Standard

RAILWAY SYSTEMS

TRAFFIC CONTROL

TELEPHONE EQUIPMENT

(REVISED EDITION)

Standard

TRAFFIC CONTROL

TELEPHONE SYSTEMS

Standard Telephones and Cables Limited

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(Photograph by Courtesy of the L.N.E.R.)

L.N.E.R. Stream Lined Express, Silver Jubilee, passing the North end of the New Southgate factory.

TRAFFIC CONTROL TELEPHONE SYSTEMS

INTRODUCTION

The efficient operation of any Railway System can only result from the careful arrangement of train schedules. Many unforeseen difficulties may interfere with running to a fixed schedule and under abnormal operating conditions efficient working can only be maintained if the arrangements are left in the hands of one controller.

The controller must be in touch with all members of the railway staff who are concerned with traffic operation and his means of communication must allow him to pass instructions to and receive reports from them without delay whenever necessary.

The telephone has many advantages over the telegraph for this purpose as it is both quicker and does not require trained operators.

A telephone system requiring an individual circuit to each telephone is generally prohibitive in cost and since, in the case of a telephone system for traffic control, all telephones occur in succession along the line, the obvious solution is to work on one pair of wires. The code ringing omnibus telephone arrangement is not satisfactory because of the time wasted in calling and the possibility of the wrong person answering.

For a two wire system it is therefore necessary to provide means of calling the required way station without producing any signal at the others.

The means adopted for selective calling must be highly reliable and must eliminate false calls, even those caused by external interference on the line. The selective mechanism should be capable of allowing a large number of differently coded way stations to be connected on one circuit and should cause the minimum of loss to speech currents, making a long line carrying many way stations practicable from the speech transmission point of view.

To reduce maintenance expense the system should preferably work without operating batteries at way stations. It should also be independent of current conditions in the line circuit to insure reliability, particularly when long open wire lines are used.

The Traffic Control System described in these pages is designed to meet all these requirements and at the same time to be suitable for superimposed telegraph circuits and phantom working. The system in its standard form provides means for calling one out of as many as 400 differently coded stations, for calling all stations simultaneously and for sending time signals.

Railway Traffic Superintendents and Telegraph Engineers will readily see how such a telephone system can best be applied to their own particular requirements, so as to effect economies over the earlier telephone or telegraph circuits installed.

Those who are interested can always see a working model of the system in operation at the Company's New Southgate factory.

Railway Companies who are using the Traffic Control System are also good enough to allow officials of other railways to inspect their plant and obtain details of their method of operation.

Among the various uses to which the system is being put at present are -

1. Train Ordering.
2. Distributing Brake Vans.
3. Requisitioning Power direct from Locomotive Sheds.
4. Moving traffic from point to point as expeditiously as possible and for recording, on forms provided for the purpose, particulars of traffic required to be moved.
5. Arranging for a minimum amount of light mileage.
6. Securing the maximum workable loads.
7. Following closely the working of all trains so that any operational difficulties can be taken up by the Traffic Department and steps taken to obviate them. For this purpose charts, diaries, diagrams or registers are at first kept of the daily working but are generally very much modified or reduced in volume when the initial difficulties have been overcome.
8. Interchanging and daily balancing of stock at engine changing stations.
9. Distributing stock in conjunction with District Offices.
10. Working and arranging all ballast and material trains.
11. Operating Engineering Blocks.
12. Controlling emergency single line working in case of obstructions.

13. Controlling banking and shunting locomotives.
14. Obtaining stock reports from all sidings and goods yards.
15. Controlling the time and working of enginemen and guards, so that they return to their depot within the working day, thereby avoiding overtime and idle hours.

It is unnecessary to point out to experienced railway men either the economies that can be effected or the favourable reception that such a system is likely'to get from the staff.

A railway engineer who visited the various installations of Standard Telephones and Cables Ltd. Train Control Systems on the Indian Railways, reports that it has been enthusiastically welcomed by all who come in contact with it. The Engineering Departments find it of great help in working their ballast trains, which before the introduction of the Control System lost 30 per cent. of their usefulness in waste time at stations, while the Locomotive Department finds that running hours are much reduced and more engine power is available.

An English railway official has stated that the reduction in locomotive running hours alone paid for the installation of the system in less than three months.A calculation made by an official of an Indian Railway shews that the cost of the apparatus amounts to about one-twelfth of the wages of the control staff and that, taking into account the saving in engine power, wagons and wages, THE TOTAL CASH VALUE SAVED ON ONE SECTION IN A FORTNIGHT PAID FOR THE EQUIPMENT TWICE OVER AND FOR ITS MAINTENANCE. The question, then, is not whether any railway company can afford to instal this system at the present time, but how much longer any railway company can afford to be without it.

On one of the Indian railways, to meet the increased traffic necessary during the war, the system of pooling locomotives was introduced. This is generally an unpopular arrangement with engine staffs and not usually recommended by those dealing with engine power, but it could not be avoided as further power was at the time unobtainable. A locomotive man was placed in the control room to deal with the pooling system and to see that the " round turn " was never allowed to be exceeded. Working in connection with the control it was found possible to operate without friction, to increase the mileage per engine by 45 per cent. and to save 10 engines. Thus for 24 engines the total running miles per month were 38,214 against 33,000 per month for 34 engines before pooling.

SOME OF THE IMPORTANT RAILWAYS USING THE STANDARD TRAFFIC CONTROL SYSTEM

AFRICA.
South African State Railway.
Sierra Leone Railway.
The Biera and Rhodesia Railways.

CHINA.
Shanghai-Nanking Railway.
Nanking-Canton Railway.

EGYPT.
Egyptian State Railways.

FEDERATED MALAY STATES.
State Railway.

GREAT BRITAIN.
London, Midland & Scottish Railway
Southern Railway.
London & North Eastern Railway.
Great Western Railway.

INDIA & BURMA.
Burma Railway.
Bengal-Nagpur Railway.
Bombay, Baroda & Central India Railway.
East Bengal Railway.
East Indian Railway.
Great Indian Peninsular Railway.
Madras and Southern Mahratta Railway.

INDIA & BURMA.
North Western Railway.
Oudh and Rohilkhand Railway.
South Indian Railway.

PALESTINE.
Palestine Railways.

SOUTH AMERICA.
All the principal Railways, including the Buenos Aires and Pacific Railway.
B.A. Western.
Central Argentine Railway.
B.A. Southern.

SWEDEN.
Swedish State Railway.

U.S.A. & CANADA.
Chicago, Burlington and Quincy.
Illinois Central.
Pennsylvania (East).
Southern Pacific.
Pennsylvania (West), Etc., Etc.
Canadian Pacific.
Chicago and North Western.
Northern Pacific.
New York Central and Hudson River.
Union Pacific.

Also used by numerous Passenger Transport Companies in the United Kingdom.

DETAILS OF SYSTEM

Selection of the required way station is obtained by a coded train of impulses, normally comprising three groups. The total number of impulses in the three groups is the same for all codes and the receiving apparatus is designed to respond only to the correct total, so that lost impulses or additional impulses, due to external interference, cannot cause the wrong way station to respond. The system, therefore, either calls the desired station or the call is ineffective.

The presence or the absence in the Controller's receiver of a “ring-back” tone generated from contacts on the way station ringer, immediately advises him of either the completion or non-success of the call.

Selector Keys

The function of the selector key is to control the operation of the battery relay and the pole-changer relay, which in turn control the main line battery current and send the sequence of current impulses necessary to operate the selectors at the station desired.

The keys are mounted in an oak case and can easily be removed with a screwdriver by turning the screw under the handle counter-clockwise. The keys when mounted make contact with the springs in the back of the key case. The springs are connected with the binding posts marked K 1, K2, K3 at the end of the case. When a key is operated, by turning the handle one quarter turn and then releasing, it should return automatically to its normal position. The speed at which it returns is regulated by a governor which can be adjusted by bending in or out the springs carrying the governor weights to increase or decrease respectively the speed of the key. The governor springs for the No. 4001-A key are so adjusted that the impulse wheel will make one revolution in not less than $7^1/_2$ seconds and not more than 8 seconds.

When the key is not operating, the end of the inner contact spring should fully clear the impulse wheel and when the wheel is revolving, should make contact with it all the time. The contacts K1-K3 between the inner spring and the impulse wheel control the operation of the battery relay.

The outer contact spring should make contact with the inner spring only when the latter is passing over one of the teeth of the impulse wheel. This spring should be so adjusted that the time this contact is opened should equal the time that it is closed, i.e., it should be opened one half and make

one half of the time which the inner spring takes to pass over the regular teeth of the impulse wheel. This, of course, does not include the time while the spring is passing over the large segments. The duration of closure of this contact can be determined by putting the contact terminal K I-K2 in series with a voltmeter and a battery or a milliammeter and battery and non-inductive resistance. Then the average reading of the meter needle, while the contact springs are passing over the small teeth of the impulse wheel, should be one half of the steady reading of the meter while the contact is held closed by hand or is shorted. All keys should be set before the telegraph relay is adjusted.

No. 4001-A Selector Key

The 4001-A Selector Key is for use with the No. 60-A or 4301-A Selector and may be set for any of the code numbers given in Table No. 1 by adjusting its segments as described in detail below.

Method of Setting Keys

In setting the key each closure of the contacts counts one and each opening of the contacts counts one. Two styles of segments are provided:- one a flat segment which closes the contacts while the inner passes over it, the other segment has a bent-up part which engages with the insulated piece on the outer spring, raising this spring sufficiently to keep the contacts open while the outer spring passes over.

Each key requires two segments to give the three sets of impulses. The setting of the segments is done by counting the first number of the code from the first tooth in a clockwise direction and the last number of the code from the ringing position in a counter-clockwise direction. The space between the two segments will represent the middle number of the code. Counting in the manner indicated, if the number ends on a tooth, use a flat segment, if in a space, a bent-up segment. Thus two of either style of segment, or one of each, may be required to give the code setting.

For example, to set the 4001-A Selector Key for selecting station 8-5-4 begin at the first tooth and count 8 (first number in code) in a clockwise direction, counting one for each tooth and one for each space--in this case 4 teeth and 4 spaces, ending with a space. As the last count was a space, take a bent-up segment and place it so as to keep the contact in the same position while passing over the segment as on the last count. This segment is set approximately flush with the edge of the next tooth, so that the outside con-

tact spring will be off this segment before the inner contact spring strikes the next tooth.

To set the other segment, begin at the ringing position and count 4 (last number in code) in a counter-clockwise direction, counting one for each space and one for each tooth, in this case two spaces and two teeth, ending on a tooth. As the last count was on a tooth, use a flat segment and set the edge on the centre of this tooth. The number of closures and openings of the contact while the inner spring passes between the two segments will be the middle number of the code (5 in this case).

To set the key so that all No. 4301 Selectors will be advanced to their " time " receiving position, place a flat segment bridging from the centre of the first tooth to the centre of the fourth tooth. This gives after the first long impulse, 22 regular impulses in succession.

The No. 4001-B Selector Key

The 4001-A Key is the one most generally used, but in certain cases, the 4001-B, which is a Grouping Key, may be required.

The No. 4001-B Selector Key, when set for the code numbers given in Table 2 is for use with the No. 4302-B Selector. This key may be set for any of the code numbers given in Table No. 2 by the adjustment of its segments in a manner similar to that explained in detail for the No. 4001-A Key, with the exception that a third flat segment is used, so that the total number of impulses is increased by 2, 4 or 6 as shown in Table No. 2.

The governor springs for the No. 4001-B Selector Key should be so adjusted that the impulse wheel will make one revolution in not less than 9 seconds and not more than $9^1/_2$ seconds.

Controller's Station Selective Equipment

The circuit interruptions of the selector keys are passed through a circuit comprising a battery reversing relay and a special network which convert the key impulses into $3^1/_2$ cycles per second alternating current. Each half cycle of the line current is one impulse of the code.

Telegraph Relay.

The function of the Telegraph Relay is to reverse the polarity of the main battery so that each succeeding impulse sent over the line is in the opposite direction to the preceding one. This relay is controlled by the local battery

and the K1-K2 contact of the calling key, the contact being made as the former passes over the teeth of the impulse wheel.

The resistance of the relay is 25 ohms. It should receive from 0.3 to 0.4 ampere of current for operation. The air gap between the middle contacts and the front contacts should be approximately 32" when the relay is not operated. When the relay is operated the air gap between the middle and the back contacts should be approximately $^{3}/_{64}$". To keep the sparking of the contacts at a minimum, it is important that the two front and the two back contacts make or break at the same time.

As the relay is operated by the short impulse from the calling key, the time elapsing while the front contacts are made should equal the time for making the back contacts, so that the time that the potential is held on the line for each reverse current impulse will be equal. This can be determined quite closely by observation, but more accurately by use of a zero centre scale voltmeter or a zero centre scale milliammeter with a resistance to limit the current.. For this test the meter should be connected directly across the line wires. In any case the swing of the needle as the contact springs pass over the small teeth of the calling key should be the same amount each side of the centre point. This shows that the positive impulses are of the same duration as the negative impulses. If this test shows that the positive and negative current impulses are not equal, the magnets of the relay should be adjusted by means of the knurled nut at the end of the magnets, used for changing the magnetic air gap. Increasing the magnetic air gap will decrease the time during which the front contacts are made. Decreasing the magnetic air gap will increase this time.

Caution.- Before attempting to adjust the relay the main battery switch should be opened.

Note.- In some installations a 4664 Type Relay is used for the pole changing relay. The operation of this relay in combination with a rheostat to control the impulse ratio is described in the section dealing with Dial Traffic Control.

Circuit Breaker.

The function of the Circuit Breaker is to open the main battery lead if an excessive amount of current flows from the battery, such as is caused by a short on the line or in any part of the sending circuit.

The resistance of the Circuit Breaker is 2 ohms and it is normally adjusted to operate on 0.6 ampere and non-operate on 0.4 ampere. On re-setting thecircuit breaker after it has been operated, care should be taken

not to hold it in forcibly by hand so that, if the trouble is still on the line, the Circuit Breaker will have an opportunity to re-open the battery circuit.

Way Station Selector

The Way Station Selector is a polarised relay arranged to advance a ratchet wheel tooth-by-tooth as successive impulses of opposite polarity are received. The ratchet wheel carries a code wheel into which code pins can be fitted in positions corresponding to any ratchet wheel tooth. The code wheel carries a contact arm which is in contact with the ringing terminal in one position of the code wheel and with the time terminal in another position.

The code wheel is normally set so that 17 impulses are required to take the contact arm to the ringing terminal and 23 impulses to take it to the time terminal. During selective calling, 17 impulses divided into three groups are received and the selector, coded to correspond with the three impulse groups transmitted, is stepped to its ringing position and operates a local bell.

The coils of the selector are wound to 21,000 ohms and are tuned to 3 cycles per second by a condenser in the selector set. The impedance at 31 cycles is 35,000 ohms and the impedance at 800 cycles is over I megohm. The loss to speech due to the selectors is therefore invariably considerably less than the loss due to line leakage.

Way Station Selector Set

The Way Station Selector is associated with a tuning condenser and a local battery ringer. The way station selector set accommodates all this apparatus in one unit thus making the selection equipment separate from the telephone set. The circuit of the way station selector set is arranged to provide ring-back tone when the local bell operates.

Controller's Telephone Set

Since the controller on duty is normally listening on the line, a head-set is the most convenient type of telephone to employ. This set is fitted with a plug and is connected to the talking circuit by jacks, which are so arranged that two controllers can be on duty together. An alarm circuit is closed when neither head-set is connected. This circuit can be used either to connect an extension bell to the line or to cut-in an amplifier and loud speaker. In the former case, way stations would require a magneto for calling the controller

while the second arrangement retains the normal method of operation but enables way station calls to be heard at a reasonable distance from the control position.

The controller's talking circuit is of the high efficiency type, so arranged that by means of a foot switch, which is operated to speak, the impedance matching is made optimum for both the transmitter and the receiver.

Way Station Telephone Set

The Way Station Telephone Set can be either a wall set or a desk set, in each case a moulded hand microtelephone and a high efficiency speech circuit being employed. The "Speak-Listen" switch takes the form of either a key fitted

in the wall set or a foot switch connected to the desk set. If more convenient, a key can be provided for use with the desk set.

Code Tables

The code system generally used contains a total of 17 impulses, the selectors and selector keys being normally coded to this total. The code total, however, may be made any number up to 27 and there is usually no advantage to be gained by using a total smaller than 17. The following tables give the code settings for 17 and 27 impulses and similar tables can easily be constructed for intermediate arrangements.

CODE TABLE No. 1

Total Steps in each Code—17. Total code settings for the 4301-A Selector—78.

2–2–13					
2–3–12	3–2–12				
2–4–11	3–3–11	4–2–11			
2–5–10	3–4–10	4–3–10	5–2–10		
2–6–9	3–5–9	4–4–9	5–3–9	6–2–9	
2–7–8	3–6–8	4–5–8	5–4–8	6–3–8	7–2–8
2–8–7	3–7–7	4–6–7	5–5–7	6–4–7	7–3–7
2–9–6	3–8–6	4–7–6	5–6–6	6–5–6	7–4–6
2–10–5	3–9–5	4–8–5	5–7–5	6–6–5	7–5–5
2–11–4	3–10–4	4–9–4	5–8–4	6–7–4	7–6–4
2–12–3	3–11–3	4–10–3	5–9–3	6–8–3	7–7–3
2–13–2	3–12–2	4–11–2	5–10–2	6–9–2	7–8–2
8–2–7					
8–3–6	9–2–6				
8–4–5	9–3–5	10–2–5			
8–5–4	9–4–4	10–3–4	11–2–4		
8–6–3	9–5–3	10–4–3	11–3–3	12–2–3	
8–7–2	9–6–2	10–5–2	11–4–2	12–3–2	13–2–2

CODE TABLE No. 2

Total Steps in each Code—17. Total code settings for the 4302-B Selector—46 (Giving 184 independent calls, 4 in each section coded with total impulses 17, 19, 21 and 23).

3–4–10	5–2–10				
3–5–9	5–3–9				
3–6–8	5–4–8	7–2–8			
3–7–7	5–5–7	7–3–7	8–2–7		
3–8–6	5–6–6	7–4–6	8–3–6	9–2–6	
3–9–5	5–7–5	7–5–5	8–4–5	9–3–5	10–2–5
3–10–4	5–8–4	7–6–4	8–5–4	9–4–4	10–3–4
3–11–3	5–9–3	7–7–3	8–6–3	9–5–3	10–4–3
3–12–2	5–10–2	7–8–2	8–7–2	9–6–2	10–5–2
11–2–4					
11–3–3	12–2–3				
11–4–2	12–3–2	13–2–2			

CODE TABLE No. 3

Total steps in each Code—17.
Code settings available for the 4302-B Selector when 4301-A Selectors are in use and the system is coded to Table No. 1. (Maximum number of independent calls—162).

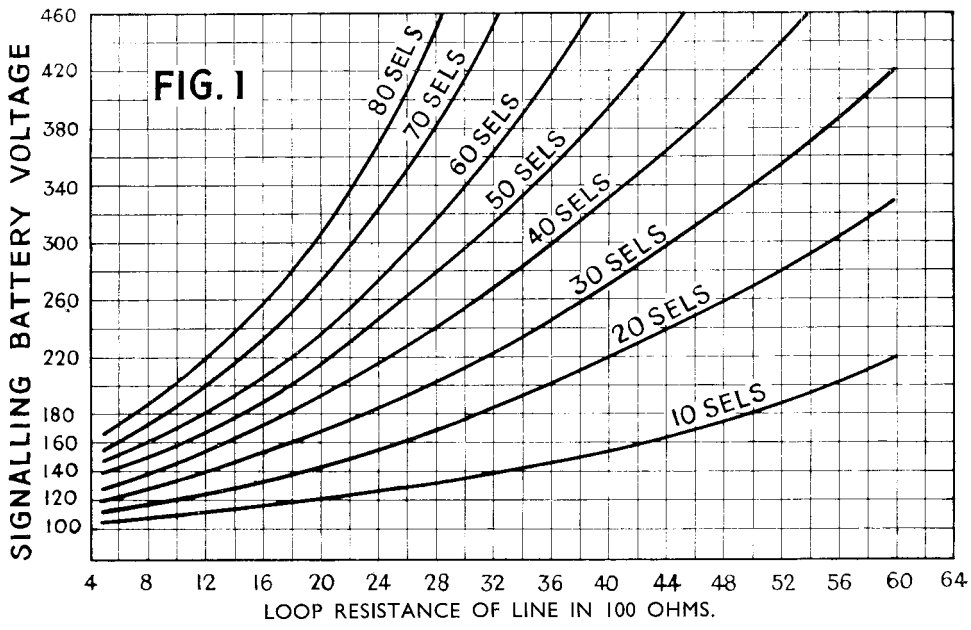
7–2–8						
7–3–7	8–2–7					
7–4–6	8–3–6	9–2–6				
7–5–5	8–4–5	9–3–5	10–2–5			
7–6–4	8–5–4	9–4–4	10–3–4	11–2–4		
7–7–3	8–6–3	9–5–3	10–4–3	11–3–3	12–2–3	
7–8–2	8–7–2	9–6–2	10–5–2	11–4–2	12–3–2	13–2–2

CODE TABLE No. 4

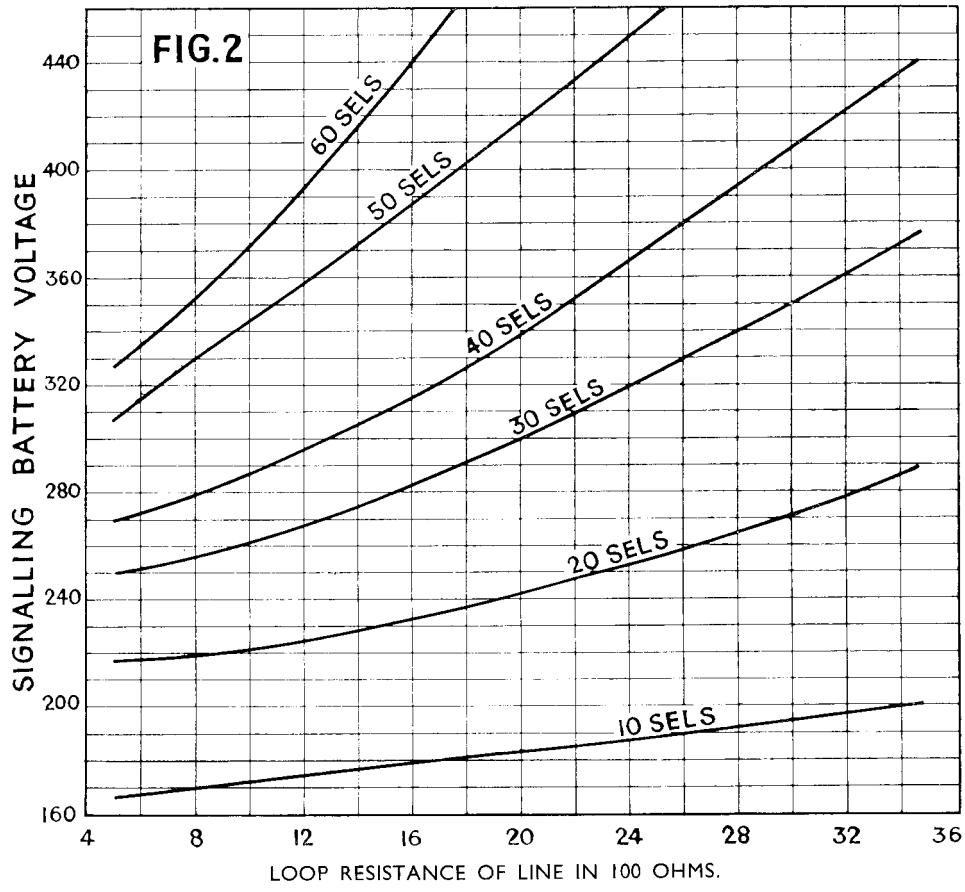
Total Steps in each Code—27. Total Code Settings for the No. 4301-A Selector—241.

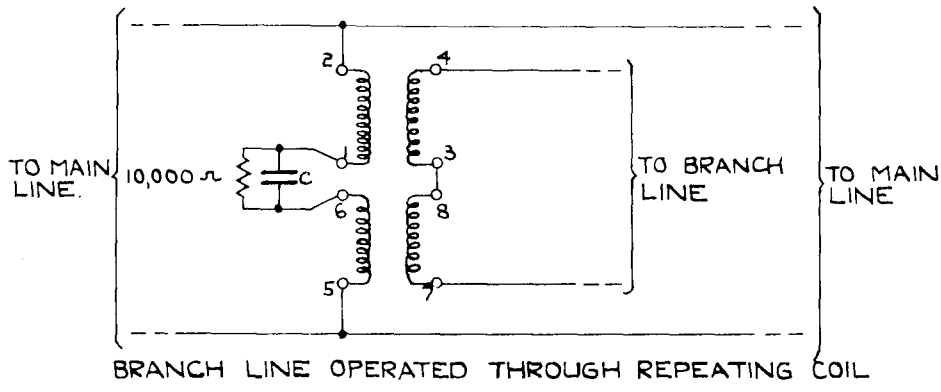
2–5–20	3–4–20	4–3–20	5–2–20			
2–6–19	3–5–19	4–4–19	5–3–19	6–2–19		
2–7–18	3–6–18	4–5–18	5–4–18	6–3–18	7–2–18	8–2–17
2–8–17	3–7–17	4–6–17	5–5–17	6–4–17	7–3–17	8–3–16
2–9–16	3–8–16	4–7–16	5–6–16	6–5–16	7–4–16	8–4–15
2–10–15	3–9–15	4–8–15	5–7–15	6–6–15	7–5–15	8–5–14
2–11–14	3–10–14	4–9–14	5–8–14	6–7–14	7–6–14	8–6–13
2–12–13	3–11–13	4–10–13	5–9–13	6–8–13	7–7–13	8–7–12
2–13–12	3–12–12	4–11–12	5–10–12	6–9–12	7–8–12	8–8–11
2–14–11	3–13–11	4–12–11	5–11–11	6–10–11	7–9–11	8–9–10
2–15–10	3–14–10	4–13–10	5–12–10	6–11–10	7–10–10	8–10–9
2–16–9	3–15–9	4–14–9	5–13–9	6–12–9	7–11–9	8–11–8
2–17–8	3–16–8	4–15–8	5–14–8	6–13–8	7–12–8	8–12–7
2–18–7	3–17–7	4–16–7	5–15–7	6–14–7	7–13–7	8–13–6
2–19–6	3–18–6	4–17–6	5–16–6	6–15–6	7–14–6	8–14–5
2–20–5	3–19–5	4–18–5	5–17–5	6–16–5	7–15–5	8–15–4
2–21–4	3–20–4	4–19–4	5–18–4	6–17–4	7–16–4	8–16–3
2–22–3	3–21–3	4–20–3	5–19–3	6–18–3	7–17–3	8–17–2
2–23–2	3–22–2	4–21–2	5–20–2	6–19–2	7–18–2	
9–2–16						
9–3–15	10–2–15					
9–4–14	10–3–14	11–2–14				
9–5–13	10–4–13	11–3–13	12–2–13			
9–6–12	10–5–12	11–4–12	12–3–12	13–2–12		
9–7–11	10–6–11	11–5–11	12–4–11	13–3–11	14–2–11	
9–8–10	10–7–10	11–6–10	12–5–10	13–4–10	14–3–10	
9–9–9	10–8–9	11–7–9	12–6–9	13–5–9	14–4–9	
9–10–8	10–9–8	11–8–8	12–7–8	13–6–8	14–5–8	
9–11–7	10–10–7	11–9–7	12–8–7	13–7–7	14–6–7	
9–12–6	10–11–6	11–10–6	12–9–6	13–8–6	14–7–6	
9–13–5	10–12–5	11–11–5	12–10–5	13–9–5	14–8–5	
9–14–4	10–13–4	11–12–4	12–11–4	13–10–4	14–9–4	
9–15–3	10–14–3	11–13–3	12–12–3	13–11–3	14–10–3	
9–16–2	10–15–2	11–14–2	12–13–2	13–12–2	14–11–2	
15–2–10						
15–3–9	16–2–9					
15–4–8	16–3–8	17–2–8				
15–5–7	16–4–7	17–3–7	18–2–7			
15–6–6	16–5–6	17–4–6	18–3–6	19–2–6		
15–7–5	16–6–5	17–5–5	18–4–5	19–3–5	20–2–5	
15–8–4	16–7–4	17–6–4	18–5–4	19–4–4	20–3–4	
15–9–3	16–8–3	17–7–3	18–6–3	19–5–3	20–4–3	
15–10–2	16–9–2	17–8–2	18–7–2	19–6–2	20–5–2	

DIRECT SIGNALLING.



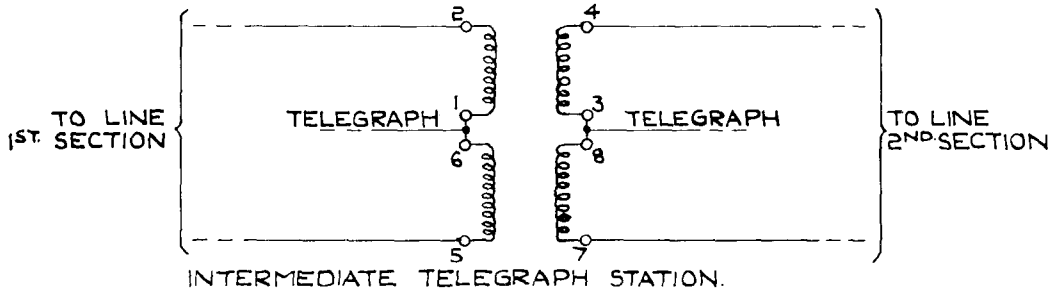
SIGNALLING THROUGH ONE TRANSFORMER





BRANCH LINE OPERATED THROUGH REPEATING COIL

Fig. 6.



INTERMEDIATE TELEGRAPH STATION.

Fig. 7.

Line Voltage Curves

The operating battery voltage required depends on the line resistance and the number of selectors bridged across the line.

Fig. I shows the voltage required for 10-80 selectors bridged across a line from 400 to 6,000 ohms loop resistance, calculated on the assumption that the selectors are equally spaced. These curves may be used for all normal arrange ments of way stations and only fail when a large number of selectors are connected to a long line at one point.

Fig. 2 gives the corresponding curves for 10-60 selectors operated over a line of 400 to 3,000 ohms through a 341-A Transformer or a 70-A Repeating Coil.

Fig. 3 gives line voltage corresponding to Fig. 2, but for operation through two 70-A Repeating Coils connected in series-aiding.

SUMMARY OF SALIENT FEATURES

1. As the number of way stations is practically unlimited, the controller can speak to any point on the line.
2. There are only two wires and no "earth" connections so that the erection and maintenance of the system is simple and rain and snow storms have little effect. Hence the system is reliable in bad weather.
3. The controller can call any station in eight seconds by turning a key. He has no need to send out special code rings or select stations by working several switches at once. Moreover he actually hears the bell of the called station ringing.
4. The way station men simply take off their receivers and speak to the controller. They do not even have to ring and, as there are no relays or other adjustable apparatus at the way stations, there is nothing to get out of order.
5. Way station men cannot ring up one another, but any two men can be connected together by the controller, i.e., THE CONTROLLER REALLY CONTROLS THE LINE.
6. Working is so rapid and the speech so clear that the controller is in touch with every point on his line ; no movement of trains, trucks, locomotives, etc. can be made without his knowledge.
7. In an emergency the controller, by turning a single key, can call every way station at once and give general instructions to all his men.
8. Without any modification of the standard apparatus, a time signal can be sent to every station simultaneously, thus enabling clocks to be checked.
9. The system is so flexible that any reasonable special requirement can be met without interfering with the efficiency of the system in its simple form.
10. The apparatus is more robust than that used on the majority of other control systems and the number of adjustable parts is reduced to a minimum which ensures reliability of action.

APPARATUS REQUIRED FOR TYPICAL TRAFFIC CONTROL SYSTEM

At Control Station

Item No. 1 — One No. 4001-B Selector Apparatus Case.

„ No. 2 — One No. 4002-A Selector Key Case (capacity twenty Selector Keys) to accommodate first twenty selector keys.

„ No. 2a— One No. 4002-B Selector Key Case (capacity twenty Selector Keys) for each additional twenty or fraction of twenty keys.

„ No. 3 — One No. 4001-A Selector Key for each No. 4301-A Selector installed at Way Stations.

„ No. 4 — One No. 4001-A Selector Key for "General Call."

„ No. 5 — One No. 4001-A Selector Key for "Time Sending."

„ No. 6 — One No. 4001-C Selector Key Space for each position in Items 2 and 2a not fitted with a key.

„ No. 7 — Two No. 41 10-A or 98-A Protectors.

„ No. 8 — One No. 4001-A Selector Time Sending Set.

„ No. 9 — One No. 4086-A Telephone Set.

„ No. 10 — One No. 4002-A Jack Box.

„ No. 11 — Three No. 4403-H Telephone Sets.

„ No. 12 — One No. 4001-A Foot Switch.

„ No. 13 — One No. IA or 1B Foot Switch Attachment (if required).

„ No. 14 — Two Storage Batteries (4 volts) for Controller's Telephone.

„ No. 15 — Two Storage Batteries (10 to 12 volts) for control and impulsing relays.

„ No. 16 — Main signalling supply voltage to be in accordance with curves on page 12, derived from A.C. mains rectifier, storage battery and charger or primary cell battery, as required.

Note.— For each way station equipped with a No. 4302-B Selector, the 4001-A Selector Key specified under Item 3 is to be replaced by a No. 4001-B Selector Key. One 4001-B Selector Key is also required for each additional extension bell connected to the 4302-B Selector.

At each Way Station

Item No. 1 — One No. 4001-A Selector Set.
„ No. 2 — One No. 4301-A Selector (for Item 1).
„ No. 3 — One No. 4308-C Telephone Set.
„ No. 4 — One No. 4003-B Battery Box (metal) or one No. 4002-A Battery Box (wood).
„ No. 5 — Three dry cells.
„ No. 6 — One No. 41 10-A or No. 98-A Protector.

If desk telephones are required in place of the No. 4308-C Wall Set, the following should be substituted for Item No. 3.

Item No. 7 — One No. 4506-B Telephone Set.
„ No. 7a — One No. 4001-A Foot Switch.
„ No. 7b — One No. 1A or 1B Foot Switch attachment (if required).

Other alternative patterns of telephone sets will be found in the Apparatus Catalogue published by this Company.

Note — Way stations equipped with the 4302-B instead of the 4301-A Selector (Item 2 above) will require from one to three Extension Bells and additional telephone sets (with dry cells and battery boxes) the quantity depending upon the number of extension sets connected to the selector. Additional No. 411 0-A or 98-A Protectors may also be required.

METHOD OF OPERATING THE SYSTEM

To Call Way Station

The controller operates the selector key labelled for the required way station by twisting the handle one quarter turn and releasing it. The key returns to the normal position under its clockwork drive, taking about seven seconds for the complete run. During the first four seconds the calling impulses are transmitted, after which the distant bell rings for 2-3 seconds. During ringing the controller can hear ring-back tone in his receiver.
Failure to hear ring-back indicates that for some reason the call has been ineffective and the operation should be repeated.

To Call all Way Stations (General Call)

The controller is provided with a key labelled " General Call." This key is operated exactly as for calling one way station and rings the bells at all stations on the line.

Time Sending

For sending time signals to way stations all selectors must be set to their time receiving position by the operation of the key labelled "Time Sending." The transmitting equipment is then disconnected from the calling keys and connected to the telegraph circuit or master clock from which the time signals are to be given by operating the switch on the time sending set to the position marked "Time."

The time signals will be transmitted as a series of impulses which will be audible to the controller as clicks in his receiver. When the time impulses are completed, the switch on the time sending set is returned to the position marked " Call " and any way station key in the key case is operated to release the way station selectors from the time receiving position. It should be noted that since no selector is in the home position, the operation of this key will not cause any bell to ring. The system is then ready for way station calling in the ordinary way.

Group Calling

Where the system is arranged to call one or more groups, each comprising several selected way stations, a selector key is provided for each group and carries a suitable label. The operation of one of these keys will ring the group of stations required.

To Call the Controller

Under normal conditions the controller is continuously listening on the line and a way station can call him by lifting the receiver and speaking.

In some cases, way stations are provided with a magneto for calling the controller at periods of light traffic when he is not on permanent duty. Under these conditions a way station wishing to call the controller should lift the receiver, listen to see that no conversation is already in progress and then speak to see whether the controller is on duty, after which, if necessary, the generator should be operated to ring the controller's extension bell.

Special telephone amplifiers for control stations are also available. They are designed to amplify incoming speech so that a loud speaker connected to them will produce sufficient volume for speech to be heard at a distance of several feet. They can therefore be used as calling devices, in place of extension bells, when the controller is not actually listening on the line. In addition amplifiers are available to replace the normal head set, thus

entirely relieving the traffic controller of the necessity of continuously wearing a head receiver when on duty.

Time Receiving

Time signals are received as a series of short rings of the bell. Local instructions will give the times of sending, the type of signal and will state which ring of the bell gives the correct time.

Operation of Telephone Sets

The telephone sets used are arranged for operation with a foot switch or key. With the foot switch depressed, the highest transmitting efficiency is obtained while with the foot switch released, the receiver efficiency is at its maximum. It is therefore necessary to operate the key or foot switch when talking and to release when listening. If full advantage of the efficiency of the telephone sets is to be taken, correct use must be made of this switching and this is particularly important on long lines.

APPARATUS FUNCTIONS AND CIRCUIT DESCRIPTION

Calling

The controller calls way stations by transmitting code impulses arranged to call only one of the stations connected to the line. Selective calling in the reverse direction, i.e., from way station to controller, is not necessary since all calls made by way stations are made to the one controller.

The impulse codes employed for calling various stations are divided into three digits, separated from one another by a steady line condition equal in duration to five impulses. The total number of impulses in the three digits is constant for all codes in any particular installation and may be any number up to 27. The larger totals give greater numbers of possible codes but occupy greater transmission time. The total usually employed is 17 which allows 78 independent codes (see Table No. 1). The impulses are normally transmitted at a speed of seven per second and a 17 impulse code takes a total transmission time of eight seconds, including three seconds ringing. Each code begins and ends with a single impulse, the final one to clear the call made and the initial one to re-set any selectors which may have been left in an intermediate position during maintenance, etc.

The constant total feature ensures that the system is exceptionally free from incorrect operation. Line interference must act equally and in opposite sense in two of the digits to alter a code and maintain the same total.

Since line interference is generally of one sense at a time and extra impulses must arrive within certain time limits to be effective, the odds against incorrect operation are enormous. Any line interference makes a call ineffective and the ring-back feature from contacts on the actual way station ringer avoids loss of time should this occur.

The impulse codes can be derived either from selector keys, of which there is one per way station, from a universal key or a telephone dial, of which there will be one for the system, or from a machine sending unit which is common to the system but has one telephone type key for each way station.

The selector key is a clockwork driven mechanism wound by a quarter turn of the handle and allowed to return to normal under the control of a governor which determines the running speed. During the return travel a toothed wheel interrupts a pair of contacts from which the impulses are derived. The code transmitted is determined by coding segments which mask three teeth of the wheel and prevent interruption of the contacts during this part of the travel. The key contacts control the coil circuit of a pole-changing relay which reverses the connections of the signalling battery to line, thus each time the key contacts open or close the line polarity undergoes a reversal. The line current passes through a smoothing network arranged to modify the square wave form obtained from the key contacts so that no objectionably sharp clicks will occur in the telephone receiver but merely dull thumps, which are not objectionable and do not interfere with telephone transmission. Each half wave is an impulse of the code and since the impulse speed is seven per second, the line current frequency is $3^1/_2$ cycles per second.

The first impulse of a code corresponds to closure of the key contacts ; therefore after an odd number of impulses in the first digit, the key contacts must be closed and after an even number they must be open. The arrangement at the end of the second digit is similar but dependent on the total impulses sent in the first two digits. If this total is odd, the contacts must remain closed and if the total is even, they must remain open during the second interdigital pause. To enable these conditions to be produced two types of coding segment are available, a flat one arranged to engage with the inner spring and maintain it in contact with the outer spring, that is, in a position corresponding to the tooth tip, and a bent up segment, arranged to engage with an insulating stud fitted to the outer spring and lift it clear of the inner spring.

The initial and final clearing impulses are obtained when the battery is connected to and disconnected from the line. This is effected by a battery relay operated by the closure of the circuit between the inner spring and the frame of the key, the inner spring being arranged to lie in a slot in the code wheel in the normal position of the key. By this arrangement the battery is only connected to the line during signalling and therefore the leakage current does not constitute a- permanent drain on the battery. The signalling battery maybe replaced by a rectifier unit which need not supply a smoothed output since speech is never on the line simultaneously with signalling.

Circuit Diagram Fig. 4 (see drawing at end of brochure) shows the arrangement of the Sending Equipment. The main signalling battery is connected to the contacts of the pole-changing relay through a circuit breaker and a main switch. The reversing contacts of the pole-changing relay are connected through the smoothing network and the contacts of the line relay to line isolating switches, the purpose of which is to enable one section of the line to be cut off when faulty and allow the other section still to be operated. This diagram also shows the connections between the sending circuit, the selector keys and the time sending set.

Several installations have been completed in which the codes are originated by telephone dial instead of selector keys. This system is described under a separate heading on page 32.

Where a large number of way stations are controlled from one office, a motor-driven sender becomes an economical proposition. The sender consists of a rotary switch arranged to send a suitable number of impulses and provided with cams to mask any five of the impulses. Any three digit code can therefore be sent by making connection to two of the cams and driving the sender. The appropriate connections are made through the contacts of lever type keys of which there may be one per station, thus retaining the rapid operation resulting from the use of individual keys and obtaining a more compact arrangement than is possible with selector keys.

Receiving

The receiving circuit employs a selector, the winding of which is connected in series with a condenser across the line. The condenser tunes the selector winding to the frequency of the impulses received. The selector is a polarised device with the armature normally resting in a central position. The windings are so arranged that current in one direction displaces the arma-

ture towards one side while current in the reverse direction displaces the armature towards the other side, the armature always returning to the central position when current ceases to flow. The armature operates a ratchet wheel through mechanical links and pawls, so arranged that the ratchet wheel takes one step for each armature displacement irrespective of direction. The mechanism is so arranged that impulses arriving as approximately smooth alternating currents step the ratchet wheel progressively and so that, during periods when current is not flowing through the windings, the pawls disengage and the ratchet wheel returns to its normal position under control of a helical spring.

The ratchet wheel spindle carries a code wheel, the rim of which is provided with a series of holes with the same angular spacing as the ratchet wheel teeth. A holding finger is positioned to lie normally just inside the circle of holes in the code wheel and is held outside the circle by the mechanism during stepping. This finger travels across a hole in the code wheel rim at the end of a series of impulses; if, therefore, a suitable pin is fitted in this hole, the holding finger will engage with it and prevent the ratchet wheel from returning to normal.

Thus the code wheel may be advanced by consecutive impulses of a digit at the end of which it may be held by a pin in the code wheel. If a pin is not fitted it will return to normal. Hence the selector can be set to advance pro gressively for all the digits of a code by fitting pins in appropriate positions and at the end of the code will have been displaced a number of positions equal to the total impulses in the code, say 17.

In the 17th position a pin is permanently fitted to the code wheel to engage with the holding finger and in this same position of the wheel a contact arm closes a circuit to the ringing terminal and operates the local bell from a local battery circuit.

Thus all selectors respond to all impulses but only one selector reaches its ringing position for a particular code of impulses.

Coding of the selector for impulse trains totalling more or less than 17 impulses is carried out by adjusting the code wheel on its spindle so that the fixed pin engages with the holding arm after the required total number of steps have been taken by the selector. The selector is designed to allow adjustment to give codes totalling up to 27 impulses.

The circuit diagram Fig. 4 shows the arrangement of the receiving equipment. In the normal position of the selector the line is bridged by the selector windings in series with the tuning condenser. When stepped to the ringing position, the contact on the selector code wheel completes the local circuit from the battery through the windings and interrupter of the ringer which operates. One side of the ringer is connected through a condenser to one line whilst the other side of the battery is connected through the holding finger to the other. Interruptions of the ringer circuit feed an alternating current at ringer frequency on to the line to indicate that the ringer is responding.

The general call, made by the controller when it is desired to communicate with all way stations simultaneously, is signalled by an unbroken train of 17 impulses. All selectors respond and, irrespective of the positions of intermediate code pins, reach position 17 and therefore all bells operate.

Selectors are set to the time receiving position by an unbroken train of 23 impulses. Again all selectors respond and, irrespective of intermediate coding pins, arrive in position 22. Instead of the normal holding pin they are held by the holding finger engaging with an arc which covers four code wheel positions beginning in position 22. Single impulses received while the selector is held in this position will cause the code wheel to advance one position and fall back into position 22; thus after setting the selectors for time receiving, single impulses will take the selector momentarily into position 23. In this position there is a contact connected in parallel with the normal ringing contact so that the momentary contact made with the code wheel contact spring results in short strokes of the bell repeating the time signal code.

Telephone Sets

The telephone sets employed both for the controller's station and for the way stations are of the local battery type with separate transmitter and receiver windings on the induction coil and so arranged that a "speak-listen" key or foot switch arranges the connections for maximum efficiency both when talking and listening. The circuits of these two sets are shown in diagram Fig. 4.

Time Sending Set

Time signals given to way stations are normally obtained from a telegraph circuit, master clock or some similar arrangement, the apparatus used for producing the signals being usually arranged to give a series of short duration closures of a local circuit. If these are directly applied to the pole-changing relay, the selectors will receive double impulses due to the

double reversal of line battery resulting from operation and release of the pole-changing relay. Circuit diagram No. 4 shows the time sending set containing a relay circuit to give successive reversals of line battery for successive closures of the local circuit.

After setting the way station selectors to the time receiving position, the key of the sending set is operated to the position marked "Time " which disconnects the selector keys from the sending circuit and connects the time sending set. The first closure of the time sending contacts (connected to terminals TI and T2) operates relay R. Re-opening of the Time Sending Contacts operates relay AN. On the second closure of the time sending contacts, relay R releases and on the second re-opening relay AN releases, thus one cycle of operations of the time sending relay circuit corresponds to two impulses from the time sending contacts. A contact of relay R operates and releases the pole-changing relay in the Selector Apparatus Case, sending two impulses to the selectors. Relay AN is made slow releasing so that when the time sending impulses are obtained from a telegraph circuit, telegraph code impulses, which may be in transmission after the key has been thrown to "Time" will be ineffective.

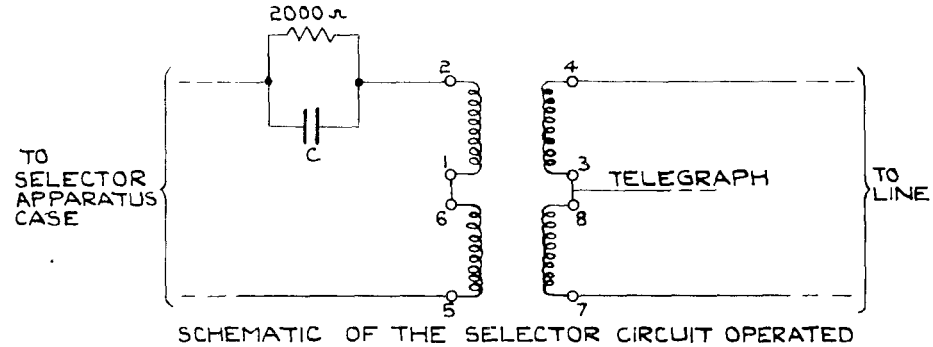
SUPERIMPOSED CIRCUITS

Since the impulses for operating selectors are transmitted as alternating current at a definite frequency, suitable repeating coils or transformers may be connected in the line. The requirements for such coils are that they shall introduce low loss at both the signalling frequency and at speech frequencies.

Operation of Selector Circuit through Transformer

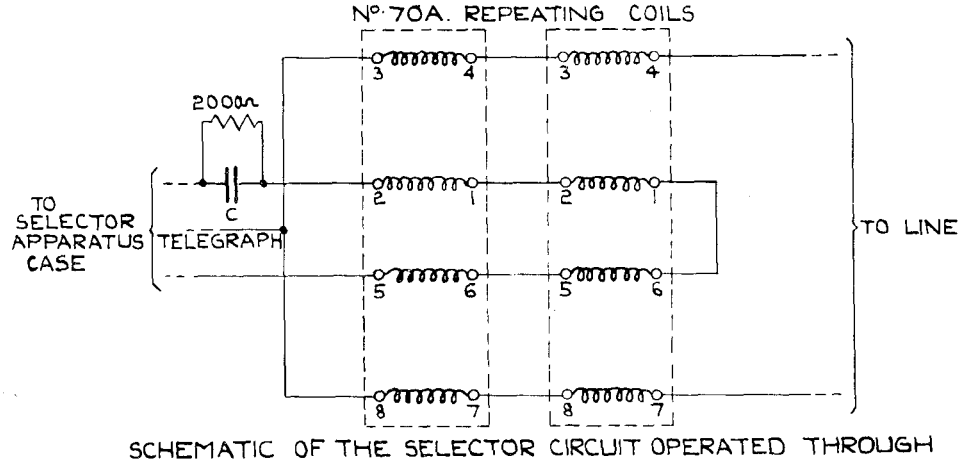
Where it is desired to operate a traffic control circuit without metallic connection between the line and the signalling battery, the transformer should be connected in the line as shown in Fig. 5. Condenser C has a capacity of 10 mf. plus I mf. for each selector bridged across the line and the condensers in the way station selector sets should be short circuited. Resistance R has a value of 2,000 ohms and must be non-inductive as its purpose is to prevent oscillatory discharge of the condenser from interfering with operation of the selectors. For maximum speech efficiency the controller's telephone set should be connected to the line side of the transformer.

Where satisfactory operation cannot be obtained through a single transformer, two or more transformers may be connected in series-aiding.



SCHEMATIC OF THE SELECTOR CIRCUIT OPERATED THROUGH N°. 341A TRANSFORMER

Fig. 5.



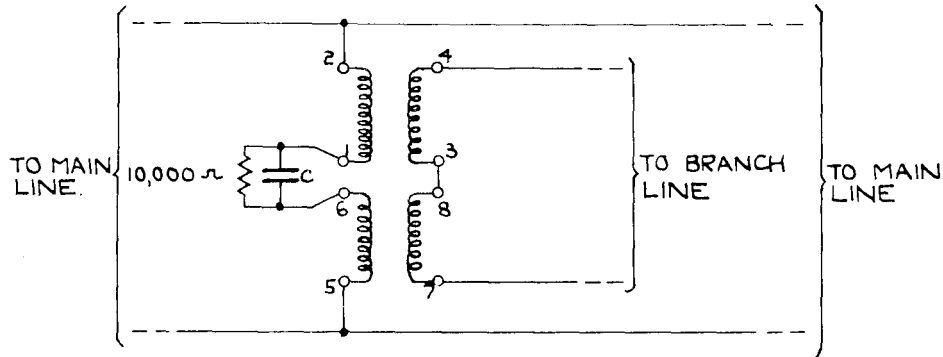
SCHEMATIC OF THE SELECTOR CIRCUIT OPERATED THROUGH TWO N°. 70A. REPEATER COILS IN SERIES

Fig. 5A.

Branch Circuit

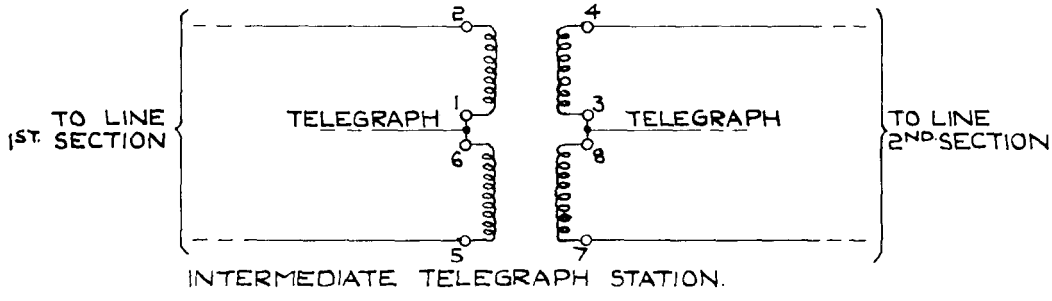
When it is required to operate selectors on a branch circuit and part of the system on the main circuit without metallic connection between the two circuits, a transformer connected as in Fig. 6 may be used between the main circuit and the branch circuit. The capacity of the condenser C is then 10mf. plus 1mf. for each selector on the branch circuit and branch circuit selector sets have their tuning condensers short circuited, sets on the main line re-

maining normal. Again, if the branch line is too long for satisfactory working through one transformer, two or more may be connected in series-aiding.



BRANCH LINE OPERATED THROUGH REPEATING COIL

Fig. 6.



INTERMEDIATE TELEGRAPH STATION.

Fig. 7.

Superimposed Telegraph Circuit

A telegraph circuit may be worked over a line used for traffic control telephone as a phantom circuit. The traffic control circuit is divided by a transformer at the first telegraph station and bridged by coils at subsequent stations. Where it is required to divide a telegraph circuit at an intermediate station, a transformer is used in place of the bridging coil. The various telegraph arrangements are shown in Fig. No. 7.

Composite Circuits

Composite circuits including one or more traffic control circuit may be set up in any of the arrangements used for telegraphy and telephony as long as the components used allow transmission of the $3^1/_2$cycle signalling current used for selective calling.

TESTS ON SELECTIVE APPARATUS

We give below suggestions for testing under two headings, viz.: periodic tests and tests for failure of operation.

If the periodic tests are made regularly, this will largely reduce the necessity for making the other tests.

Periodic Tests

1.—Line tests should be made daily, as the line as a rule is subject to extreme variations due to its exposed condition and interference from outside sources, also to the variable weather conditions, etc. No attempt will be made here to indicate the best way to determine the faults in the line such as opens, shorts, crosses, leaks, etc., as this depends in a great measure on the local conditions and the testing apparatus available.

2.—Test (every two weeks) the potential of the local and main batteries when the normal operating current is flowing.

3.—Test (once a month) by operating each calling key and determine for the regular stepping impulses, that the time the positive potential is put to the line is equal to the time that the negative potential is put to the line, as described on pages 7 and 10. If the results for all keys are the same, the local battery in good condition and the time that the positive and negative potential is put to line is still not equal, then the Telegraph relay should be adjusted by changing the magnetic air gap.

If a few keys give unequal results, the KI and K2 contact on these keys should be adjusted to give the same result as the other keys.

4.—Test (once a month) the time of one complete operation of each key. The time should be within the allowable variation for each key given on page 7. If not, adjust the governor springs as described to make it so. A convenient way to do this is to make sure that one key is right by timing with a stop watch, if one is available (if not, with an ordinary watch). Then test the remaining keys by winding the timing key up with one hand and the key under test with the other hand ; release both at the same time and see if they

complete their operation at approximately the same time.

Note.-If the keys become noisy in operation, a little " 3 in I " oil or watch oil on the governor balls and the worm will help. The amount of oil used should be exceedingly small and no other kind of oil should be used under any circumstances as heavier oils tend to become gummy.

5.—Another test that should be made when the selectors are installed, and one that it is well to make from time to time (say, every three months) after the line tests and tests on apparatus in the calling circuit are made and found correct, is to reduce the potential of the main battery by 50 to 75 volts or such value as the local conditions warrant, and then call each station in turn. If there is a failure it will show that some of the apparatus has not the margin that it should have above the minimum operating voltage. This will give an opportunity to investigate any weak points that may exist so that they may be remedied and thus avoid future failure.

Tests for Failure of Operation

When a call is made and the bell does not ring or no answer-back is heard in the receiver, it is an indication that there is trouble somewhere in the system.

First notice if the usual dull thumps are heard in the receiver when a key is operated, if not, this is an indication that battery is not being supplied to the line. The battery connections and operation of the relays in the calling circuit should be examined. Then call the station on each side of the station that failed. If these do not respond, it is an indication of line trouble or else trouble in the calling apparatus. Test the line wires, and if found correct, test the apparatus in the calling circuit as described under Periodic Tests 2, 3 and 4.

If the stations on each side of the station that failed respond, it is an indication of trouble with the calling key or else in the apparatus at the way station. This key should be tested as described under Periodic Tests 2 and 3. If the key is in order, have the call made for that station and observe if the selector steps up properly to the ringing position ; if it does and the bell does not ring, test the bell by making a metallic connection between terminals 1f and 2 on the selector. If the bell rings, it shows a poor contact or loose connections on the selector. The wiring to the contact springs and the contact itself should then be examined.

If the bell does not ring when a connection is made between terminals I and 2 on the selector, test the local battery and examine operation of the bell and the answer-back.

If it is possible to call the stations on each side of the station that fails and the calling key for this selector and the bell circuit are correct, it indicates that the selector is at fault. If the selector does not move at all when a call is made, it indicates an open in the selector circuit at the way stations.

It is difficult to measure the current through the selectors, due to the very small current and the fact that each impulse is of short duration and in an opposite direction to the preceding one. However, with a zero centre 10 milli ampere-scale ammeter the swing of the needle on each side of the zero point should be eaual for the regular stepping impulses. The value of the reading will depend on the damping of the meter and a minimum value only can be obtained by trial.

If a voltmeter is used to measure the potential at that station, a high resistance meter, of not less than 15,000 ohms, must be used. A centre zero scale meter is preferable and, in this case also, the swing of the needle on each side of the zero point should be equal for the regular stepp.ing impulses. The amount of the swing will somewhat depend on the damping of the meter and a definite value cannot be given. A minimum value can be obtained by trial.

As a general rule, adjustment of the selector in the field is not recommended inasmuch as the selectors are sealed. If the cause of failure of operation of the selector is quite obvious there is no objection to correcting the trouble at once. Extreme care should be taken in adjusting the selector. If the cause of the failure is not easily seen or corrected, we recommend that a spare selector be substituted in its place and the faulty selector returned to Standard Telephones and Cables Limited for investigation. When a selector is returned, a statement of the conditions and, as nearly as possible, the manner in which the selector acted, should be sent along with the selector to aid in determining the cause of failure.

DIAL TYPE TRAFFIC CONTROL APPARATUS.

The dial system is particularly suitable either where one controller may be required to handle a large number of way stations or where the control of several line circuits is concentrated on one control desk. In such instances the controller would be provided with a small switchboard giving access to the necessary lines with a common dial.

The various line circuits can also be multipled to several control switchboards as desired.

In order that the speed of impulsing and the wave form of the traffic control code shall be independent of the operation of the dial, a system has been devised wherein the Ist and 3rd digits of the selector code are dialled and stored on standard telephone line switches. Thereafter, the full selector code is transmitted automatically with a predetermined speed and wave form, the second digit being inserted to complete the constant total of 17 impulses.

Where a controller is required to handle several lines some method of indicating incoming calls is necessary; this can be effected either by providing magneto generators on way stations or by a central battery system with loop calling.

It will be found preferable to use magneto calling on very long lines or lines where the leakage resistance is liable to be low. For reliable working of the loop calling system the minimum line leakage resistance must be at least twice the maximum loop resistance.

Facilities for general call and time sending are available under control of simple push keys.

Certain group calling facilities are obtained by dialling on the standard equipment. Four such groups can be called by dialling two digits which total 17 impulses, for example, the code 89 would call all stations having a first digit of 8 or a last digit of 9, that is, eleven stations.

A prolonged ring can be given on any call, so that instead of the usual short ring of two or three seconds duration, ringing will be continued until the controller restores the prolonged ring key. When this feature is in use the way station sets may with advantage be modified, so that although the ringing continues until cut off by the controller, the ring back tone from each way

station will be suppressed as soon as the telephone is lifted. When used in conjunction with general call or group call, this arrangement enables the controller to verify that all way stations are listening before he starts to give instructions.

The Dial Traffic Control System is readily adaptable for inter-call work, since it is only necessary to provide each way station with a dial set which will operate the storage line switches over the control line. The traffic control code will subsequently be transmitted back over the same line to actuate all selectors and call the desired party.

A number of installations have been completed where the control apparatus associated with each line has been constructed on a "Jack in" Panel, the circuits in one control room being housed in a sheet steel cubicle. This arrangement has obvious advantages in respect of replacement or maintenance.

The following circuit description refers to schematic diagram Fig. 8. (See schematic at end of brochure.)

Incoming Calls

Calls from way stations are obtained by depressing the calling key which loops the line and completes the circuit for the relay TC.

The relay TC remains operated over a stick circuit and illuminates the calling lamp TCL. This visual calling signal continues until the controller operates the speak key. The operation of the speak key actuates the relay BC, thereby de-energising the relay TC which in turn dims the calling lamp. The operation of the relay BC illuminates the busy lamp BL, which remains illuminated until the speak key is returned to normal. The operation of the speak key also connects the controller's telephone set to the particular line associated with the key.

Outgoing Calls

To call a way station, the controller uses his dial key together with the speak key of the required line which operates the relay BC, illuminating the busy lamp BL. The dial key also operates the relay IR in series with the dial interrupter springs.

The guard relay G operates in series with the resistance YE over a contact of the relay IR, breaking the self interrupting homing circuit for the line switches SA and SB and completing, via level 2 of line switch SA, the operating circuit for the digit counting relay DC.

After the operation of the relay DC, relay G is held operated over a contact of the relay IR, resistance YA and winding of relay DC in parallel, and line switch magnet coil SA. The controller then dials the first and last digits of the way station code. Relay IR will release on the first impulse from the dial and the line switch magnet, SA, will be energised via contacts of the relays IR and DC, resistance YA and winding relay DC in parallel and relay contact DS. When the relay IR is operated at the end of the first impulse, the line switch magnet SA is de-energised and switch SA will take one step. When switch SA steps away from the home position the pre-energising circuit for the relay DC is broken at the home contact of level 2 of the line switch SA, and during subsequent impulses relay DC which is slow to release will hold on its other winding over impulses provided by relay IR. During the time that the relay IR is deenergised the relay G is short circuited, making it slow to release so that it will remain operated during the impulse train. The line switch SA will take one step for each impulse in the first digit. During the inter-digital pause relay IR will remain operated for a sufficiently long period to allow relay DC to release. Relay DS then operates via contacts of the relays TS, GC and G, level 2 of line switch SA and contact of relay DC.

The relay DS is then locked over its own contact independently of the further operation of the relay DC and completes the circuit for the re-operation of the relay DC via contacts of relays TS, GC, G and level 2 of line switch SB. Relay DC then re-operates.

When the second digit is dialled, relay IR responds as before but the impulses from its contact are routed to the line switch magnet SB via contact of relay DS.

Line switch SB will then take one step for each impulse in second digit dialled, relay DC being held as before during the impulsing of the relay IR, releasing at the end of the second train of impulses when relay IR is again held.

On the controller restoring his dial key, relay IR will release completing the circuit for the relay LC via level 2 of line switch SB and contact of relay G, the relay G remaining operated for a short period due to its winding being short circuited by the release of IR.

On operating, the relay LC locks over its own contact via levels 3, 4 of line switch SC and completes an operating circuit for the relay BR. The relay BR connects the impulse battery on to the lines via the choke coils of the smoothing circuit and relay CB.

The relay CB, or circuit breaker relay, may be designed to operate on various overloads. Normally, relay CB is held operated mechanically until the overload occurs when the armature of the trip coil is operated and un latches the normally held armature. When the relay is tripped, lamp CBL is illuminated on the circuit breaker indicator panel, until the reset key CBK associated with the lamp is operated, thereby resetting the relay CB.

The relay LC also operates the relay SD via the interrupter contacts and level I of line switch SC. On operating the relay SD it completes a circuit via level I of line switch SC and relay contact LC for line switch SC, which operates. The interrupter springs of the line switch SC open when the magnet

is fully operated and break the circuit to the relay SD. On the-release of the relay SD the line switch magnet is released and the switch takes one step. Relay SD then re-operates via the interrupter contacts and level I of the line switch SC, this circuit being independent of the condition of relay LC. This cycle of operations between relay SD and the line switch magnet SC will continue until relay LC is released and wiper SCI has reached its home contact.

It will be noted that the relay SD is shunted by a rheostat and by its adjustment the release time of the relay SD can be varied until line switch SC steps at the correct speed.

As line switch SC steps under control of relay SD, the impulse sending relay IS will be operated in accordance with the connections made to levels 5, 6 and 7, S of the line switch SC. For the first few steps IS will not be operated, allowing a short preparatory period before the start of impulsing out to the line. When line switch SC reaches its 4th step, relay IS is operated from positive applied over level 5, 6 of line switch SC. Ignoring any positive connection from levels 3 and 4 of line switches SA and SB, IS would be operated and released on alternate steps of line switch SC until IS has completed 25 reversals.

Line switches SA and SB having been stepped in accordance with the two digits dialled, these line switches are used to select the two interdigital pauses in a 3 digit code, so arranged that the total number of impulses in the 3 digits of each code is always 17.

The digits dialled represent the first and third digits of the traffic control selector code, the second digit automatically bringing the total number of impulses to 17.

For example, assuming that the code dialled was 5-3, when line switch SC begins stepping, line switch SA will already be standing on its sixth contact and line switch SB on its fourth contact. Relay IS will be operated when line switch SC reaches its fifth contact, released on the 6th, re-operated on the 7th, released on the 8th and re-operated on the 9th.

When line switch SC steps on to its 10th contact relay IS will be held operated by positive applied to the 10th contact over level 4 of line switch SA. IS remains operated on the 11th contact from the positive on SC5, 6, on the 12th by the positive applied over level SA3, on the 13th from the positive on SC5, 6, but releases on the 14th contact to commence the second digit. Thereafter IS operates and releases on alternate contacts until line switch SC steps on to contact No. 23. At this point relay IS is about to operate but is prevented from doing so because of the positive applied from level 3 of line switch SB which is standing on its third step, this positive being connected over the 23rd step on level 7, 8 of line switch SC to short-circuit relay IS, resistance YF being inserted to limit the short circuit current. On the 24th step there is no positive feed for relay IS and it therefore remains unoperated. On the 25th step it is again short-circuited by positive applied over level 4 of line switch SB, and on step 26 there is no positive feed. On step 27 relay IS will operate, release on 28 and operate on 29, and remain operated for a relatively long period.

Each operation of relay IS makes a connection between positive and K2 and this has the effect of operating the relay SR which reverses the polarity of the battery fed to the line.

It will be noted that the relay SR is shunted by a rheostat and by adjusting this the release time of the relay SR can be varied, thereby controlling the impulse ratio of the impulses transmitted on the line.

It will be seen, therefore, that in the case described above, relay IS causes five reverse impulses to be sent over the line, then remains operated for a period corresponding to five impulses, then transmits a further nine reverse impulses, remains de-energised for a second interdigital pause equivalent to five impulses, then finally sends a third digit of three impulses remaining energised for a relatively long period while line switch SC is stepping from its 29th to its 45th contact, during which time a way station selector which is coded 5-9-3 will be standing in its ringing position and consequently the battery bell at this station will ring for about two seconds.

On the final release of IS a single reverse impulse is sent over the line which will clear down the called selector.

When line switch SC, still stepping under the control of relay SD, steps beyond contact 48, relay LC will be released at SC3.4. The release of LC will release the battery relay in the traffic control equipment and remove the line battery from the line, thus completing a homing circuit for line switches SA and SB over their homing arcs and interrupter contacts. Line switch SC will continue to step until it reaches its first or home contact where it will stop, there being no circuit for relay SD owing to the release of LC.

General Call

To call all way stations on a line the controller operates the speak key for the line and the common General Call Key. The relay GC then operates and locks over its own contact and level 3, 4 of line switch SC. The operation of GC completes a circuit for relay LC and puts a positive feed on to contacts 22, 24, 26 and 28 of level 5, 6 and line switch SC.

The operation of LC causes switch. SC to step in the manner described above for an ordinary call, and relay IS will operate and release on alternate steps of line switch SC from contacts 5 to 22, thus sending 17 reverse impulses to the line. These 17 impulses will step all selectors to their ringing position and cause all way station bells to ring. This ringing period will continue while line switch SC is stepping from its 22nd to its 45th contact.

Prolonged Ringing

If it is desired to prolong the ringing on any call, the controller operates the appropriate speak key and the prolonged ringing key PRK. This completes the circuit for the relay GCA which operates and removes the positive from contact 40 of level I of line switch SC, so that when the line switch SC is passing through the ringing position it will be halted on contact 40 where it will remain until the key PRK is returned to normal.

Time Sending

To send the time signal, the controller operates the appropriate speak key and the time sending key TSK, which completes a circuit for the relay TS which operates and locks over its own contact and level 3, 4 of line switch SC. The operation of relay TS completes the circuit for the relay LC and puts a positive feed on to contact 28 of level 5, 6 of line switch SC.

The operation of LC causes the line switch SC to step in the manner described for an ordinary call ; relay IS will operate and release on alternate steps of line switch SC from contacts 5-27, thus sending 23 reverse impulses to the line. These 23 impulses will step all selectors to their time sending position.

The key TSK also operates the relay GCA which removes the positive from contact 40 of level I, thus stopping the line switch SC.

The time signal is sent through the medium of a time sending unit as previously described.

Relay TS removes the positive from contacts 40, 42 and 44 of level 5 and 6 of line switch SC so that as the line switch returns home on the release of the key TSK the relay IS is alternately operated and released over contacts 41-45 of level 5 and 6 of line switch SC. This sends 6 impulses over the line which step the selectors from their time sending position.

Special Adjustments

When adjusting the speed of the line switch SC it has been found convenient to time three complete revolutions of the line switch which should take about 20 seconds. If it is necessary to increase the speed of the line switch, adjust the rheostat YJ by turning the adjusting screw in a clockwise direction.

For reliable working the positive and negative impulses sent over the line should be equal; this can be tested by placing a centre zero voltmeter across the line as previously described.

If it is necessary to make any change to the impulse ratio, adjust the rheostat YH. To increase the time during which the relay SR is on its back contact, turn the adjusting screw of the rheostat in a clockwise direction.

Edward Everard, Limited,

FORM OF ENQUIRY OR ORDER

RAILWAY TRAFFIC CONTROL

When asking for a quotation or when ordering a Traffic Control System, a sketch of the line showing location of Controller's Station and Way Stations, with distance between each should, if possible, be supplied. The following information is essential, viz. :—

Name of Railway .....
.....
.....
Mileage to be equipped.....
.....
Size and kind of wire.....
.....
Number of Stations to be equipped.....
.....
.....
Controller located at.....
.....
New control line or extension to an existing control line ?.....
.....
What style of Telephones are required at Way Stations ?.....
.....
Will the Controller always wear his telephone set when on duty, or will it be necessary to fit a bell or loud speaker so that Way Stations can call him ?
.....
.....
Is the General Call required ?.....
Is Time Sending required ?.....
Will any auxiliary apparatus, such as Portable Telephones, Siding Telephones, or Testing Boxes be required ?.....
.....
What style of calling unit is required ? Individual Keys, Universal Key, Dial, Machine Sender, or Key Sender.....
.....

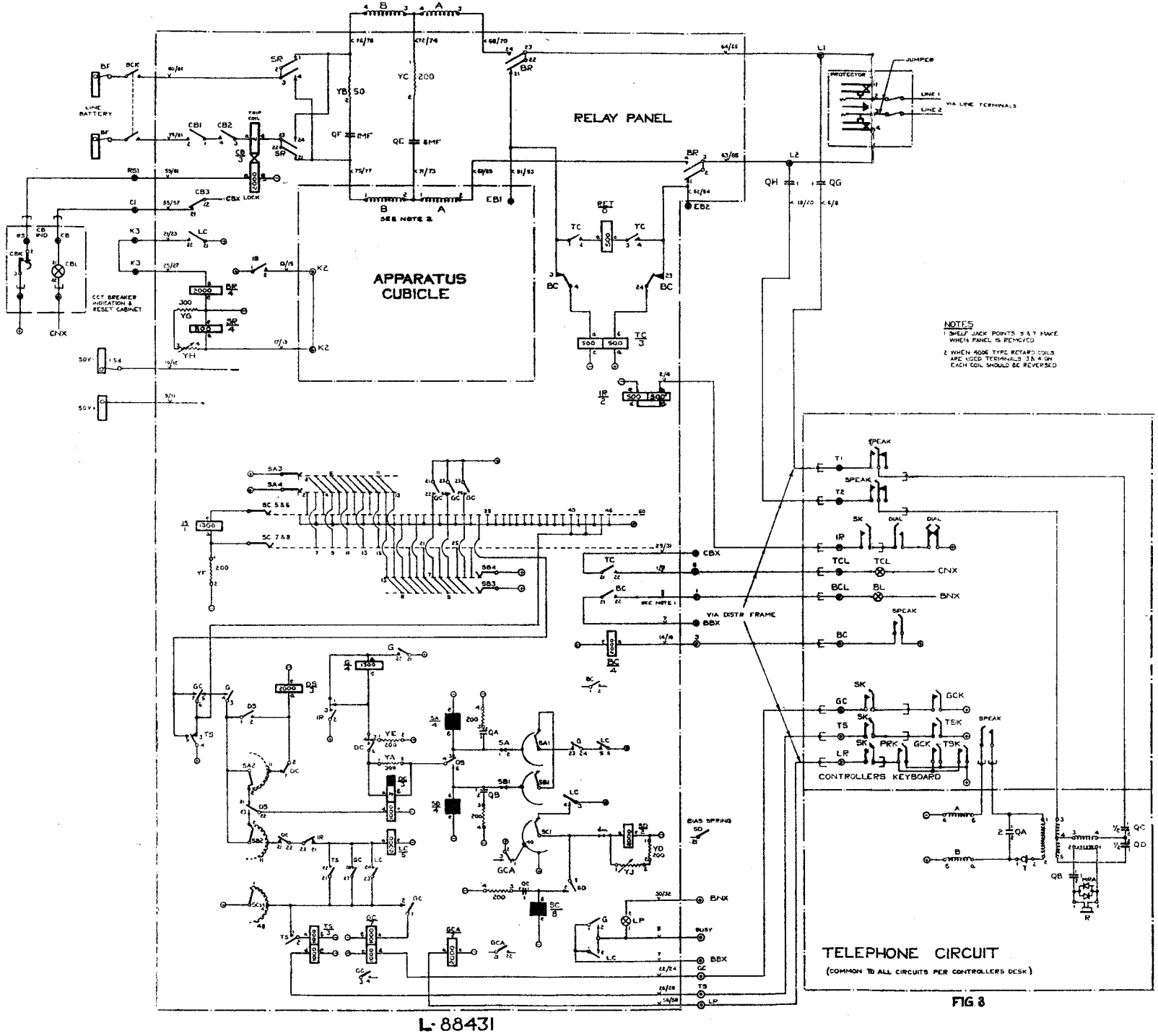
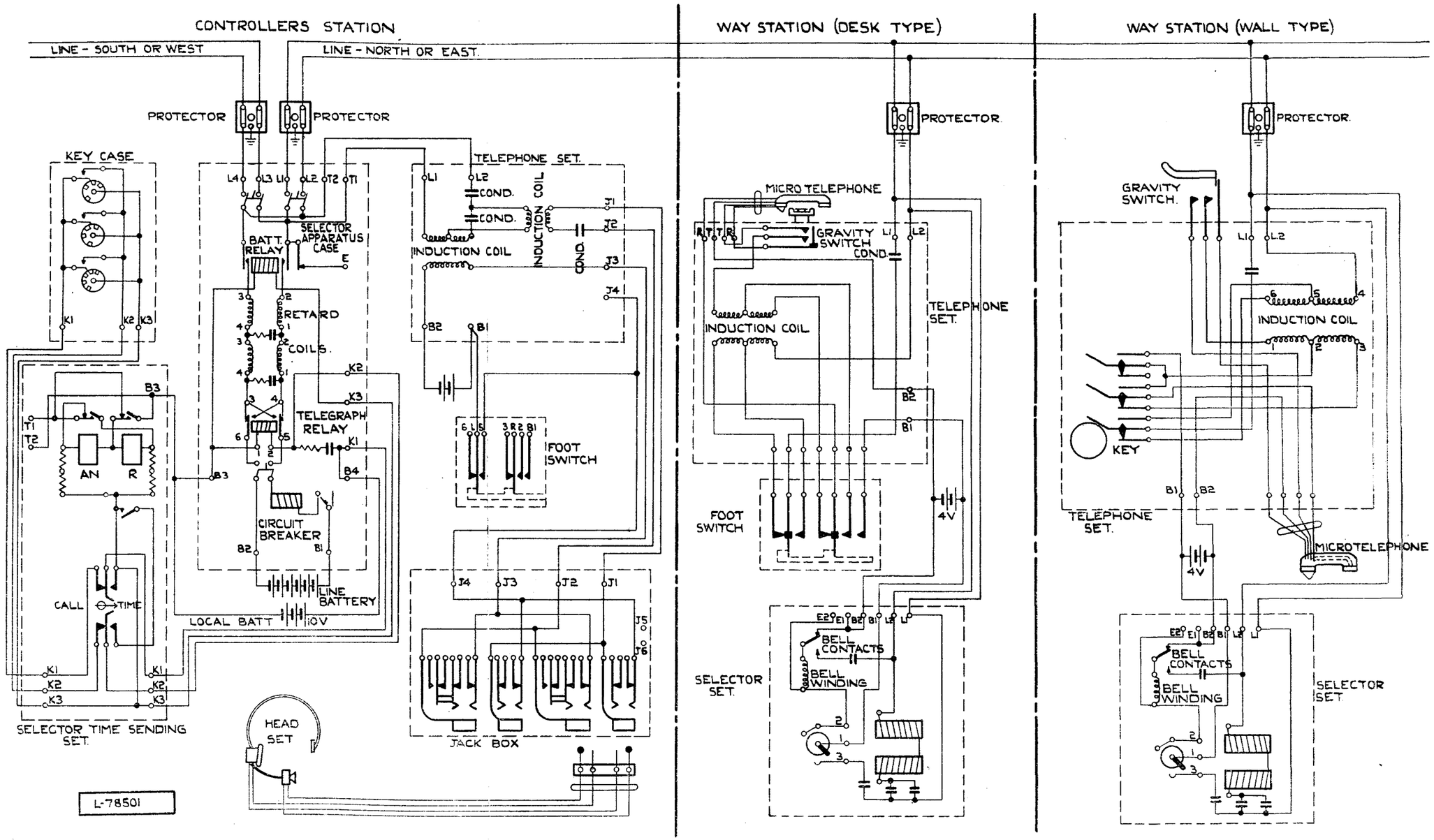


FIG 8

Fig. 8. Schematic of Dial Type Traffic Control Apparatus.

(Fig. 4 on reverse.)



NOTE:- WHEN 4006 TYPE RETARD COILS ARE USED TERMINALS 3 & 4 ON EACH COIL SHOULD BE REVERSED.

Fig. 4. General Schematic of Traffic Control Telephone System.

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