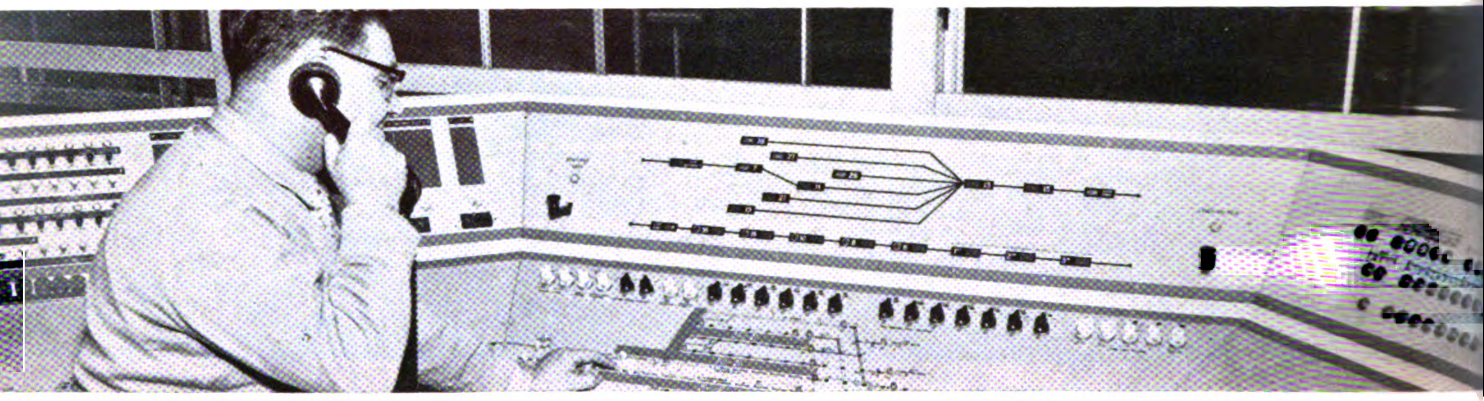
TRAIN DESCRIBERS:

A step toward ATI



Train identity numbers are displayed in black rectangles on sloping panel above interlocking operator's hand.

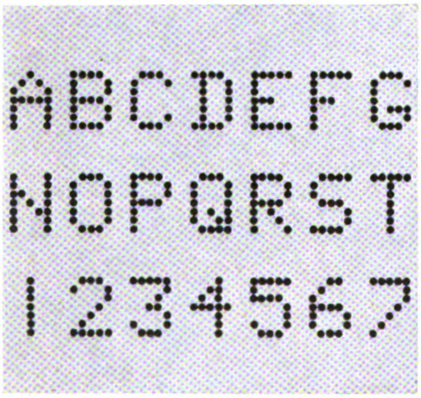


Figure 1: cathode ray tube display.

Automatic train identification would give interlocking operators the correct identity of approaching trains sufficiently in advance to allow them to position switches and clear signals without delay to the trains. In commuter territory where several trains are often closely spaced, ATI could be of importance in expediting movements at interlockings.

British Railways have installed several train identity systems which might be considered semi-automatic, that is, once the train number is initiated by pressing numbered buttons, this number is automatically transmitted and displayed at control consoles in towers. Also, as the train progresses along its route, the number is sent to succeeding towers and displayed. This transmission from tower to tower is automatic over communications or signal circuits without manual intervention.

This article, describing recent developments in train describers, is by A. J. Mullarkey, an engineer with Standard Telephones & Cables Ltd., London, England. Our thanks to the Institution of Railway Signal Engineers for permission to abstract from Mr. Mullarkey's paper, presented herewith:

The advent of centralized signaling schemes brought about the miniaturization of control panels and diagrams and in consequence less space was available for the inclusion of train describer indicators. It was not until late 1957 that indicators other than the lamp and stencil type became available in this country. The first new type was the in-line projection model and this was soon followed by the edge-lit perspex and gas tube types, etc.

Prior to the availability of the in-line projection indicators it was decided to investigate the possibility of displaying descriptions on cathode ray tubes. The use of large numbers of CRTs as might be required for train describer systems was unknown in any other application, and although at the time there was a number of published methods of writing alpha-numerical characters on CRTs, it was doubtful if any had been usefully employed. Most of the methods published made use of the well-known Lissajous' figure technique, in which two separate sets of scanning waveforms are required to be switched to the deflector plates of a CRT for every character displayed.

For reasons of economy in the production of a complete train describer system, it is desirable to keep the design of the storage and switching apparatus identical to that already in use for lamp type indicators. In this case it is only necessary to switch one supply channel for the display of one character. To make use of the Lissajous' figure technique it would have been necessary to switch two channels of information to the CRT, and as electromechanical apparatus was then used (as it is today) it would have been necessary to double the number of contacts, and this would have been a costly procedure.

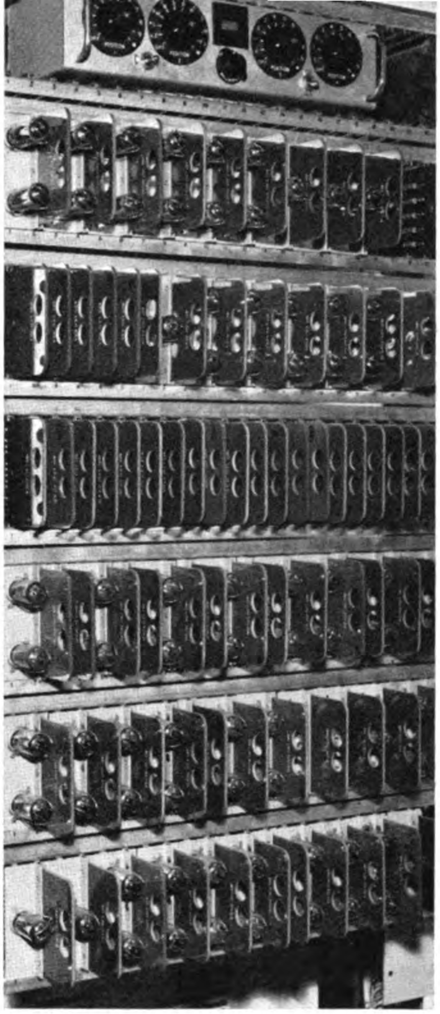
To overcome this difficulty a new method of CRT display was developed in which only one channel of information was required to be switched for the display of every character.

In recent years it has become common practice to display train descriptions by indicators denoting the actual signal the train is approaching; this method has become known as train berth describers. Just before the authorization of the four alphanumerical characters for train descriptions, four numerals only were generally required. In either case four characters must be displayed for a train description.

Various sizes of characters have been required, ranging in height from ⅜" to 1". In all cases, the facial area of the indicator displaying the description must be at a minimum proportional to the size of the characters.

Cathode ray tubes are manufactured in a variety of shapes and sizes for a number of different applications. The most suitable types for use in train describers are the small ones, which are manufactured with electrostatic deflection. The smallest CRT available is just over 1" diameter by approximately 4" long. It is a low voltage tube requiring from 350 to 1,000 volts on the final anode. It is self-focusing and requires no external control for this purpose. A rectangular tube has recently been developed especially for CRT indicators. The dimensions are 2" by 1" and it is particularly suitable for ¾" or ⅝" characters. The final anode voltage in this case is up to 2,000 volts. With 1" tubes it is possible to use two tubes for the display of one description, two characters appearing on each tube. Two tubes per berth are not generally favored because of the large gap between the first two and second two characters. In future the 2" by 1" tube will obviously be favored when ⅝" or ¾" characters are required.

In applications where characters of ¼" or ⅜" are required the 1" diameter tube serves a useful purpose. At the present time 1" tubes only have been in service but installations using the 2" by 1" tube will be commissioned in the near future.



Vacuum tube type of character generator.

In the display system to be described the formation of characters is based on the principle of a number of elements being selected from a matrix of elements to give the desired character. Examples of this may be seen in music hall type route indicators in which lamps are used as the elements, and by selecting certain lamps in the matrix in the shape of the desired character a clear indication results.

The matrix can be made up of any number of elements, but for the sake of economy and simplicity of switching, the number must be kept to the minimum necessary to give unambiguous characters.

The number greatly depends on the use for which the information is required. For instance, if it is required to convey the written word, the word is quickly recognized as a whole, and not by the individual letters, in which case the shape of the individual letters need not be perfectly defined. In the case of coded information, the individual characters comprising a code must be unmistakeably recognized, and therefore the shape of the characters must be clearly defined. Train descriptions obviously fall into this latter category.

For CRT (cathode ray tube) displays it has been found that a matrix consisting of seven lines of five elements is sufficient to give well-formed numerals. There are limitations in the use of such a matrix in constructing letters. The numerals 0 to 9 can be clearly defined when constructed from horizontal and vertical lines, whereas letters of the alphabet require diagonal lines of various angles to give the conventional notation. A five by seven matrix can produce diagonal lines at one angle only, and because of this limitation the shape of some letters is not entirely conventional.

The construction of alphanumerical characters on a five by seven matrix is shown in Figure 1 and it can be seen that letters requiring angular lines, other than at the natural angle of the elements in the matrix, appear somewhat unconventional. This applies to the letters A, N, V, W and X. Although this limitation is present it will be appreciated that each letter is very near the conventional shape and it would be practically impossible to mistake one letter for another, even when seen for the first time.

In the system about to be described the writing of the alphanumerical characters on cathode ray tubes is controlled from a centralized unit, namely the character generator. The generator produces a train of pulses for every character required in the system, and any number of characters can be produced.

The characters authorized for use on British Railways consist of ten numerals and twenty letters. Thirty character outputs would therefore be provided to cater for this requirement. The generator also produces the necessary time-base waveforms for the scanning of the CRT.

The scanning waveforms are permanently connected to the X and Y deflecting plates of all the CRTs in the installation, and cause the beam of each tube to trace four separate patterns across the screen for the construction of the characters. Each pattern consists of seven evenly spaced horizontal lines. The lines are not normally visible because the beam of each tube is blocked by a negative biasing potential applied to its grid.

Associated with each berth is a means whereby a train description comprising four characters can be stored. The store usually consists of four groups of relays or uniselectors, each group representing a particular character position in the display. The character pulse trains from the generator are connected to each group according to the selected characters required to be displayed in that group. The pulse trains are multipled in this way to every store in the system. When it is required to display a train description the relays or uniselectors of each group in the store are operated to select the particular character pulse trains comprising the description. Four individual pulse train outputs are therefore delivered from the store. The CRT can only deal with one impulse at a time and it is therefore necessary to serialize the four pulse trains before they can be applied to the tube. This is achieved by feeding the pulse trains into four individual gates and each gate is opened in turn to connect the pulse trains to the grid of the tube. The gates are controlled directly from the generator, each gate being opened for the scanning duration of one seven-line pattern to allow the complete train of pulses to reach the grid of the CRT. A pulse arriving at the grid will remove the bias to unblock the beam and so produce a bright spot on the screen. The position of the spot is determined by the timing of the pulse in relationship to the scanning waveforms. The completion of the four pulse trains will produce spots on the screen to the shape of the selected characters. The speed of the whole operation is sufficient to give the appearance of four stationary characters, and will remain displayed while the information is held in a berth store.

Thermionic vacuum tube circuitry was used in the construction of the original system, but a later version has been produced making use of solid state circuitry. Both systems work on the same principle but as the vacuum tube version is in operation in a number of signal towers, it is proposed to give a detailed description of this one only.

For the construction of the characters it is necessary to produce a 35-way pulse distributor from which the pulses forming the characters may be selected. A 35-way counter would fulfil this purpose, but at great expense. A co-ordinate gating method of distribution was found to be much cheaper and was therefore adopted. The block schematic for the complete system is shown in Figure 2 in which the whole operation of generating and displaying characters may be followed.

A multivibrator (MV) produces square-wave impulses which are used to drive either directly or indirectly all the digital circuitry within the generator. The output pulses from MV are positive-going, and are fed into the horizontal driver (HD). Here the pulses are inverted and amplified to produce a steep sided, negative-going pulse for the driving of the ring counter (HRC). The counter consists of six bistable circuits, each circuit being switched on in turn on receipt of an impulse from HD. Each bistable circuit consists of a double triode vacuum tube and the circuit is either ON or OFF depending upon which half of the triode is conducting. The counter is designed so that only one stage of the circuit can be on at a time and it will remain in that condition until the next pulse is received from HD. On the arrival of the pulse, the ON stage is switched OFF and the next stage switched ON, and as the counting proceeds pulses will appear at the output of each stage in turn. When the sixth stage is reached the next driving pulse transfers the ON condition to the first stage, and the counter continues to cycle all the time pulses are received from HD.

The vertical ring counter (VRC) is identical to the horizontal ring counter except that there are seven stages in the ring, and its driving pulse is received from a separate source. The vertical driver (VD) receives a positive-going pulse from the sixth stage of HRC, and after inverting and amplifying, provides the driving pulse for VRC. It will be seen that each stage of VRC remains ON during a complete cycle of HRC, and therefore the rate

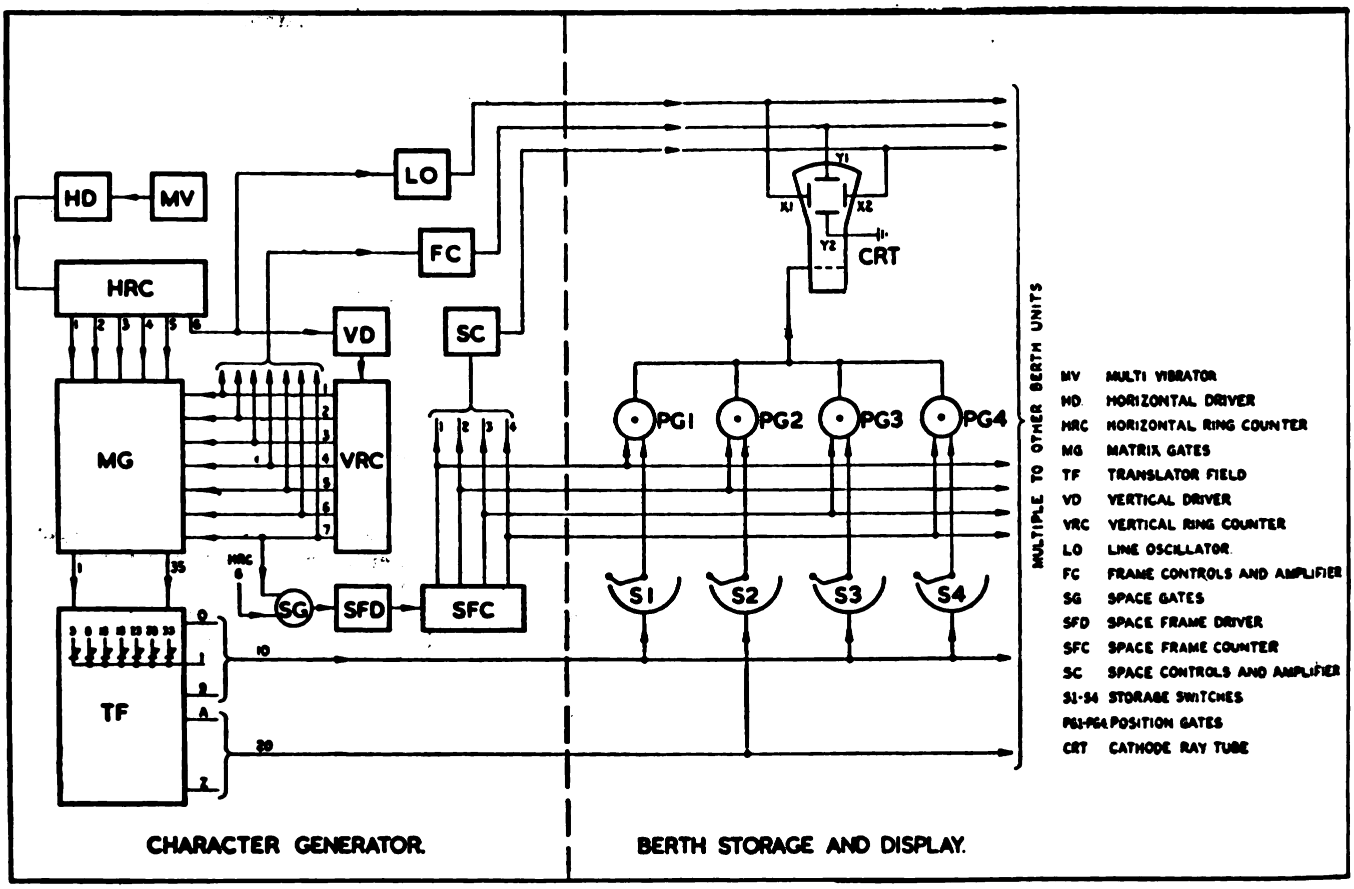


Figure 2: Block diagram of train describing system showing character generator and storage and display portions.

of count is six times slower than HRC.

The matrix (MG) consists of 35 two-input diode gates arranged in seven rows of five, which are controlled from the output pulses of HRC, and VRC. Outputs from HRC 1-5 feed all the gates in the respective columns and VRC feeds all the gates in the respective rows. A gate will open and a pulse will appear at its output when pulses are applied to the two inputs in coincidence. Assuming VRC is standing in the first stage, the output will supply a positive-going pulse to all gates in the first row, and as HRC steps into each stage a positive-going pulse is applied to each column of gates in turn. Only the first row of gates in the matrix will receive coincident pulses, and an output pulse will appear from each of the five gates in sequence. As VRC progresses through every stage, a pulse will appear at the output of every gate in the matrix and the operation of forming a 35-way pulse distributor is completed.

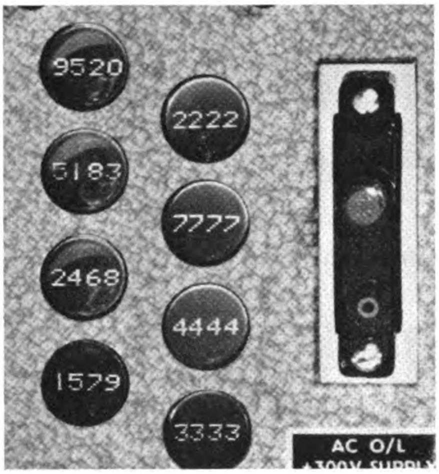
The 35 outlets from the matrix gates are fed into the translator field (TF) where the characters in the form of brightening pulse trains are produced. The field consists solely of diodes, which are used to pick off particular pulses to form a combination for every character required in the system. A typical example is shown in Figure 2 inside the translator field, the character being the numeral ONE. For this character the pulses representing the center column of the matrix are required and are numbered 3, 8, 13, 18, 23, 28 and 33, making seven pulses in all. Each pulse is connected via a diode to the outlet terminal, from which the seven pulses will appear in sequence representing the numeral ONE.

Pulse trains for all characters are built up in this way, there being one outlet from the translator field for every character required. An outlet buffer is provided for each character pulse train to provide sufficient power to handle the loading, when the pulse trains are multipled to the berth stores.

Before proceeding to the berth stores it is necessary to describe the generation of the time bases, so that the order of events is kept in sequence.

Three separate time bases are required for the reproduction of a four character display, namely the line, the frame, and the space. The line time base provides for the scanning of the CRTs in the horizontal direction. A sawtooth oscillator (LO) is provided, and the output is connected to the X1 plate of all the CRTs. The length of the line is governed by the amplitude of the sawtooth waveform, which is made adjustable. The oscillator is synchronized from the sixth stage of the horizontal ring counter so that one line is produced for every complete cycle of HRC.

The frame time base provides for the scanning of the CRTs in the vertical direction. A staircase waveform of seven steps is produced, and when connected to the Y1 plate of the CRTs will (in conjunction with the line scan) produce seven lines on the screen. One line is traced during each step of the staircase, which is made up from the individual output pulses from the vertical ring counter (VRC). Each pulse is taken to the frame controls (FC) by which the amplitude of every pulse is adjusted to form a precise step in the staircase. The pulses are then combined by the aid of diodes to form a complete seven-step staircase. The resulting waveform is amplified to give the necessary deflecting voltage for scanning the CRTs and a gain control is provided to enable the height of the characters to be adjusted.



Cathode ray tube type indicators show how characters are formed.

With the running of the two time-bases just described, a single character scan only is produced, and for a four-character display four separate scans over the screen of the CRTs are required. A third time base provides the displacement voltages for the positioning of the four scans. A staircase waveform is produced similar to the frame time base staircase but consisting of four steps only. Each step represents one complete frame duration, and when connected to the X2 plate of all CRTs will produce four complete frames on the screen. The waveform is originated from the four-way space frame counter (SFC). The circuit is identical to that of the horizontal and vertical counters except for the number of stages in the ring. The counter is stepped one position at the end of every frame scan and is controlled by the diode space gate (SG). The two inputs to the gate are received from HRC6 and VRC7, and when they are both in coincidence the gate opens and produces a positive going pulse to the space frame driver (SFD). The driver amplifies and inverts the pulse for the driving of the SFC counter. Each stage of the counter remains ON for the duration of one complete cycle of VRC. It will be noticed that the counter is stepped when HRC is in stage six, so that the space shift takes place during a period in which there are no brightening pulses. The space staircase is generated from the individual outputs of the SFC. Each pulse is connected to the space controls (SC) by which the amplitude of each pulse is adjusted to form a precise step in the staircase. The pulses are then combined by the aid of diodes to form a complete four-step staircase. The resulting waveform is amplified to give the necessary deflecting voltage for the spacing of the four characters. A gain control is provided so that the spacing of the characters may be adjusted.

The individual pulses from SFC are also used for the control of the position gates PG1—PG4, which are associated with every berth store.

The second half of Figure 2 shows the block schematic of a complete berth unit which consists of the storage apparatus, the position gates, and the display tube. Every display berth in the system is identical, and is therefore repeated for as many times as necessary throughout the system.

As previously stated, the information concerning a train description is stored by electromechanical means consisting of relays or uniselectors. The principles of the CRT display do not change according to the type of storage used, and therefore it is not necessary to consider the various means of storage in describing the display. To simplify the block schematic drawing, the store has been shown as four multi-point switches (S1—S4). It is assumed that each switch can be moved to any one of its contacts for the selection of a particular character, and while the switches are held in the selected position the information will be displayed. When the switches are returned to their home position the display will obviously be cleared.

For the display under consideration, the arrangement of characters in the four positions is as follows:—first position, the numerals 0—9; second position, the letters A—Z omitting I, Q, R, U, W and Y; third and fourth positions, the numerals 0-9. To handle this arrangement it is necessary to provide an 11 point switch for the first, third and fourth positions, and a 21 point switch for the second position. The pulse trains from the generator for the characters 0–9 are multipled to the first, third, and fourth position switches of every berth in the system, and the characters A–Z are multiplied to all the second position switches in the system. The information to be displayed can now be selected by positioning the four switches to the required character. The selected pulse trains will then appear at the respective wiper of each switch. The pulse trains appearing on each wiper will all be in phase, and before applying the pulses to the CRT (cathode ray tube) it is necessary to serialize the four trains so that each pulse arrives in synchronism with the scanning waveforms. For this purpose four diode gates are provided (PG1–PG4) each being associated with a switch in the store. The gates have two inputs, one being connected to the wiper of the respective switch, and the other connected to a time position pulse supplied from the space frame counter (SFC). A time position pulse is present for the scanning duration of one frame, and when applied to a particular gate, will hold the gate open and direct the character pulse train (selected by the switch) to the grid of the CRT. It will be seen that each gate is opened in sequence to allow the four selected pulse trains to reach the grid of the CRT in sequence with the scanning. The pulse trains are positive-going and their arrival at the grid will overcome the negative bias and produce a series of bright spots on the screen to the shape of the selected characters. Both the positioning of the four scanning frames on the CRT, and the opening of the berth-positioning gates are controlled from the same pulse source, and therefore it is impossible for the display to get out of synchronism. The rate at which the characters are displayed is determined by the speed of the multivibrator (MV) and it has been found that 15 kc is sufficient to give a flickerless display of four characters when using a medium persistence green fluorescent CRT.

The character generator is housed in a cubicle situated in the apparatus room of the signal tower. Monitoring facilities are provided in which the outputs of the generator may be checked and adjusted without interfering with the service. The monitor is similar to a complete berth display unit, but with manual switches fitted in place of the storage relays or uniselectors. Any of the available characters can be selected and displayed in all four positions on the monitor tube. The monitor also provides a useful aid to fault finding because the loss of any character pulse train or failure of time bases is immediately apparent on the display tube.

One page 21 is a photograph of the thermionic vacuum tube version of the character generator. All the vacuum tubes and associated components are mounted on plug-in panels, so that in the event of a failure of any one of the circuits, a panel may be quickly replaced by a spare. The monitor unit may be seen mounted at the top of the cubicle. The front panel carries the display tube, the four character-selection switches, brilliance control, and ON/OFF switch. Heater supplies for the vacuum tubes and CRTs are obtained from transformers (not shown in photograph) mounted in the base of the cubicle, and alarm-type fuses are fitted at the rear. An earlier version also had the heater transformer power supply mounted in the lower portion of the cubicle, but in the later version it was found to be more convenient in servicing to mount all the power units together in one rack. For convenience of maintenance and design, the rack has four stabilized units for the supply of the whole system. The power supplies are 300 volts for the character generator circuits, 100 volts for the gating circuits, 750 volts for the CRTs and 100 volts negative for the CRT biasing. The 750-volt supply is interlocked with the 100-volt bias, so that in the event of failure of the bias the 750-volt supply is automatically switched off. This prevents the burning of the CRT screens should no bias be present. A metering panel is provided, and all supplies (voltage and current) can be checked by the turn of a switch. All connections to the supply units are by means of plugs and sockets, which enable a quick interchange for a spare to be made in the event of failure.

The gating circuits and output buffers associated with the berth stores are mounted in the same cubicles as the train describer switching apparatus. Figure 3 shows a group of panels for 18 berths mounted below the storage apparatus. The panels are similar to the type used in the character generator, and each panel carries two circuits. Double triode vacuum tubes are used for the output buffers, each circuit using one half of a vacuum tube.

The mountings for the 1" diameter cathode ray tubes occupy a panel area of 1½" square. The brilliance control and associated components are fitted at the rear of the mounting and the complete unit is made to plug in to a nearby terminating box mounted at the rear of the control panel. Train describers are on the console in Barking signal tower on the Eastern Region. The train describer displays, using 1" diameter tubes, are mounted on a mimic diagram immediately above the control panel. Rectangular cut-outs in the panel provide a viewing window for the CRTs and the signal number is signwritten alongside each window. A close-up photograph of the mimic panel is shown in Figure 4 with descriptions shown in the "LAST SENT" display positions.

The most recent installation making use of CRT displays is at Nuneaton on the London Midland Region. The panel is at least three by eight feet for the complete signaling installation, and at first glance it is difficult to realize that there are over 70 display tubes on the panel. One-inch diameter tubes are used and ⅜" high characters are displayed through the rectangular cut-

(Please turn to page 40)

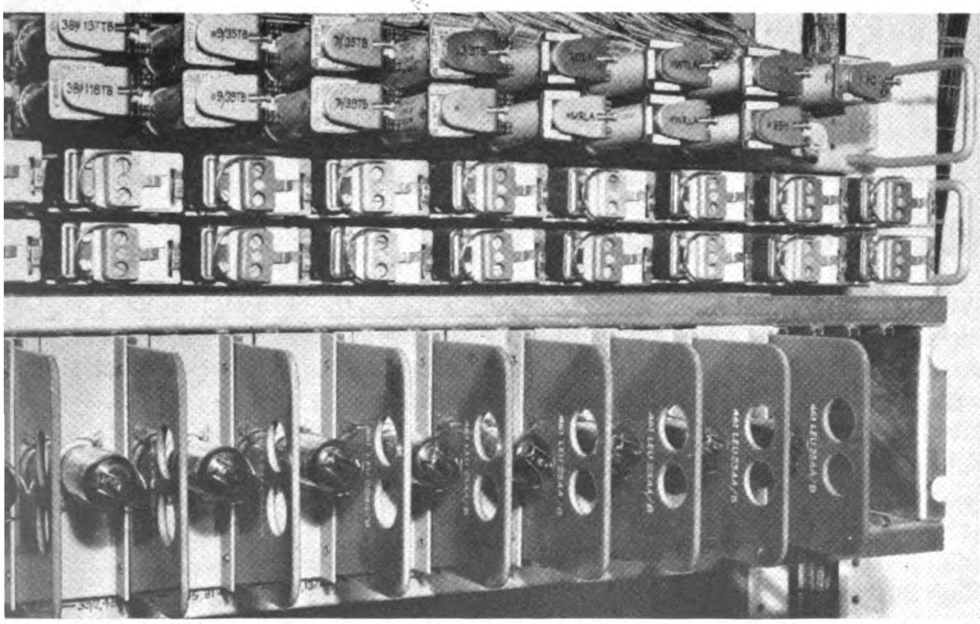


Figure 3: panels for berths are below storage apparatus.

TRAIN DESCRIBERS

(Continued from page 26)

outs in the track diagram. A close-up portion of the panel is shown in Figure 5 and the description 1A25 is clearly visible in signal berth No. 2.

Up to date, six signal towers on British Railways have been equipped with CRT displays, namely Potters Bar, Barnet, Southend Central, Pitsea, Barking, and Nuneaton. In these installations considerable experience has been gained in the operation and servicing of the system. Due to the use of relatively low-speed digital circuitry with conservatively-rated vacuum tubes and other components a high order of reliability has been achieved. Operational reports from the field show very few catastrophic failures of vacuum tubes or CRTs. The vacuum tubes used are in the services CV 4000 series, which were designed for use in conditions of severe mechanical stress. It has been stated that when operating these vacuum tubes 24 hr per day, lives of up to three and five years are by no means unknown. In practice these figures are being obtained. Two of the installations have been in commission for over three years and the majority of the original tubes are still giving good service. The life of a CRT varies according to its duty cycle. "LAST SENT" descriptions are continuously displayed unless a means is provided to clear the information. When indications are continuously displayed a life of up to 5,000 hr can be expected. The majority of signal berths are only occupied for short periods, and under these conditions lives of up to two years have been obtained.

The CRT display system can be manufactured to work in conjunction with any form of storage apparatus (electromechanical or electronic), and is capable of displaying any size of character required for train describers. In particular it has fulfilled an urgent need for miniature displays occupying a minimum of panel space, and in consequence has given the signal engineer a much wider scope in the design and layout of signaling consoles.

The use of electronic equipment in railway signaling and communications introduces problems for those concerned with maintenance. The major part of equipment at present in use is either mechanical or electromechanical, and maintenance staff are familiar with this type of equipment. A very important difference exists between mechanical or electromechanical apparatus as compared with electronic. In mechanical apparatus faults usually due to the wearing of component parts and may be quickly detected because they are easily seen. Faulty components in electronic apparatus do not appear to be any different from good components, except in certain circumstances. Because of this difference, the detection of faulty electronic equipment usually entails elaborate and expensive test gear, and even when this is available it requires considerable experience on the part of the tester to interpret the results. The testing of systems incorporating electronic digital circuitry invariably requires an oscilloscope for measuring and checking pulses of various shapes, sizes and speeds encountered throughout the system.

Built-in test gear can involve considerable expense, especially if it is designed to test every circuit and give a precise indication of whether it is good or bad. Justification for such test gear can be claimed when a large number of identical circuits are involved, but in systems with small quantities of dissimilar circuits, the cost of built-in test gear can often exceed the cost of the actual system.

In the CRT display system already described, the use of an oscilloscope in testing and fault finding would undoubtedly be a great asset, but there is already an oscilloscope with admitted limitations built into the system. A fault in the system will be indicated immediately in one or all of the tubes depending upon which part of the system is affected. The loss of one or more characters in a particular berth would

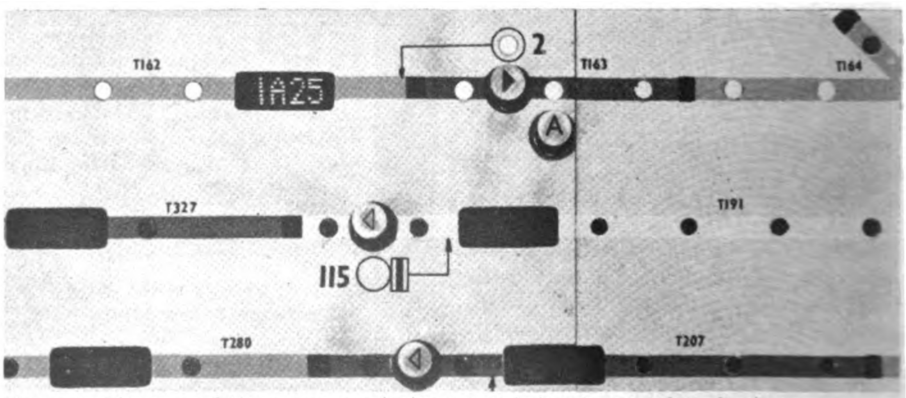


Figure 5: Close-up of Nuneaton interlocking panel showing number display.

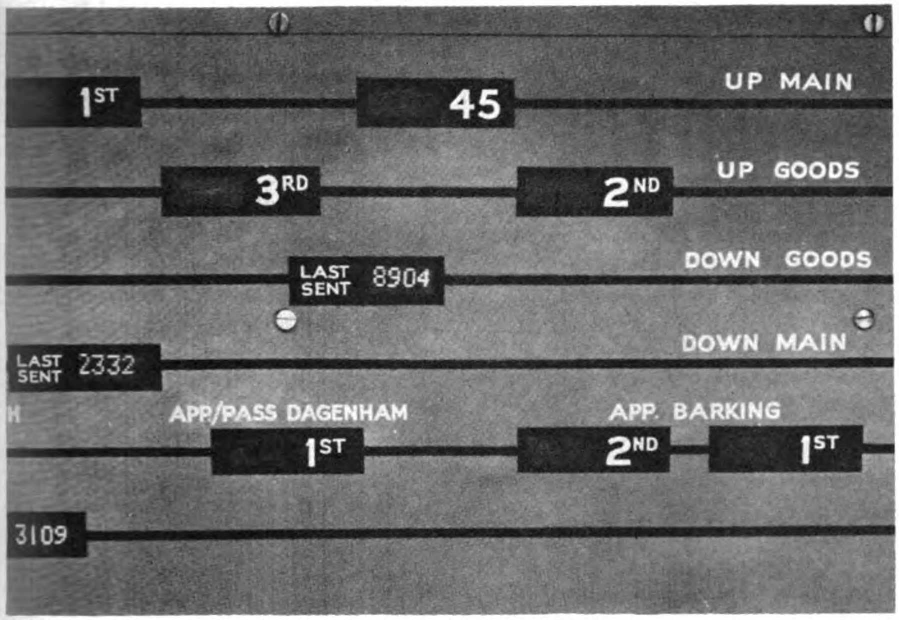


Figure 4: Barking tower display shows number of train last sent.

indicate that the fault lies within that part of the equipment associated with the berth, whereas the loss of one or more characters in every display would indicate a fault in the common equipment and most likely this would be in the character generator or power supplies. Further deductions can be made from the appearance of the characters in the display. For instance the loss of output from the line oscillator would give the appearance of four figure "ONES" on the tubes, and the loss of the space-scanning waveform would remove the deflection potential of the X2 plate and four character displays would appear as a jumble of bright spots in the center of the tube. If a particular character is missing in a number of display tubes, the character output buffer is the most likely offender.

Numerous cases such as these can be mentioned but the examples quoted are enough to show that when the maintenance personnel have gained sufficient experience of the system fault finding can be handled with ease.

Having described an electronic display system, the question of using electronic techniques throughout the whole train describer system might be raised. A considerable amount of thought has been given to this question and investigations have been made into various methods of electronic switching that could be adapted to train describer requirements. Results of investigations made a few years ago showed that when converting from electromechanical to electronic switching, the cost of the electronic switching was far in excess of its electromechanical counterpart. More recent investigations, however, have shown that with the progressive reduction in cost of component parts and improved methods of manufacture, the cost of a complete electronic system can be considerably reduced.

Over the years electromechanical systems have reached a high standard of reliability, and development in this technique is still progressing. A possibility that must not be overlooked is the combining of the best features of both electromechanical and electronic switching to form a hybrid system. The reason for prompting this suggestion is that the speed of operation of electromechanical apparatus is sufficient for most purposes and it is possible that the advantages of both techniques may be used to make a very economical system. Opposed to this suggestion is the possibility of making use of the high speed features of electronic switching to form the basis of a completely new design. With the present day knowledge of electronic switching it should be possible to design a packaged unit system consisting of transmitters, receivers, stores, and displays from which any number of the various units could be interconnected to form a complete system. This method of construction would eliminate costly tailor-made systems, and as each type of unit would be interchangeable, service and maintenance would be greatly simplified.

At present the train describer system gives the signalman a picture of all trains under his control, and from this information he makes the signaling decisions. A forecast of future developments might therefore include a train describer system that gives direct instructions to the interlocking machine of the route the train requires to travel, the responsibility for safety still remaining with the interlocking machine.

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