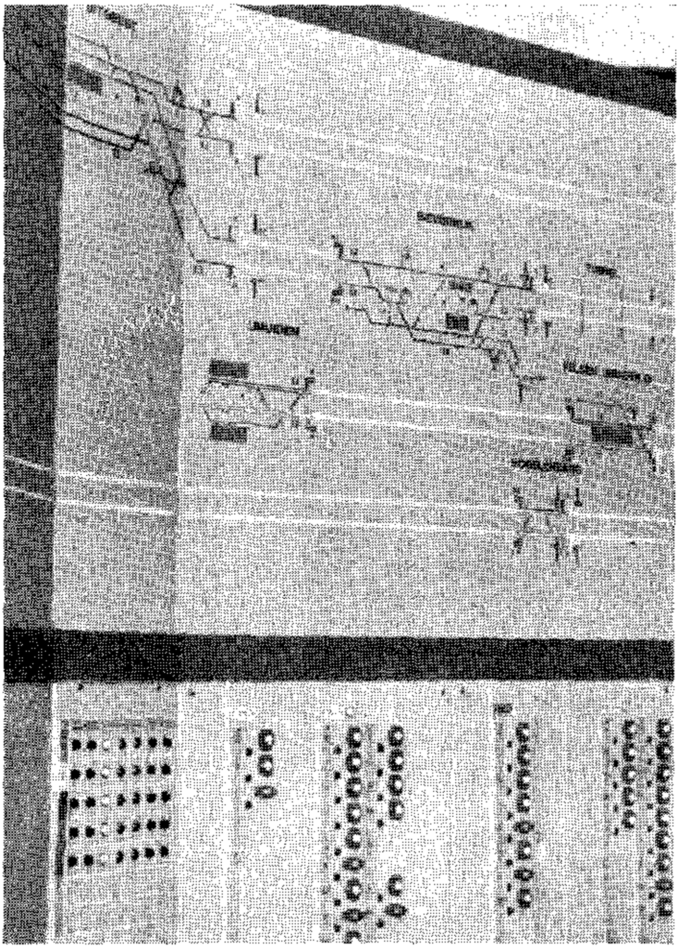

Fig. 14 Detail of a remote control panel

the Control Station to the remote station. The pulse train contains an indentification code for the remote control station concerned and an instruction code for the apparatus to be switched. The remote control station sends an identical pulse train in return to the Control Station.

Both pulse trains are compared in the Control Station. If there is a complete accordance between the two pulse trains the execution can take place. In this way a high degree of reliability is obtained.

6. AUTOMATIC TRAIN CONTROL

When in 1954 Netherlands Railways decided to introduce a new signalling system it was taken into account that sooner or later the question of automatic train control would present itself. Therefore the signalling described above was chosen. For although modernisation of signalling eliminates many risks of human failure, in the last resort the safety of rail traffic is still dependent on the driver's reaction to orders given to him by means of signals along the track.

Checking and if necessary correcting this reaction was the last link missing in the modern safeguarding system.

After the tragic rail disaster near Harmelen on January 7th, 1962, we realised that the introduction of automatic train control should be expedited. The Railway Accident Investigation Board made a recommendation to the Government to request the General Management of the Netherlands Railways to introduce an automatic train stopping system. After a profound study of the various systems we decided to introduce a continuous system of automatic train control.

The choice that the Netherlands Railways made in favour of a continuous system of automatic train control was mainly based on the following arguments:

(*a*) a continuous system with cab-signals provides the train driver with the best available information and also supplements sighting in the case of poor visibility of signals;

(*b*) a change of the signal aspect in a more favourable or unfavourable sense is immediately communicated to the train and made visible in the cab.

(*c*) the speed is continuously monitored; if the driver does not correctly respond to the signals shown to him along the lineside and also in the cab, the emergency brake is brought into operation and the train is brought to a standstill

(*d*) A continuous system is fail-safe and consequently offers the highest degree of safety.

(*e*) as 40 per cent of our network had already been equipped with automatic block installations and as it was the intention of Netherlands Railways to introduce these installations on all other lines as well, continuous automatic train control was the most appropriate system.

(*f*) The GRS-type of control accords favourably with the Netherlands Railways signalling system.

(*g*) If a continuous system is introduced it will always be possible to extend automation in future.

As regards the practical execution it has been decided to introduce four speed levels: viz. 125, 80, 60 and 30 km/hr.

When the engine driver receives an order to slow down and complies with this order correctly he is permitted, when the required speed has been reached, to continue travelling at this speed, until another order is given to him. When travelling at a low speed (30 km/hr), he is obliged to press a vigilance button at regular intervals. If the train driver does not comply with the order given to him, the emergency brake operates and the train is brought to a stand. Our object of introducing the above-mentioned 4 speed levels is to provide a continuous control of the maximum permissible speed, taking into account the varying speed restrictions resulting from points positions and the fixed speed restrictions arising from curves and bridges in the track.

7. MAINTENANCE OF THE SIGNAL INSTALLATIONS

The Signal Department has introduced a maintenance system which aims at:

(1) maximum reliability of the equipment;

(2) maximum efficiency of the maintenance work;

(3) a minimum of maintainers

To achieve this, all the installations which have to be maintained have been catalogued, with descriptions of all the operations necessary for maintenance, the frequency of them, the critical measures of length, current, time, and so on.

Each maintainer has a pocket book which tells him all this systematically and in brief. This booklet is loose leaf and is maintained up to date by the staff personnel.

The hours spent on maintenance are registered and the results of the different maintenance crews are compared periodically to find out whether methods can be improved or if better training is needed locally.

All failures in apparatus are also registered and catalogued and staff personnel have to examine whether improvements in maintenance or construction can keep them down.

Studies have been set up to determine which work has to be done by a higher classified man and what can be entrusted to less experienced and lower-graded men.

Finally it may be noted that we feel it important that maintenance is not done more than necessary, not only to save time and money, but also as too much maintenance work is likely to provoke extra failures.

8. CONCLUSION

This year the execution of a new large modernisation plan has been taken in hand by the Netherlands Railways. Our aim is to equip before January 1971 all sections on which passenger trains travel at a speed exceeding 100 km/hr and to equip all other passenger-carrying sections before January 1st, 1975 with automatic block installations having colour-light signal aspects, centralised traffic control and automatic train control. At the same time the guarded level crossings, if possible, will be equipped with automatic half-barriers and all unprotected level crossings on metalled roads will be furnished with automatic flashing lights. Besides providing a higher degree of safety to rail and road traffic, this modernisation will contribute noticeably to the efficiency of the Netherlands Railways.

DISCUSSION

MR. E. G. BRENTNALL opening the discussion, said he thought that Mr. de Vos was to be congratulated on a very courageous approach to the re-signalling of the Netherlands Railways. He had an awkward task to simplify and alter a system which had been introduced not very long before, and which, despite its apparent simplicity, had caused some little difficulty. He knew that Mr. de Vos had decided to continue speed signalling in rather a different form, and he mentioned that it was found necessary to have more than the three indications.

It was interesting that at a U.I.C. Committee on which Mr. Brentnall had served, the same difficulties were found in giving speed indications for a proposed universal system.

He asked if Mr. de Vos had ever considered going in for route signalling as distinct from speed signalling.

With regard to the signalling aspects Mr. de Vos had shown in his paper, Mr. Brentnall raised one or two points:

In figure 3, item 2, the flashing yellow aspect appeared to lead into an occupied section, and warned the driver so that the train could pull up short of an obstruction. What happened if the flashing system failed and exhibited plain yellow without flashing? Would that not be a less restrictive aspect? Was the flashing yellow aspect delayed until the train had passed the warning signal, or could the signal with the flash be seen from the warning signal?

In figure 3, item 5, if the figure 3 at the warning system failed, was the warning signal put to a more restrictive aspect?

Mr. de Vos stated that a train driver need not remember anything; but it would appear from figure 3, item 5, that the driver had to remember the 30 Km hour restriction at the warning signal when he was passing the stop signal at green, otherwise he would pass too fast.

It was interesting to note that apparently the warning yellow did not precede the red in all cases as is the case in this country.

Mr. Brentnall was interested to know that Mr. de Vos seemed to have reached that ideal for signal engineers when planning a new system, namely that the full requirements of traffic for the years ahead were known when the planning started. Good luck to him!

In connection with the provision of C.T.C., Mr. de Vos mentioned that he avoided doubling a single track line. He asked if an indication of the intensity of traffic on that line could be given.

Mr. Brentnall said that he very much admired the Netherlands Railways in the way they tackled the level crossing question. Having decided to go forward with a plan, they were very courageous in doing so. He referred particularly to the automatic half barrier crossings. One in particular, in Utrecht, was of great interest. It was a very busy crossing, traversed daily by 44 trains, and situated on an important thoroughfare in the town. Full barriers, operated from some distance away, had just been introduced, and some of the people were rather worried that Mr. de Vos would run into trouble. But he had gone ahead, and even converted the full barriers to half barriers.

The timing of the operation of half barriers in Holland was interesting as compared with the arrangements in force in this country, which are as under:—

(*a*) Red lights flashing alternatively and warning bell ringing, 6-8 seconds before the barriers start to fall.

(*b*) Lowering of the barriers, 6-8 seconds.

(*c*) Arrival of the fastest train at the crossing—6 seconds minimum after barriers are down.

The speed of trains was not a limiting factor providing that the difference in time between the fastest and slowest train reaching the crossing after the warning was initiated was not more than 40 seconds. Speed discrimination trials might be necessary on high speed routes.

He asked Mr. de Vos whether any speed discrimination was carried out now on the Netherlands Railways. He believed there was one case where that was done.

In connection with automatic train control, was it intended that the cab signals and the lineside signals should remain, or would the fact that the signals are provided in the cab enable the lineside signals to be eliminated?

He asked whether the emergency track came into force at any point, or only at line signal locations.

He was interested in Mr. de Vos's description of the maintenance arrangements, and most particularly in the little black book, in which he stated that every maintenance action is set down in some detail. If Mr. de Vos had an English translation he would like to see it.

Was any incentive bonus paid to staff in Holland, for doing the work quicker, or was payment on a flat rate?

Finally, he would like Mr. de Vos to comment on the cryptic remark that too much maintenance work is likely to provoke failures!

MR. F. W. YOUNG, continuing the discussion, and remarking upon Mr. de Vos's courage in addressing the Institution in our own language, went on to say that he was most interested in the development of speed signalling, which Mr. de Vos had explained—a system which was quite clear and easy to understand. He wondered if in practical experience it had been found that where the speed indications were provided for the higher speeds whether any special arrangements were necessary, or was the stencil indicator quite adequate for all conditions of weather and climate.

He was very interested to learn that all the planning proposals for layout and so forth were considered by the Departments concerned working under the chairmanship of a signal engineer, as opposed to the British practice of working under the chairmanship of an operator.

The reference to the general description of C.T.C. under the name of "Quiktrol" C.T.C., was, Mr. Young presumed, a development of the system with the mechanical oscillator sometimes known as the syncro-step system. The syncro-step system was much slower in terms of transmission of control and return indication than the 1.5 seconds quoted as the time of operation of the "Quiktrol" system. He wondered what developments had enabled the much faster time to be achieved?

Mr. Brentnall had made particular reference to maintenance, and to the query posed by Mr. de Vos that too much maintenance may provide extra failures. He was glad that Mr. de Vos had underlined the intensive research and investigation that had gone into the maintenance requirements on his railway. It might be there was a tendency to over-maintain, because they were responsible for safety equipment. Mr. de Vos had stated that he had attempted to achieve the maximum maintenance with the minimum staff. Does that mean there was a day turn only, and no shift working? If that was so, did he find that a satisfactory and practical procedure, especially as regards attention to failures at night?

MR. B. REYNOLDS said that he would like to join with Mr. Young in offering his congratulations to Mr. de Vos on his command of technical English, and on the way his paper had been put together. He thought the magnitude of that feat could only be appreciated if one imagined one of our members attempting to present a paper in Dutch in the Netherlands. Also it was very satisfying to read and hear about the installations they had so recently seen for themselves.

Mr. de Vos had referred in his paper to the use of automatic flashing lights at unguarded crossings. Attention was now being paid to that in England. In many cases the use of such road traffic signals would avoid the need to retain crossing-keepers. Our signal presentation, however, is a little different from that used in the Netherlands, although in Great Britain a feature was made of always presenting one light or the other to road users.

In trial installation the lamps were placed one above the other and were both mounted on a common display board. Suitable legends were used to explain the lights to the road users and both lights were at present flashing at 90 flashes per minute. Trials were being carried out with crossing lights of this kind and attempts were being made to get the approval of all interested parties. He added: "We shall be very fortunate, Mr. de Vos, if we can get the Government to pay for our installations!"

Continuing, Mr. Reynolds said that like Mr. Brentnall, he was interested in the diagrams of signals; all the diagrams seemed to suggest that the commands were given on a speed basis. Was there no direction indication at all so that drivers could be informed of their routes as well as their maximum speeds?

In the case of the "Quiktrol" control panel, if a mistake had been made while the switches were being positioned, and the start button had been pressed, what sequence of events had to be carried out to cancel that and re-set the control for the correct route.

Finally, there was a comment he would like to offer on figure 12. A similar system had been introduced by one of the Regions of British Railways, to give an indication of failed signal lamps. It was the practice on British Railways to give an indication of a chain of signal lamps into the box on one common circuit, and in that case the principle had been adopted of putting in a different resistor for each signal into the common circuit, that resistor being held short circuited by contacts on the lamp proving relays. If any of the signal lamps failed, the appropriate contacts opened and inserted a resistance in the line, the value of which was used in the signal box to indicate precisely which signal lamp had failed.

MR. M. S. PATKIR said that in respect of the C.T.C. Remote Control System he would first like to draw attention to page nine, top paragraph on right.

> "The system can operate . . . . until line becomes free".

What interested him immensely was the reference to the line becoming occupied and free. The description of the system indicated that:

1. Both control and indications are sent over a two wire line.
2. Control and indication systems are completely independent in operation, so that controls may be transmitted and indications received at the same time.
3. The Control Office indication receiver can handle one indication cycle from each station simultaneously.

With this data it would be interesting to know . . . .

(*a*) Assuming a man could not set a complete route faster than a code cycle, why a particular line should be occupied at all at any time when it was required to transmit a control and/or indication cycle.

(*b*) Could a code such as replacing a signal to red be stored due to occupation of line wires?

(*c*) Was that line shared by other functions besides the C.T.C. Transmitters?

(*d*) By incorporating storing facilities, did he intend to introduce preselection? For it seemed that conditions might not exist to set a route at the time when "Start" button was pressed, and if the line was occupied at that moment the coded instructions would be stored and transmitted when the line was available. Thus the interval between setting a route instruction code and the route being actually set depended on the availability of line, and thus introduced preselection.

Very little had been said in this paper regarding telecommunications, which formed an integral part of any modern signalling system. He had gathered the following information from the paper:—

1. The public telephone system was the only means of communication on lines exclusive to freight traffic.
2. That a pair of line wires had been provided for telephone circuits for communication between control station and feeder stations for remote control of power distribution.
3. No telecommunication was provided at the lifting barriers. He would be pleased if Mr. de Vos would give them a brief picture of the telecommunication system, with particular reference to:—

1. Signal post, Ground frame, and maintenance tele-circuits.
2. Signal box tele-circuits.
3. What exact part the public service telephone lines played in the present signalling system.

MR. R. A. GREEN said he thought Mr. de Vos was to be congratulated, not only on his interesting paper, but on "getting away" with so much good modern signalling. There was no mention though anywhere in his paper of the financial or economic aspects of his signalling. He did not mention anything about costs. Mr. Green would like to know whether he provided his signalling section by section, as a matter of policy, or did he have to produce financial justification, i.e. show a return on the capital invested, as must be done in this and other countries. Everyone realised the benefits of modern signalling, but rarely could all these benefits be costed beforehand. When it was in operation the benefits were frequently priceless, and the operators wondered how they ever managed without it.

The arguments on "speed" as against "route" signalling had raged for more years than he cared to remember, and he would like to know if the signalling described by Mr. de Vos took care of temporary speed restrictions. Did the signal show, say, a "6" as the maximum permissible speed of the line, even though permanent way or other work necessitated a temporary speed reduction; or was the signal indication temporarily modified?

At his unguarded crossings he says that if the lights failed at RED a Yellow light was displayed after 5 minutes. Five minutes must seem an eternity when waiting at a crossing with no barriers, and no trains, and it was surely asking too much of human nature not to cross before 5 minutes has elapsed. Could Mr. de Vos say whether they had had any complaints or accidents on this account?

MR. G. W. GORE said he had a very brief question to ask. Early on in the paper under Section 4 (2) the author mentioned that six levels of speed were originally permissible, and in introducing the signal system, these were reduced to three speed aspects. Yet later on in the paper, the author referred to automatic control, and stated that the Netherlands Railways had decided to introduce four speed levels. He would like to know how these variations were rationalised in terms of line capacity.

MR. J. C. KUBALE said that he found it very encouraging to find a Signal Engineer speaking to them for an enlightened management, who had decided that signalling was something good for their railway. He would, therefore, like to congratulate Mr. de Vos and the Netherlands Railways for what he considered was a very bold and far-sighted plan of modernisation for their signalling. He thought the status of the signal engineer in Holland was shown by what Mr. de Vos had told them and by what Mr. Young had just referred to, namely that the Signal Engineer was the Chairman of the Committee who, amongst other things, decided station layouts, and the form of signalling. Therefore, let them hope that both the plan and the systematic way in which it had been developed might be emulated in the United Kingdom, where during the last decade or so they had gone through various phases of modernisation, and another seemed to be on the horizon.

He was interested too, that Mr. de Vos pointed out the justification which had obviously been the result of application of remote control and centralised traffic control.

In his opinion, the Netherlands Railways had shown great wisdom in adopting the continuous system of train control. It was to his knowledge, the only railway system in the world which had had the courage of their conviction to do so. Many railways had used various forms of train control, and so far it had been mostly an intermittent system which had been adopted. The intermittent system was an end in itself and it was very difficult to build on to it. With a continuous system one could commence with cab signalling and carry on to full automation if so desired; therefore, he thought, it was an investment that could be made gradually, and built up as far as it was economically advisable to do so.

He would like to ask Mr. de Vos where the maintenance of his equipment was carried out. Was it done by the makers or in railway workshops?

He would also ask how the Management decided the question of the initial cost of a signalling modernisation plan. Did it demand a monetary return, and if so, how was that calculated?

MR. A. W. WOODBRIDGE said he could not let the opportunity go of joining with everybody in saying a few words of appreciation of Mr. de Vos's paper. He was a very old friend of Mr. Woodbridge's, and they had discussed signalling problems in quite a number of countries in Europe.

It was Mr. Kubale, he was afraid, who had really provoked him to get on his feet. He had been talking about enlightened management. The Dutch Railways had been very fortunate in that respect, and they had carried out their re-signalling plan some long time ago. In this country the railways had got themselves completely bogged down, and by legislation anybody could object to any bit of railway they want to close, and they could spoil any scheme that they had. Consequently it was taking very nearly as long to rationalise the railway as it did to build it.

Now one word of warning from a management that was trying to be enlightened. They did not do signalling for the sake of doing signalling, and notice was taken of some of the schemes that were seen in Holland, and indeed had been seen in the pictures, the layouts had been completely rationalised. They were very much more simple than anything in this country. When there was talk about financial discipline, it meant that there would be signalling, but not too much of it; that point had never been rammed home hard anough. If proper regard was paid to cutting out redundant and little-used facilities, they would get tremendous progress, because all the schemes would show a return.

MR. J. H. CURREY said he would like to make a few remarks on the question of the automatic train control, prompted by Mr. Kubale's remarks. He was not going to enter into discussion on the merits of the continuous or the intermittent systems, but to ask a few questions about the continuous system employed on the Netherlands Railways.

He gathered from one of the remarks made, one reason for it was that it fitted in very well, because of the final universal adoption of the automatic block. That, of course, was a very economic way of producing the effect for continuous control; but it did mean that in all cases the transmission point of the code must be in advance of the train. The current for the codes must be approaching the pick-up gear of the locomotive.

A difficulty then arose, because unless the track was split up into a numerous number of small sections it was going to be more complicated bonding to make sure the code was meeting the train. It would be found that the axles of the train were short-circuiting the code instead of meeting it. That was a big trouble they had met when it was considered in that way. At the larger interlockings it was virtually impossible to cover the area, because they could not guarantee that in all cases the current for the codes would be meeting the train.

Another secondary difficulty was also met with in the large interlockings. To ensure continuous track circuiting over the interlocking it was often necessary to use a large measure of common rail. Where there was common rail and it was being used partly for automatic train control coding, any one rail could be carrying different codes for one line and another. So there was uncertainty as to which code might predominate on the pick-up gear on the locomotive.

He would like to ask Mr. de Vos how those two particular difficulties of the continuous code signalling had been met with on the Netherlands Railways?

MR. H. A. E. de Vos, first of all thanked the members present for their contribution to the discussion and for their kind remarks and reception of the paper, especially because among the members there were not only very old friends of his, but also some who had known his father. He replied immediately to the various questions, but said he would give his considered replies to the interesting points raised in the printed proceedings.

THE PRESIDENT, MR. J. S. S. DAVIS said, in concluding the discussion that he was sure it was not only a matter of considerable pride and satisfaction to Mr. de Vos that he had followed in his father's footsteps. That evening they, on their part appreciated not only the remarkable presentation in English of the technical paper, but of the manner in which he had read it and for the discussion which it had created; no less to the excellent manner in which he had answered that discussion, in English.

At the invitation of the PRESIDENT the meeting showed its appreciation by prolonged applause.

The discussion as recorded in London and as printed in the preceding pages was submitted to him after his return to Holland, and Mr. de Vos replied as follows:

SIGNALLING SYSTEM IN 1955

There were some questions about the new signalling system. We have weighed up the "pros and cons" of both systems, route and speed signalling. We chose speed signalling on principle, as we are of the opinion that it is sufficient if the engine driver knows at what speed he must drive. We think that the speed signalling system gives him this information in the most direct and clear way.

There is only one exception, and that is in the case of a bifurcation, where the same speed applies on both branches and consequently speed signalling does not inform the engine driver of the route to be taken. In such a case the delay due to travelling on a wrong route would be particularly heavy. In that case the home signal is provided with an extra route signal aspect, viz. with two white aspects which are positioned in an angle pointing to the right, to the left or upwards in accordance with the established route.

At junctions leading to branches with different speeds, the route appears clearly enough from the speed signalling aspect.

The flashing yellow aspect (fig. 3, item 2) means that an occupied section or a non-insulated section is being approached. If the flashing system fails the signal automatically shows a red aspect, because a plain yellow aspect would be dangerous.

The flashing yellow aspect is preceded by the yellow aspect in the warning signal (the distant signal) and so the engine driver has to slow down to the restricted speed (to a maximum of 30 kms/h) and see what the next signal shows. That is the reason why we do not delay the flashing yellow aspect in the home signal until the train has reached the signal, whether this flashing yellow aspect can be seen from a great distance or not. If in figure 3, item 5, figure 3 fails there is still a yellow aspect left which orders the driver to slow down to a maximum speed of up to 30 kms/h, and to prepare to stop for the next signal; this is a more restrictive aspect. In figure 3, item 5 the driver received, when passing the warning signal, an aspect ordering him to reduce his speed to a maximum of 30 kms/h. He must reduce his speed when passing the signal, so in this respect there is not anything for him to remember.

To assume that the red aspect is not always preceded by the yellow aspect is a misconception. On the contrary the yellow aspect is not always immediately followed by a red one. Sometimes, and rather often at the larger stations, it happens that the driver passes two or three signals showing a yellow aspect before coming across the stop signal at red. This does not matter, because the yellow aspect does not mean: "slow down to stop", but: "slow down to restricted speed and be prepared to stop before the next signal".

The stencil indicator is visible in all weather conditions. But it should also be remembered that it is sufficient if the driver, when passing the signal, clearly distinguishes the stencil indicator. It is not necessary for him to see the indicator far off.

We do not modify, temporarily, the signal indication to signify temporary speed restrictions. For temporary speed restrictions we use boards made of reflective material with lights. In addition the driver receives a very distinct notification.

It is true there is a contradiction in the introduction of four speed levels with the automatic train control, and of speed levels for every 10 kms/h in the original system. This is only a matter of money. It is always possible to introduce more speed levels, later on, while on the other hand permanent way engineers are obliged to improve the track in such a way, that four levels only are necessary.

5.22 C.T.C.

The intensity of traffic on the line Nijmegen-Blerick is 90 trains a day. Besides an hourly passenger service there is coal traffic from the mining district in the South to the North.

The "Quiktrol" C.T.C. is a system which applies a mechanical oscillator. However, the "synchrostep" is not a C.T.C. system, but it is only used for coded-remote-control of only *one* field location in the case of interlocking consolidation. Transmission cycle time of a coded remote-control system depends on the *number* of steps used on the *length* of these steps. The "synchrostep" system uses different numbers of steps. The length of 2 steps in the "synchrostep" system is longer than in the "Quiktrol" system. The transmission time of a control for 2 complete routes depends on the use of progressive delivery or group delivery. The "Quiktrol" system is based on progressive delivery, but the "synchrostep" system used by Netherlands Railways has group delivery. In the latter system the transmission time of a control for a complete route depends on the number of points which have to be set, and the control for the signal is sent only after the indication has been received that all points are in the required position.

It is true that a man cannot set a complete route quicker than a code cycle, but when the operator has positioned the levers beforehand, then he can press a number of start buttons almost simultaneously, after which the controls are sent one after another in numerical sequence. The start of a particular indication cycle may occur when another indication cycle is in progress. These are the cases in which a control or indication start has to be stored because the line is occupied. The waiting time, however, is very short.

There is no difference between a control for replacing a signal to red and a control for clearing a signal. Thus a control for replacing a signal to red may be stored a short time because the line is occupied. On Netherlands Railways the line is only used for C.T.C. transmission; however the line may be used for other functions, such as telephone, telex and date transmission.

Preselection is not applied, because the controls are transmitted in numerical order.

General

We have not any difficulty with the occupation of the line on our double track between Utrecht and Amersfoort, which handles 350 trains daily. This installation issues 1,400 control cycles daily and about 40,000 indication cycles are received. (Most of them simulatneously so that the indication receiver in the control office is 20,000 times a day operated).

The cancellation of an established route in a "Quiktrol" C.T.C. installation of the individual lever type (as shown in my paper) can be effected simply by putting the signal lever in its normal position and by pressing the start button again. The "stop" order is then transmitted to the field location, and from there to the signal. The signal turns immediately to red and the route is released either immediately (if no train occupies the approach section) or after the two minutes time release has elapsed if the approach section is occupied.

5.31 PROTECTION OF LEVEL CROSSINGS

It is internationally recommended to take measures for speed discrimination, when there is a ratio of 1 : 3 in speed—in other words when the normal announcing time will be three times the time of the train running at the highest speed. Therefore, it is not necessary to use speed discrimination on the free track in the Netherlands. However, for installations at nor near stations, where the announcing times vary according to the speed of the different routes, we use speed discrimination. We also use speed discrimination, by measuring the speed, when there is a level crossing, a stopping place, or a siding with locked manually operated points in the announcing track.

As I pointed out in my paper, in Holland we use a green flashing light when no train approaches and a red flashing light when a train is approaching. The green light flashes at the rate of 45, and the red light at 90 flashes per minute. I would like to add that the different flashing rates were chosen on behalf of colour-blind persons.

It is true it seems an eternity, when one has to wait at a crossing which has no barriers for five minutes and *no* train is passing by. There have, however, been no complaints, and no accidents on this account. On the one hand a failure is an exception, and on the other hand it is exceptional if the failure occurs when a car is near the level crossing. So normally he will see the red light quite within five minutes.

6. AUTOMATIC TRAIN CONTROL

At first we shall maintain the wayside signals, notwithstanding the cab signals. We do not know at present if the wayside signals will be taken away later on.

As the A.T.C. system we are going to install is a continuous system, in which the information is sent to the approaching train by means of coded currents in the rails, a service brake order will be transmitted to the train from any point of the track, and at any moment when the situation in front of the train alters. In case the driver does not react properly, within a short time (e.g. two seconds) the emergency brake will come into force. Mr. Currey is right when he states that the code carrying the information must always be sent in such a direction that it meets the head of the train. But it is not necessary to split up, for that purpose, the routes and the tracks "into a numerous number of small sections" as you suppose. The only thing you need to do is to make it possible that the code can be applied to either end of the track or insulated section. The choice from which end of the track the code shall be sent is made by the direction of the established route.

In this way it is always possible to make sure that the right code will meet the right train.

In all our interlockings we use single rail track circuiting with a common rail for the propulsion return current.

Of course a code in one track can leak anyway by the common rail to another track, and special measures are necessary to avoid the danger that such a false code will be picked up and accepted by another train. As far as I know GRS is the only firm that has so far succeeded in applying automatic train control to single rail insulated territory.

7. MAINTENANCE OF THE SIGNAL INSTALLATION

The remark "too much maintenance" means that apparatus properly working should not be touched more than is absolutely necessary for the prevention of failures or danger.

By touching the apparatus for maintenance work one always runs the risk of causing a failure, such as breaking off of wire ends after the latter have been damaged by pliers or any other tool; insulation of contacts by brush hair, or the thread of a cleaning cloth; breaking of screws which have been tightened too hard; bad contacts, where nuts were not tightened hard enough. Maintenance work in the field can never be tested in the same way as work in workshops, or factories.

Maintenance of modern equipment is mainly carried out in the factory; but our own workshops are doing it to a small extent. By doing part of the maintenance work themselves the railways are not entirely dependent on a firm, and consequently get a better knowledge of the qualities of the equipment.

An incentive bonus is not being paid. In the Netherlands payment is generally at a flat rate. In the industries in Holland, however, there is a bonus system, on account of which higher wages can be paid. We are now studying the introduction of such a system in order to get into a more competitive position on the labour market.

We have a continuous day shift from 7.30 a.m. till 5 p.m., including a 30 minute lunch break. In case of failures at night, and during week-ends by weekly turns, an employee (e.g. a fitter) is indicated to be within reach out of the normal day shift.

This means an inconvenience to the employee, for which he receives extra payment. Every fitter has also a public telephone at home which is paid by the railways.

The above mentioned procedure proves to be satisfactory and practical, and is accepted by the staff.

9. FINANCIAL

Mr. Kubale, Mr. Woodbridge and Mr. Green mentioned the problem of the cost of a signalling modernisation plan. Netherlands Railways are a limited company, so in principle there must be a financial justification. Every plan of Netherlands Railways is therefore submitted to the Working Committee of Investments Selection (WIS). Members of this committee are young engineers of the various Departments, and they work under the chairmanship of a representative of the Finance Department. They draw up a report independent of their own Department on behalf of the General Management. In reliance upon this report the General Management takes their decision. An example of such a report is the following (I only used the symbols a, b, etc., for the real costs).

Report of the modernisation of the signalling equipment of station x and surroundings.

1. Description of the proposals of the entire works.

2. The total costs of the investments are:—

   signalling equipment
   permanent way
   catenary
   Total cost Y guilders.

3. *Alternative.* Proposal, maintain the present equipment and make no alteration. The difference in annual costs, taking into account a market interest of $4\frac{1}{2}\%$ is:—

	higher costs in case of a new installa-ation	higher costs if the present equipment is maintained
interest and depreciation allowances	a	—
working expenses		
staff	—	b
additional expenses on account of higher wages in future	—	c
maintenance of signal cabins	—	d
lighting and heating	—	e
maintenance signalling equipment	—	f
power costs signalling equipment	g	—
damage	—	PM
maintenance points, etc.	—	h
total	g	k

After the modernisation plan has been carried out the number of staff at the station can be reduced by 51.

According to the specification above the annual costs when modernisation is carried out are k-g less than at present.

4. *Rate of Return*

Investment of the modernisation (duration of life 25 years)	
higher working expenses on account of the present equipment	k
higher working expenses on account of the new equipment	g
available for depreciation allowances and interest	k-g per annum
annually gross profits in this case	$5\frac{1}{4}\%$
market interest	$4\frac{1}{4}\%$
annual net profit	1%
total net profit	15%
pay-out period	20 year

5. *Imponderables*

(*a*) More safety, specially on account of by improved signal aspects, improved occupied track indication, etc.

(*b*) Less number of staff, specially at places where staff is hard to get.

(*c*) If the wages increase by more than 2% a year, modernisation will become still more attractive.

(*d*) Increased capacity, which facilitates the drawing up of a good time-table.

(*e*) Higher efficiency by closing down signal cabins.

6. *Conclusion*

The WIS, is of the opinion, that modernisation should be recommended, specially on account of the reduced number of staff.

Sometimes there is a small deficit, but the conclusion may be that modernisation is still advisable, on account of the imponderables.

10. TELECOMMUNICATION

I know there is very little that has been said about telecommunications. I agree that telecommunication forms an integral part of any modern signalling system. If I had included the subject of telecommunication in my paper it would have become twice as long. However, I should like to answer Mr. Patkar.

It is a misunderstanding there is no telecommunication provided at the lifting barriers. Every automatic level crossing is provided with a plug contact. So in case of a failure the temporary level crossing keeper can get into contact with the stations at both ends by means of a portable telephone.

The public telephone service plays no part in the present signalling system, only on lines for freight traffic exclusively and with a relatively few trains a day running at a maximum speed of 30 km/h.

In Holland there is an automatic telephone system, specially for the railways. The signal cabins have direct lines with the neighbouring stations.

Every automatic signal along the track has a telephone connection with the cabin at the end of the line.

NX stations are equipped with talk back apparatus. Every cabin is connected with the dispatching control room. For maintenance purpose the staff use the plug-contact on every relay box or the telephone apparatus near the signals along the track.