WESTINGHOUSE

Centralised Traffic Control

THE WESTINGHOUSE BRAKE & SAXBY SIGNAL CO. LTD.

82, YORK ROAD, KING'S CROSS, LONDON, N. 1.

D.P. 20

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CENTRALIZED TRAFFIC CONTROL

March, 1931

THE
WESTINGHOUSE BRAKE & SAXBY SIGNAL CO. Ltd.,
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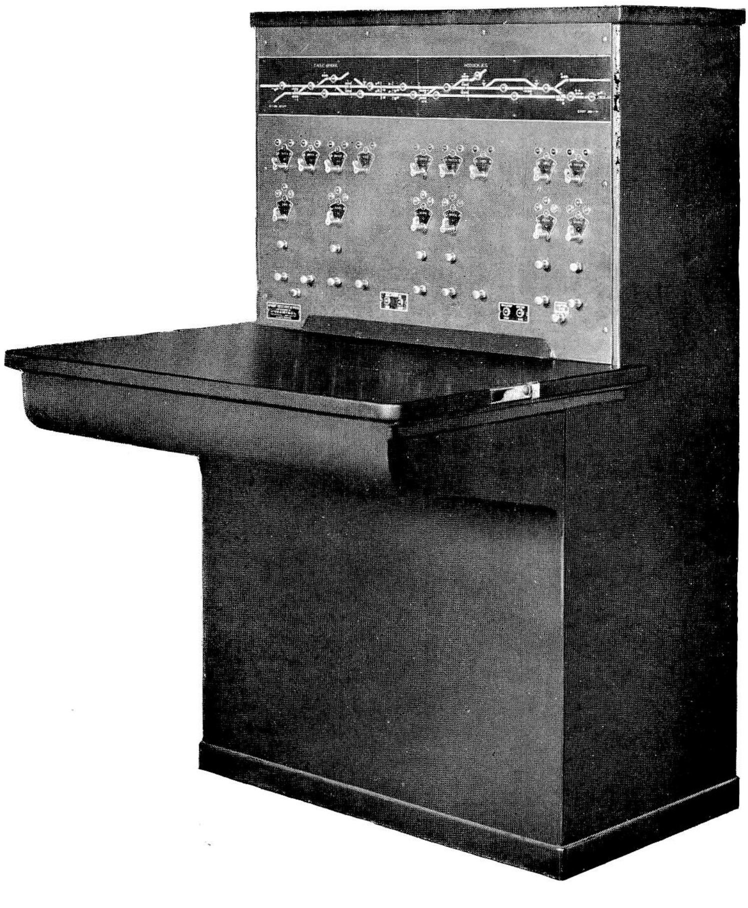
CONTROL MACHINE



For the control of 10 switches and 14 signals over 3.5 route miles (7 track miles).

Centralised Traffic Control

The name Centralised Traffic Control is given to any system whereby all points, signals, switch locks or other functions to be operated along a stretch of railway track are brought under the control of an operator at a single control point. Such a system also provides for return indications to be given to the operator of the state of track circuits, signals and points.

The groups of apparatus which may be placed under central control may comprise anything from a simple layout of one switch, and its associated signals at the end of a passing loop or siding connection, to a complete interlocking layout. Centralised Traffic Control is applicable to single or double track or to reversible road working, as well as to many subsidiary uses.

The operator at the Central Office is in sole charge of all train movements in the control area and no other signalmen are employed. For practical purposes the extent of the signalling installation which can be controlled is limited only by the capacity of the operator.

The control of points and signals or other apparatus is effected by means of thumb switches mounted on a control machine placed in an office anywhere within, or reasonably close to, the length of railway to be controlled.

Centralized Traffic Control is designed to be added to any of the standard and well known signal circuits at the outlying stations. Points are preferably operated by electric or electro-pneumatic point machines which take power from a local source. The signal operating circuits are also directly controlled by the operator, the signals being of any desired type.

Complete and continuous indications as to the state of all apparatus throughout the area are given by means of small lamps on the Control Machine. Track circuit indication lamps are mounted on a diagram of the track, which is placed above the control thumb switches.

In this way information regarding the position of all points and signals, and the condition of all important track circuits, is constantly available for the operator.

Furthermore, all indications are sent to the Control Office automatically in the event of any change occurring at the remote stations.

If desired an Automatic Train Graph Recorder can be installed at the office, and thus a continuous record of all train movements within the control area can be obtained.

Automatic or Semi-Automatic operation of individual signals can be determined at will, by the operation of a push button provided for each signal lever.

Two separate systems of Centralised Traffic Control have been developed, both achieving the results outlined above, but in different ways.

The first system which is known as the TIME CODE SYSTEM requires only two wires extending throughout the length of track on which stations are to be controlled.

The second system is known as the CIRCUIT CODE SYSTEM and requires three wires instead of two.

The Time Code System has been developed to a total capacity of 35 such " stations " on one pair of line wires.

The Circuit Code System provides for a maximum of 81 such " stations " on three wires. The distance of the furthest station from the control point is limited only by the line resistance and insulation.

Both systems have one main feature in common, namely, that should the operator require to make any traffic move at an outlying station, he sets certain thumb switches on the control machine in the positions reqired for that move and presses a starting button. The control instruction to the outlying station is then transmitted over the line wires in the form of a complete code. It should be understood that this code contains the call for the station wanted, as well as the instructions for the movements of points or signals at that station. In a similar way, when any change in the condition of a track circuit, a pair of points, or a signal, occurs at an outlying station, a complete code is sent back by that station to the Central Office, this code including the station's call sign and all the information regarding the state of each function at the outlying station.

Installations ranging up to over 100 miles distance between the control point and the furthest station which it controls are giving satisfactory performance. The line current in either case is about 120 milliamperes, and as all relays are in series this is a constant load. The voltage used for transmission is raised according to the number of series stations which the installation requires.

For the purpose of describing the capacity of each system a "Station" is considered to be one point lay-out which may be either a single end or a cross-over, two track circuits and a complement of signals for directing traffic moves in either direction through the point lay-out, as shown in figure 1 below.

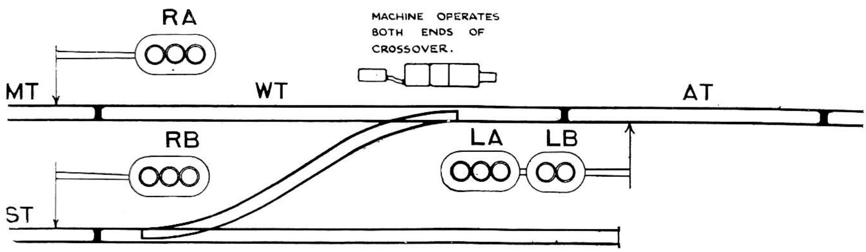


Fig. 1. Typical Station Layout.

Note: With standard code equipment, either "time code" or "circuit code" applied to the above layout, the following "controls" and indications are obtainable.

CONTROL.	INDICATION.
i. All Signals.	i. All Signals.
ii. Point Machine.	ii. Point Machines (nr. or open).
iii. Semi Auto or Auto Operation of Signals.	iii. Track Circuit, A.T.
	iv. Track Circuit, W.T.
	v. Automatic Train Graph Recorder.

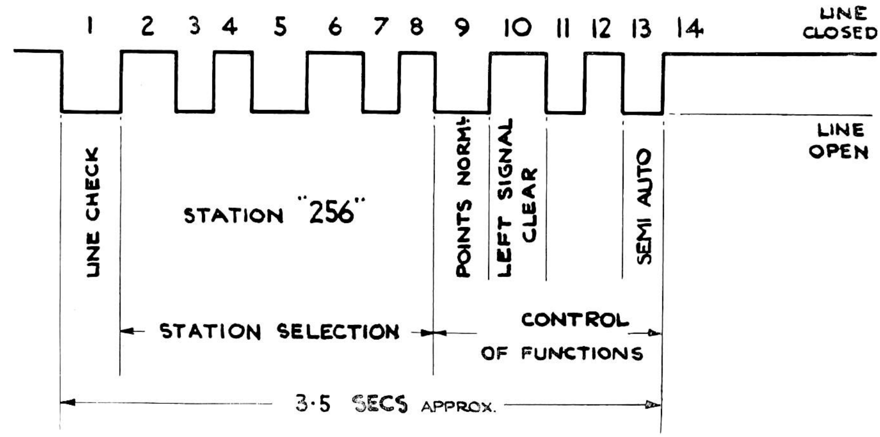
THE "TIME CODE" SYSTEM

In the Time Code System a complete code comprises a consecutive series of openings and closings of the normally closed line circuit. *In this system, and in the circuit code system, the line circuit is normally closed, and relays at the control point and all outlying stations are connected in series in the lines.*

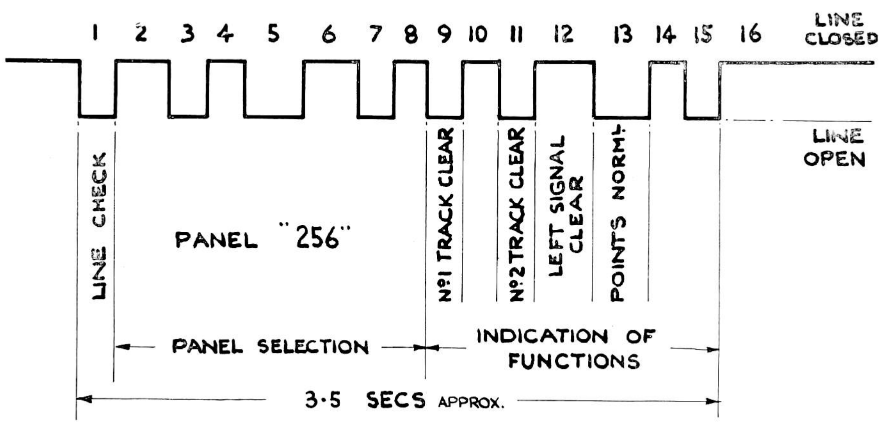
Seven openings of this normally closed circuit occur in each complete control code (outgoing) and eight openings in each complete indication code (incoming).

The open-circuit period in the code can be either of long or short duration, and the line closed period between the successive open circuits can also be long or short.

Figure 2, page 6, shows the interruptions of the line circuit during the transmission of one code. There are seven periods of open circuit on the line of differing durations, and seven periods during which the line is energised between the open circuit impulses, these periods also differing in time.



Typical Control Code.



Typical Indication Code.

Figure 2.

In practice the line circuit is arranged as shewn in Fig. 3.

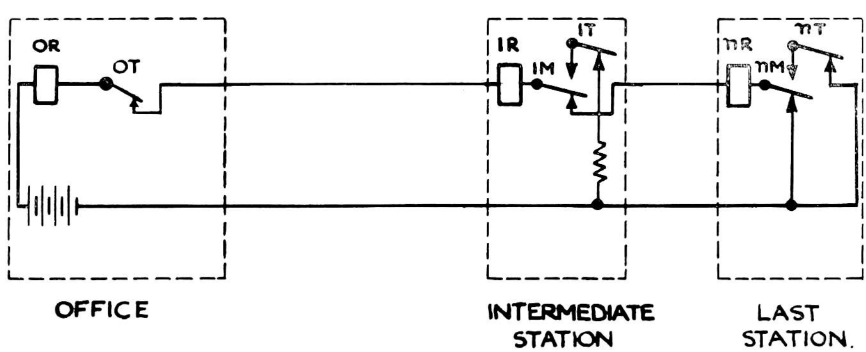


Figure 3.

When a code is transmitted or received, the seven " Line Open " and " Line Closed " periods are allocated as follows :—

The first step prepares all stations for the reception of a control code, and is a " Line Open " impulse which is always of long duration, in order to distinguish an outgoing " control " code from an incoming " indication " code.

The next portion of the code, impulses 2 to 8, is used to call the particular station wanted, and the second step is a " Line Closed " one, the third a " Line Open," the fourth a " Line Closed," etc. Each of these steps is in effect an impulse on the line and the duration of each impulse may be either long or short.

Impulses from 9 to 14 inclusive are used for transmitting control orders to the functions at the station called, or in the case of incoming codes bring in a complete set of indications of the state of every function at that station. A typical arrangement is to allot these impulses as shown below.

Note L=Long Impulse.
S=Short Impulse.

Step No. 1 line open and code proceeds, line closed, line open, line closed, etc., to No 16 line closed.

CONTROL			INDICATION		
Step No.	Character.	Function.	Step No.	Character.	Function.
1	L	Line Check.	1	S	Line Check.
2	L or S	Station Selection.	2	L or S	Panel Selection.
3	L or S		3	L or S	
4	L or S		4	L or S	
5	L or S		5	L or S	
6	L or S		6	L or S	
7	L or S		7	L or S	
8	L or S		8	L or S	
9	L	Points Normal	9	L	Track Occupied.
	S	—		S	Track Clear.
10	L	Left Signal Clear.	10	L	All signals at "stop"
	S	See note below.		S	
11	L	Switch Reverse.	11	L	Track Occupied.
	S	—		S	Track Clear.
12	L	Right Signal Clear	12	L	Left Signal Clear.
	S	See note below.		S	—
13	L	Call On Clear : or Auto Operation.	13	L	Points Normal.
	S	No call on or Semi-Auto Operation.		S	—
14	L	Code Complete.	14	L	Right Signal Clear
				S.	—
			15	L	Points Reverse.
				S	—
			16	—	Code Complete and Line Clear.

N.B.—If steps 10 and 12 short, both signals placed to "Stop." If "call-on" used, then step 13 short, "Call-on" signal placed at "Stop."

N.B.—If steps 15 and 13 short, then points are open. If steps 12 and 14 short, then signals are "wrong."

The circuits are so arranged that to call a station, three of the impulses 2 to 8 must be long and the remainder short.

The first long impulse energises a first selector relay, the second long impulse a group selector relay, and the third long impulse the station selector relay at the station called. On the first, i.e. control code impulse, all stations up to the maximum of 35 are called. On the second impulse 15 first selector relays at stations are energised and 20 stations drop out.

On the third impulse 5 group selector relays at stations are called and 10 further stations drop out, and on the fourth impulse the final station wanted is called and all other stations drop out. This is assuming that the station called had a code number 234. The way in which 35 stations are allocated call signs is shown in Table below. The call signs shown indicate the long impulses, all other impulses from the second to the eighth inclusive being short.

Station.	Call-Sign.	Station.	Call-Sign.
1	234	19	348
2	235	20	356
3	236	21	357
4	237	22	358
5	238	23	367
6	245	24	368
7	246	25	378
8	247	26	456
9	248	27	457
10	256	28	458
11	257	29	467
12	258	30	468
13	267	31	478
14	268	32	567
15	278	33	568
16	345	34	578
17	346	35	678
18	347		

Station Call Signs, Time Code System.

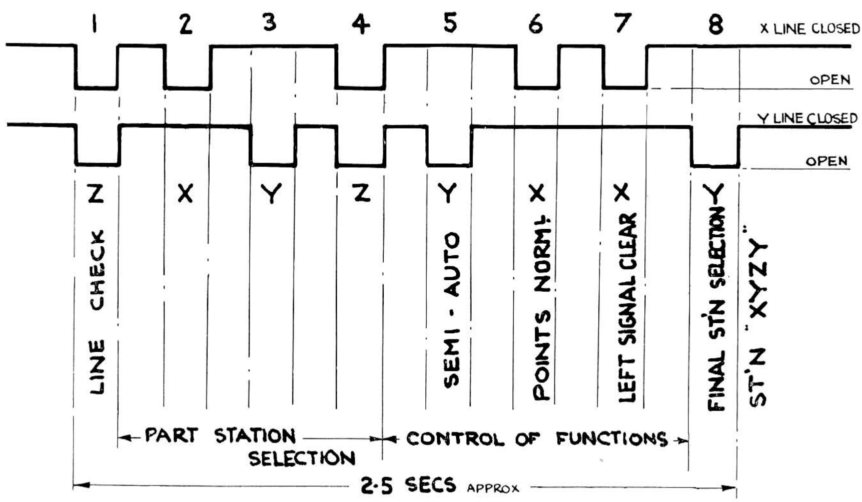
The time taken for the complete transmission of a code containing the station call sign and control or indication group of impulses is approximately $3\frac{1}{2}$ seconds.

The impulses and their duration are determined entirely by the relays housed in the control machine and in the station storage units. There are no moving parts other than relays, and the control thumb switches in the whole system. No ratchet devices are used, and under normal conditions the line current, and that taken by the indication lamps at the control station, represent the only steady load. The system is therefore economical in operation.

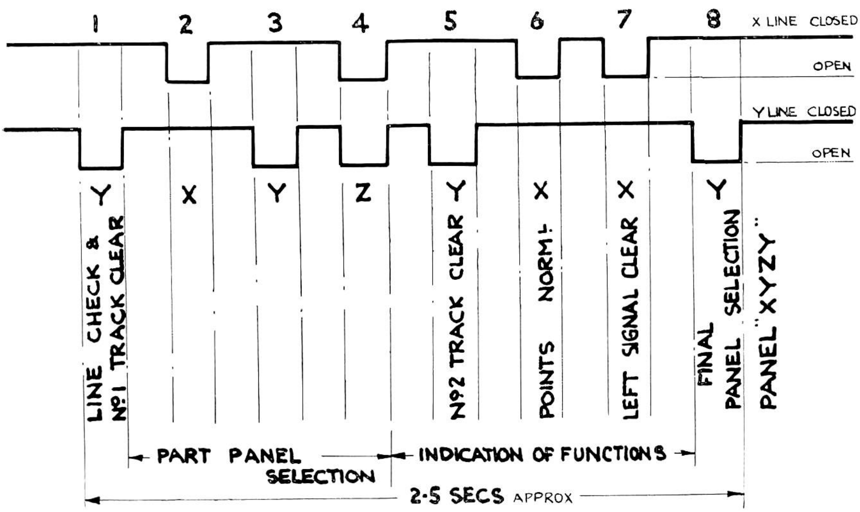
THE CIRCUIT CODE SYSTEM

In the Circuit Code System each code comprises a series of eight characters ; the term " character " here is used to indicate whether one wire " X," a second wire " Y," or both wires together " Z," are open-circuited during an impulse. All characters are of equal duration.

In Figure 4 the corresponding circuit code is shown, three lines X, Y and Z being used ; Z in effect being the common return for apparatus on lines X and Y. Impulses of either X de-energised, Y de-energised or both de-energised simultaneously (Z) are shown. In practice the line circuits are arranged as shown in Figure 5, page 10.



Typical Control Code.



Typical Indication Code.

Figure 4.

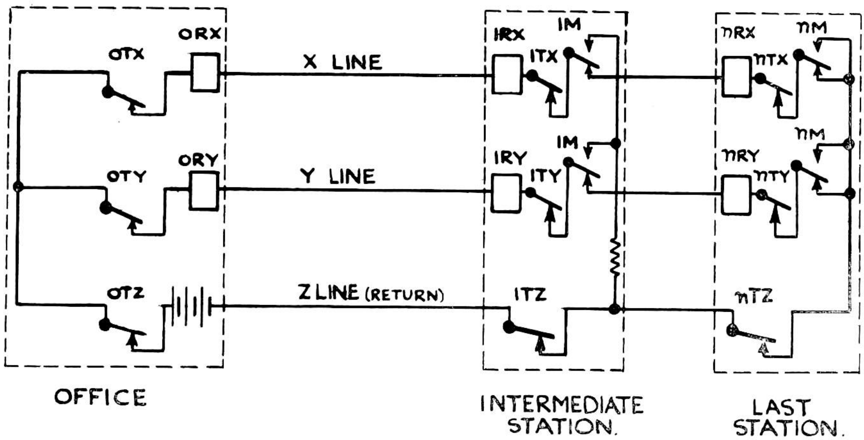


Figure 5.

Stations are called by character, each station having a call sign of four letters using only letters, X, Y and Z. The total number of four-letter " words " which can be made up from these three characters is 81. As an example, one station may have a call sign XYZZ, another one ZYZZ, another YZZX, etc. (See Table below)

Station.	Call-Sign.	Station.	Call-Sign.	Station.	Call-Sign.
1	XXXX	28	YXXX	55	ZXXX
2	XXXY	29	YXXY	56	ZXXY
3	XXXZ	30	YXXZ	57	ZXXZ
4	XXYX	31	YXYX	58	ZXYX
5	XXYY	32	YXYY	59	ZXYY
6	XXYZ	33	YXYZ	60	ZXYZ
7	XXZX	34	YXZX	61	ZXZX
8	XXZY	35	YXZY	62	ZXZY
9	XXZZ	36	YXZZ	63	ZXZZ
10	XYXX	37	YYXX	64	ZYXX
11	XYXY	38	YYXY	65	ZYXY
12	XYXZ	39	YYXZ	66	ZYXZ
13	XYYX	40	YYYX	67	ZYYX
14	XYYY	41	YYYY	68	ZYYY
15	XYYZ	42	YYYZ	69	ZYYZ
16	XYZX	43	YYZX	70	ZYZX
17	XYZY	44	YYZY	71	ZYZY
18	XYZZ	45	YYZZ	72	ZYZZ
19	XZXX	46	YZXX	73	ZZXX
20	XZXY	47	YZXY	74	ZZXY
21	XZXZ	48	YZXZ	75	ZZXZ
22	XZYX	49	YZYX	76	ZZYX
23	XZYY	50	YZYY	77	ZZYY
24	XZYZ	51	YZYZ	78	ZZYZ
25	XZZX	52	YZZX	79	ZZZX
26	XZZY	53	YZZY	80	ZZZY
27	XZZZ	54	YZZZ	81	ZZZZ

Station Call Signs, Circuit Code System.

The first impulse in a control code is always the character Z, the second, third and fourth impulses are the first three letters of the call sign of the station wanted. The final letter of the call sign is sent on the eighth and last impulse; the fifth, sixth and seventh impulses are used for control code transmission.

On an incoming or "indication" code the first impulse is always X or Y, and this distinguishes all indication codes from control codes, and in addition X or Y are used in the indication code to convey distinctive information.

The second, third and fourth steps are the first three letters of the station's call sign for panel selection; the last letter of the call sign is sent on the eighth and last step. The fifth, sixth and seventh impulses are used to give an indication of the state of all functions at the station sending. Each of these impulses can have the character X, Y or Z, depending on whether one or both of the lines are open-circuited. On one impulse, therefore, we can convey any one of three different meanings.

The table shows how the steps in the code and the characters of each step are allocated when applied to a typical "station." A complete code takes about $1\frac{1}{2}$ seconds to transmit or receive.

CONTROL			INDICATION		
Step No.	Character.	Function.	Step No.	Character.	Function.
1	Z	Line Check.	1	X or Y	Line Check and X Track Occupied. Y Track Clear.
2	X,Y or Z	Part Station Selection.	2	X,Y or Z	Part Panel Selection.
3	X,Y or Z		3	X,Y or Z	
4	X,Y or Z		4	X,Y or Z	
5	X	No call on or Auto Operation.	5	X	Track Occupied.
	Y	Call on or Semi-operation.		Y	Track Clear.
	Z	—		Z	—
6	X	Points Normal	6	X	Points Normal.
	Y	Points Reverse.		Y	Points Reverse.
	Z	—		Z	Points Open.
7	X	Left Signal Clear.	7	X	Left Signal Clear.
	Y	Right Signal Clear.		Y	Right Signal Clear
	Z	All signals at "stop"		Z	All Signals "stop."
8	X,Y or Z	Final Station. Selection	8	X,Y or Z	Final Panel Selection.

Note.—i. X=X Line Open. Y=Y Line Open. Z=X & Y lines open together.
ii. All lines closed between each step for period equal to line open impulse.

The following features are common to both systems.

A control code always takes preference over an incoming indication code. Should the operator be transmitting a control code at a time when some function outside has changed and therefore commenced to send in an indication code, such an indication code is stored at the outlying station until the line clears. It will then be transmitted into the Control Office in the normal way. If two or more outlying stations commence to transmit incoming indications simultaneously, the nearest station takes precedence and cuts out the more distant stations, which continue to store their codes until the line next clears. On the line clearing again these outlying stations will send in their indications successively, starting with the one nearest to the control station. If for any reason an outlying station repeatedly tries to send in an indication code, a time element device comes into operation and cuts the station transmitter portion out. The station can be brought on the line again by the operator when required.

The storage of indications by the outlying stations avoids the loss of indication, which would otherwise occur if a train passed over a short track circuit during a time when the lines were fully occupied with control codes. In such a case the field storage units from the outlying station send in the " Track Occupied " indication as soon as the line clears, and follow this immediately with a further " Track Clear " indication, thus ensuring that the train graph at the control station correctly registers the passage of a train.

In the event of any of the point machines located at the outlying stations failing to complete their stroke and running on the clutch, a thermal time element relay cuts the motor out of circuit after a predetermined interval has elapsed. The operator, having received no return indication, can then move the points back to their original position, and if he wishes, can make further attempts to clear the obstruction by repeated operations of the point machine.

Codes may be varied in use for a number of reasons and purposes ; for instance, it may be desirable at one outlying station to have a comparatively large number of track circuits repeated, and the whole of the indication portion of a code may be given up for this purpose. Special information, such as a warning of low air pressure at an outlying point or the operation of a Highway Crossing Signal, may be transmitted by code.

Another possible application is the switching on of lighting circuits at distant points and the indicating back of this lighting to the control point.

In both systems the power for operating the relays used in generating the code is provided by small local batteries, kept trickle-charged by rectifiers from an A.C. power line. These batteries provide a standby in the event of power line failure.

In the Time Code System 16-volt local batteries are used, and in the Circuit Code 24-volt, both being normally of about 10 ampere-hour capacity.

The relays in the coding units handle only the very small currents necessary for control purposes, and are therefore of small design. A typical relay is shown in Figure 6.

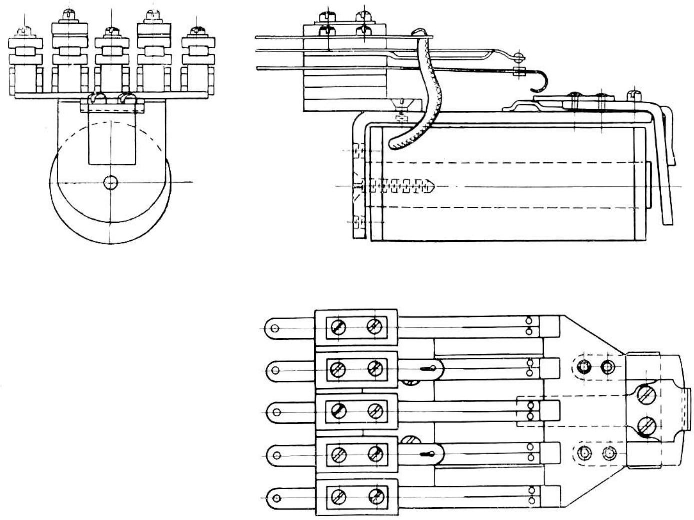


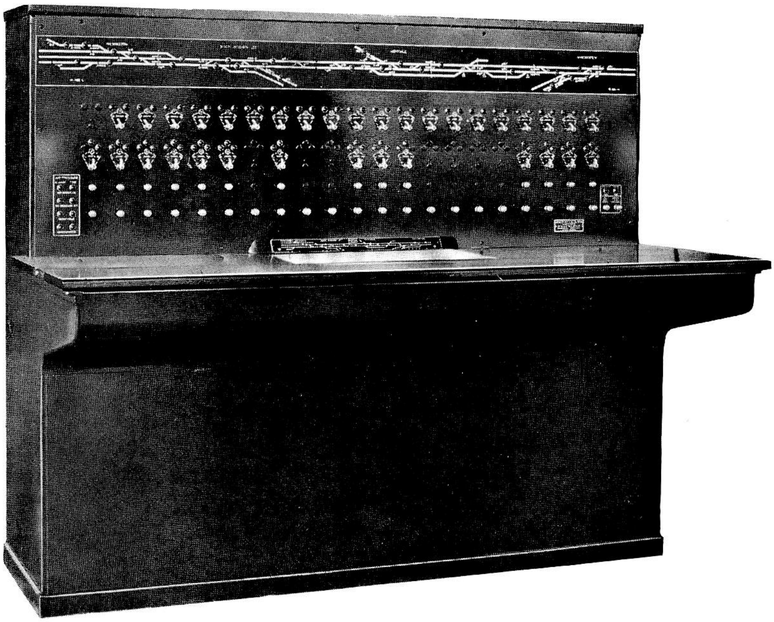
Figure 6.

The standard signal relays, point detection relays, point controllers, and other apparatus are controlled by the final relays at each station, power for this control being furnished by the local battery. All the usual protection of track circuits, point detection, track locking, and approach locking remains as in a normal signal system, and the C.T.C. systems do not in any way affect the safety which these features provide. Any lay-out of points and signals can be controlled and repeated back by these systems, and the application of code control to double line and reversible lines does not present any difficulties.

As the stations are remote from the control points, the maximum advantage of the system is obtained when the operator has clearly in front of him the position of every train within the area which he controls. In order that this information may be completely maintained, a train graph recorder can be provided and built into the central control machine (see pages 15 and 16).

In the following pages are brief descriptions of the main apparatus units that go to make up the complete C.T.C. System,

CONTROL MACHINE.



for the control of 26 switches and 24 signals over 8.5 route miles (17.4 track miles).

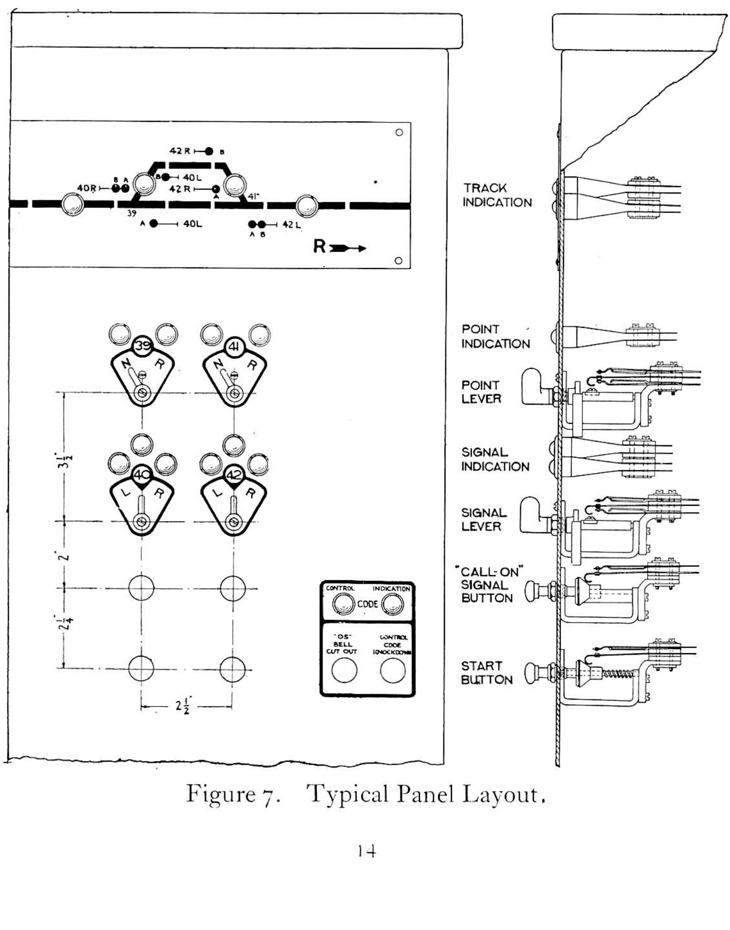


Figure 7. Typical Panel Layout.

THE CONTROL MACHINE

The machine comprises a desk type cabinet of sheet metal having a number of thumb switches and press buttons mounted on the front panel as shown in Figure 7, and a number of indication lamps, some of which are located in a track diagram to indicate the track circuits, and some over their respective thumb switches to indicate the state of functions controlled. The control board panel also has additional lamps, one of which shows that a control code is being transmitted and another that an indication code is being received.

There is no electrical or mechanical locking between any of the thumb switches and push buttons.

A special " knock-down " press button is fitted. If the operator has started a transmission of a code and wishes to cancel this before completion, he can stop the outgoing code by pressing this button.

If he wishes to check the indications existing at any point on the panel, he can send a recall code by pressing the starting button on that panel. He will then receive a fresh set of indications showing the position of every function at the station whose starting button has been pressed.

Built into the flat portion of the control machine is the train graph recorder, having a number of pens responsive to the condition of certain selected track circuits in the control area. These pens make a record showing the time a track is " clear " and the time it is " occupied," and by joining up the record of such successive track circuits, a diagram showing the complete passage of all trains is made. The recorder mechanism is shown diagrammatically in Figure 8.

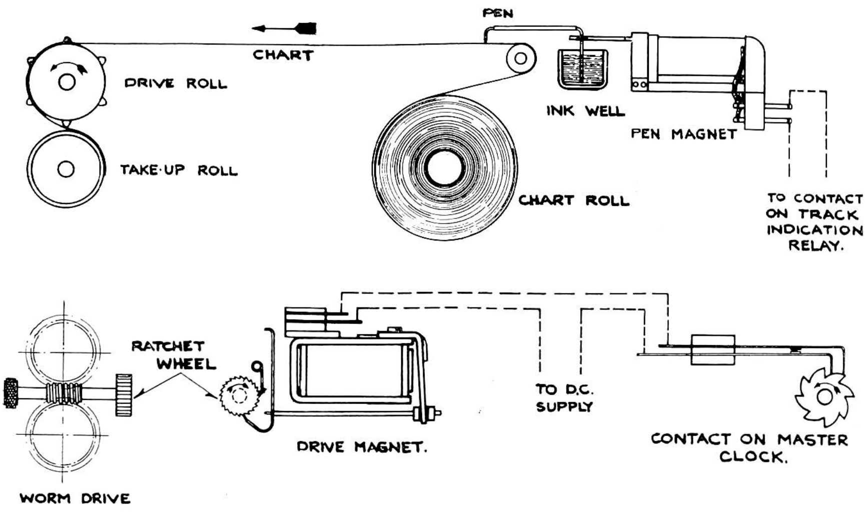
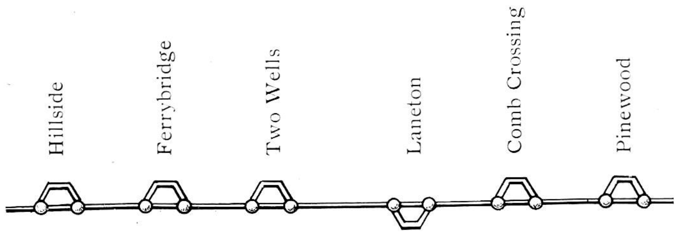


Figure 8. Train Graph Recorder.

A glass top is fitted over the exposed portion of the chart and this facilitates the making of any notes on the chart for record purposes. Figure 9 gives a reproduction of a portion of the chart, the diagonal lines have been made by the operator to show the passage of the trains. The chart will run for approximately 48 hours without attention, and arrangements can be made to give warning of when attention—such as renewal of ink or paper—is required. A small diagram of the lay-out controlled is fitted just above the recording pens on this chart.



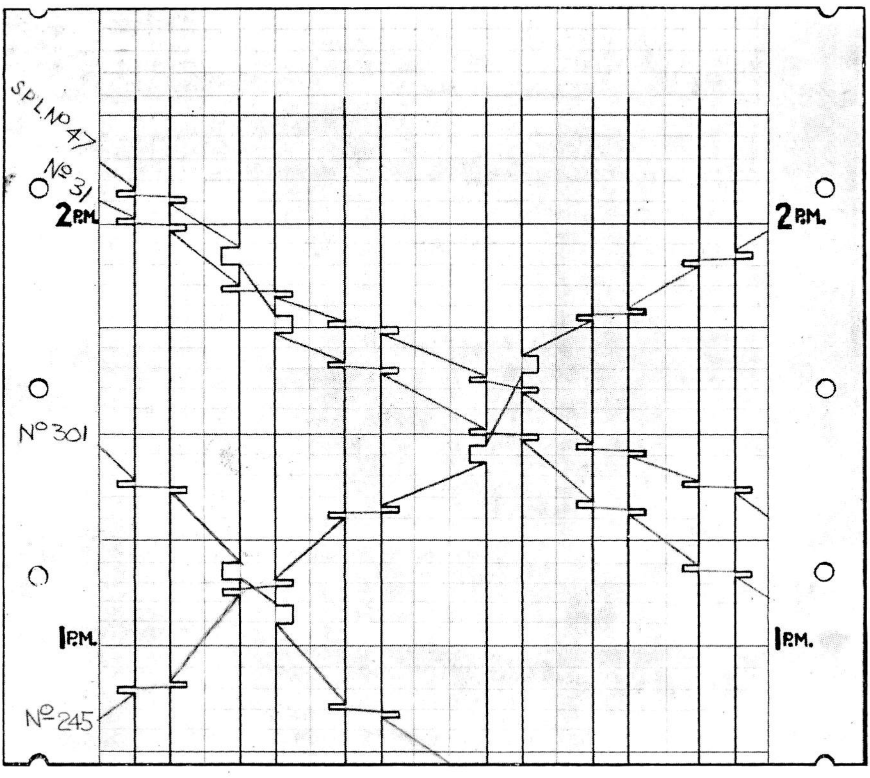


Figure 9. Chart from Automatic Train Graph Recorder (12 Pens).

Figure 10 is a rear view of the Control Machine, illustrated on page 14, inside of which are the office line (A), coding (B) and storage (C) units, consisting of cases containing the relays for these purposes. These cases are fitted with standard signal terminals at the back, and with detachable frames to which interwiring is connected. This facilitates the changing of any unit without disturbing the wiring. D is the Train Graph Recorder.

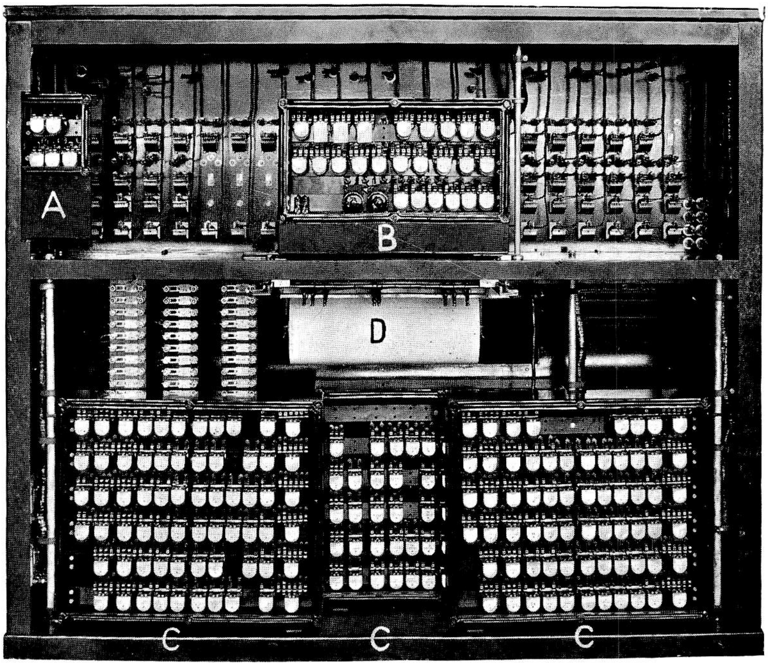


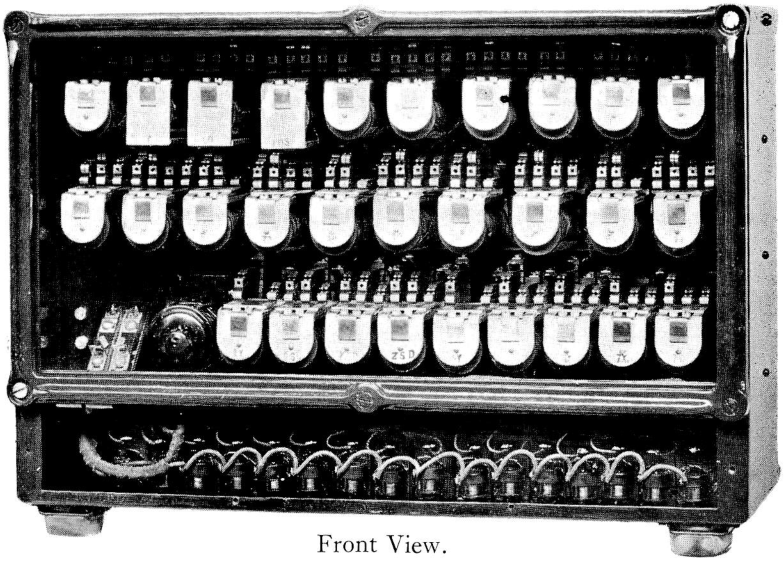
Figure 10. Rear View of Control Machine.

The Station coding, line and storage units are illustrated on pages 18 and 19, Figures 11, 12 and 13.

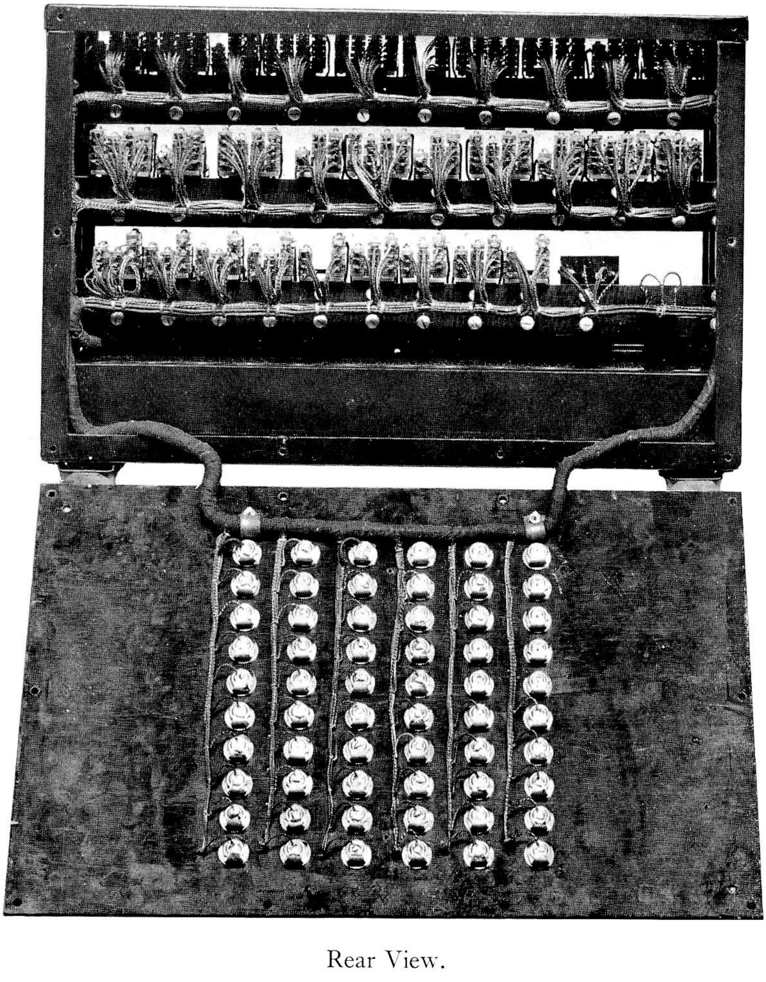
The titles of the different cases of Code and Storage Equipment used at the control office and at stations, and their relative positions in relation to the line circuits, are shown on page 20, Figures 14 and 15.

It often happens that additional points or track circuit indications are required at one or more stations along the route, and means are available whereby these extra functions can be controlled and repeated back by the use of additional apparatus. In such a case extra switches and room for track indications are provided for on the control machine.

Figure 11. STATION CODING UNIT.



Front View.



Rear View.

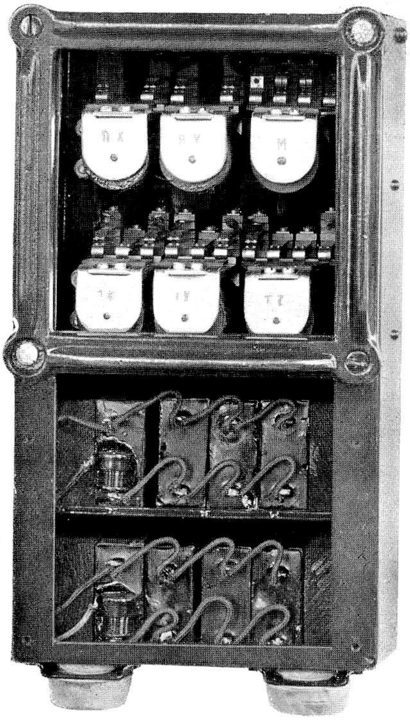


Figure 12. Station Line Unit.

Although the cases of code apparatus contain a number of relays, the design has been arranged so that these are housed in a minimum of space, and that all relay wiring is completed in the cases before despatch from the Factory, leaving only the connections to the main terminal frames outside to be carried out in the field.

Station storage units are fitted with the terminals which form the connecting link with standard signal circuits, and from these, wires run to signal and point control and indication relays, which are normally of the wellknown standard patterns.

The outside dimensions given below of the various cases for units indicate the small size of the code apparatus :

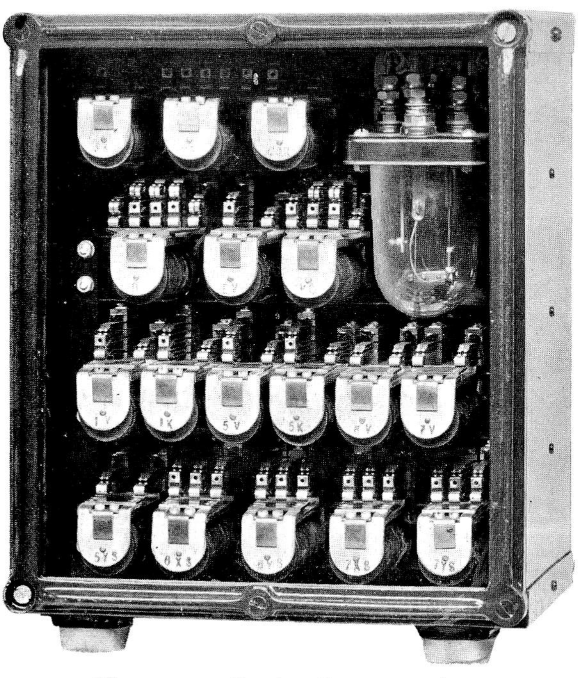


Figure 13. Station Storage Unit.

TIME CODE SYSTEM.

Line, Coding, and Storage Units, $20\frac{1}{2}''$ wide ; $15\frac{3}{4}''$ high ; $7\frac{3}{4}''$ deep.

CIRCUIT CODE SYSTEM.

Office or Station Coding Unit, 19″ wide ; 13″ high; 8″ deep.

Office or Station Line Unit, $6\frac{1}{2}''$ wide ; $12\frac{1}{2}''$ high ; 7″ deep.

Station Storage Unit, 11″ wide ; 13″ high ; 7″ deep.

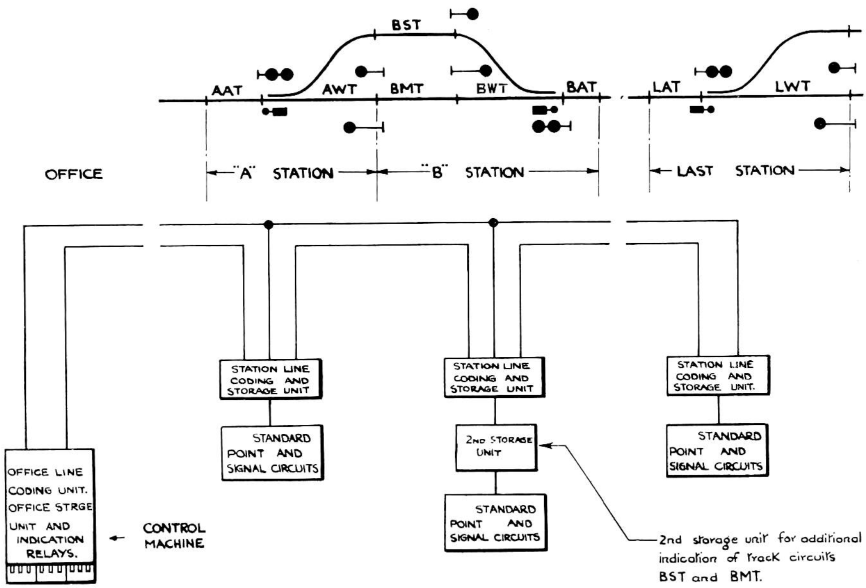


Figure 14. Allocation of code equipment, Time Code System.

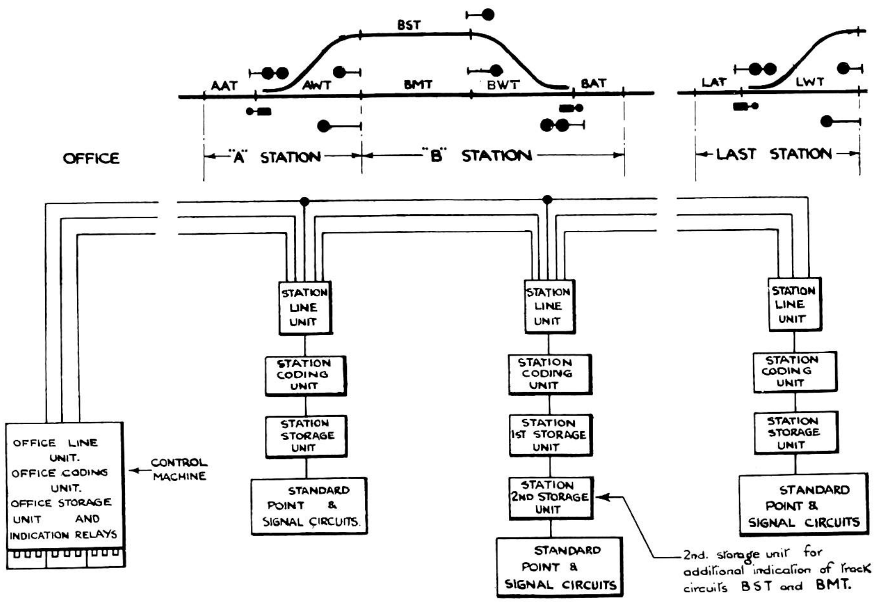


Figure 15. Allocation of code equipment, Circuit Code System.

Point Machines for use at outlying stations, where C.T.C. Systems are in operation, may be of the Dual Control Type, or of the ordinary type, provided that, if hand operation is to be employed, an interlocked circuit controller normally containing the hand operating lever for the point machine is fitted in the control circuits.

The thermal cut-outs necessary to protect point machines against prolonged running on the clutch, are referred to on page 12, and on page 3 the method of obtaining approach locking, by the use of time element relays for preventing operation of the point movement if the approach track is occupied after a signal has been cleared.

If the points at passing loops are to be operated by the train crew, and not power worked under control of the C.T.C. operator, switch locks may be provided, these being released by code and indicated back. In such cases approach locking is made effective on the switch lock instead of on a point machine.

The power supply has already been referred to, and it remains to say that small switches are provided at each station to enable that station to be cut out if required, and a resistance equivalent to the line relays at that station inserted in the code lines. This enables any station to be taken off the line for testing purposes without interfering with the operator's control of other stations. Adequate line protection in the way of lightning arresters is provided for.

Some indication of the extent to which C.T.C. has already been applied may be gained by reference to the installations already made. Up to the end of 1930, 38 installations were actually in service and a further 7 in process of installation. These installations cover a total of 755 route miles having a total of 904 track miles. The number of passing loops controlled in the 45 installations is 129, the number of points being 348.

Some of these installations are signalled with semaphore signals and some with light signals, the totals being 205 semaphore and 767 light type.

These installations are not confined to a few railways, but are distributed over 16 different roads, and include many examples of the application of both the Time and the Circuit Code System.

In order to enable schemes and estimates for C.T.C. Systems to be prepared with reasonable accuracy, information on the following 12 points should be given.

(1) Plan of new signalling giving details of type of signals, distances, operation of points (hand or power), existing track circuits, etc.

(2) Operation and description of traffic through the length to be signalled with C.T.C.

(3) Details of optional semi-automatic and/or automatic operation of all or certain signals.

(4) Details of existing or proposed mechanical or power interlockings in the area.

(5) Minimum number of indications to be sent to the Office.

(6) Is Automatic Train Graph required ?

(7) Details of power supply available.

(8) Details of any pole line available for C.T.C. line wires.

(9) *Position of Control Office.

(10) Details of space available in Control Office.

(11) Details of type of apparatus housings required at the layouts, and along the track.

(12) Details of intermediate section signalling with circuit plans (if existing).

*With regard to the position of the Control Office, this is generally determined by operating requirements rather than by engineering facilities; and there is no difficulty in meeting operating requirements, should it be desired to locate the Control Office at some point not on the section of line to be controlled.

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