Maintenance of Western Electric Calling Apparatus

used in connection with

Railway Train Dispatching Telephone Systems

Western Electric

Maintenance of Calling and Receiving Apparatus Used in Connection with Railway Train Dispatching Telephone System

This booklet deals with the operation and maintenance of the apparatus of the A. C. selector calling system used for train dispatching, together with some tests that it is well to make from time to time to insure the working of the system under the most advantageous conditions. The functions and operation of the apparatus listed below are described on the pages designated.

General Sequence of Operations in Calling a Station

Refer to figure 2 or 3 for the sending circuit and figure 10 for the receiving circuit.

The sequence of operation of the various parts of the system when a call is made is as follows: A key in the key case at the dispatcher's office corresponding to the selector at the station to be called is operated by winding it up a quarter turn. In releasing the key, contact K1-K3 is closed continuously and the No. 122-EW relay is operated,

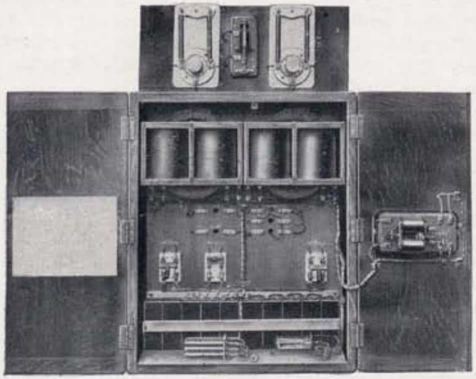

FIG. 1. No. 60-A Selector Apparatus Case—Open

connecting the main battery through the contacts of the No. 26-A relay and the two No. 5-AD retardation coils to the line wires L1 and L2; also, the key contact K1-K2 is closed intermittently, operating the pole-changer relay (No. 26-A) in such a manner as to send a sequence of reverse impulses to the line corresponding to the unmasked teeth on the impulse wheel of the calling key operated. This sequence of impulses will operate the selector at the station called so as to close its bell circuit. The bell at that station will ring for about two seconds, then another impulse from the key will release the selector and open the bell circuit. While the bell is ringing a tone or answer-back will be heard in the receiver notifying the dispatcher that the bell is ringing.

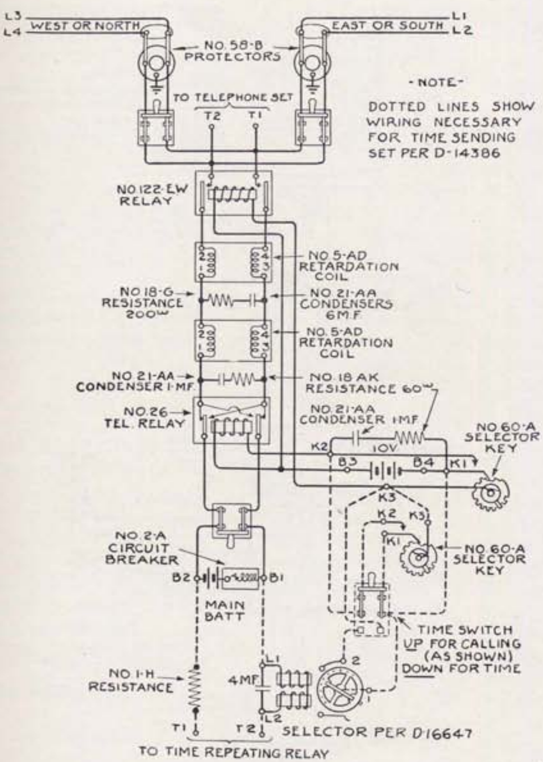

FIG. 2

Schematic Wiring of
No. 60-A Selector Apparatus Case
(as now furnished)

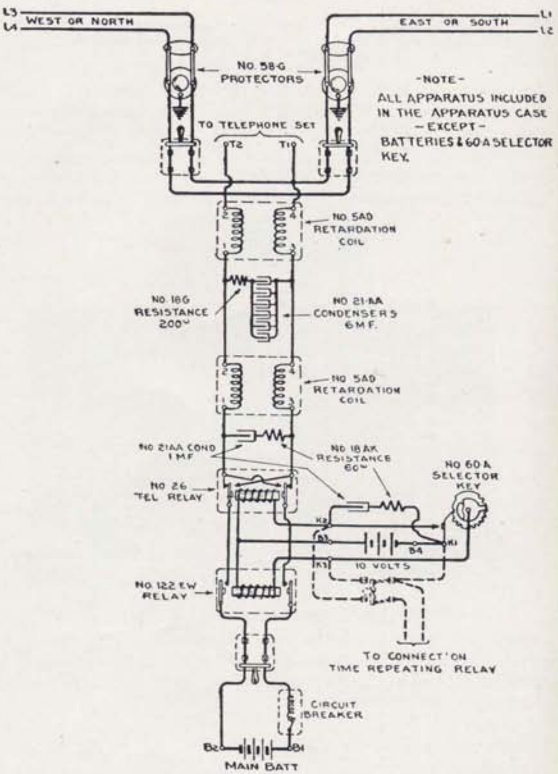

FIG. 3

Schematic Wiring of
No. 60-A Selector Apparatus Case
(as formerly furnished)

Current Supply

The current supply for this system consists of a main D. C. source of 100 to 350 volts and a local battery of 10 to 12 volts at the dispatcher's stations and a 4 volt battery at each way station.

The main source furnishes the current for operating the selectors at the way stations. The voltage depends on the loop resistance of the line wires and the location and number of selector sets on the line. For standard circuits (using 160 type sets with condensers in set) the voltage required for normal operation can be determined from the voltage-line selector curves of figure 4. These curves show the voltage required for different length lines of No. 9 B. & S. copper wires—8.3 ohms per loop mile—equipped with selector sets uniformly distributed. The voltage specified for normal operation is higher than the minimum operating voltage required. This insures the operation of the selectors when the line insulation is low during wet weather and allows for a slight decrease in the potential for any reason. The potential should in no case be allowed to decrease more than 15 per cent.

Dry cells, storage cells, a motor generator set or a Western Electric No. 60-A Vacuum Tube Rectifier may be used for this main current source. When dry cells are used, frequent measurements should be made to determine the potential of the battery when the current is flowing under operating conditions. This is necessary because the gradual increase in internal resistance of the dry cells will lower the voltage available for operating the selectors.

60-A Vacuum Tube Rectifier

The 60-A Vacuum Tube Rectifier, figure 5, is operated from a 110 volt—60 cycle—alternating current source and may be used instead of dry cells, storage cells or a motor generator to furnish the main power for operating one or two selector circuits. It does away with the periodic tests of dry cells, the charging of storage cells or the continuous large power drain of the motor generator sets.

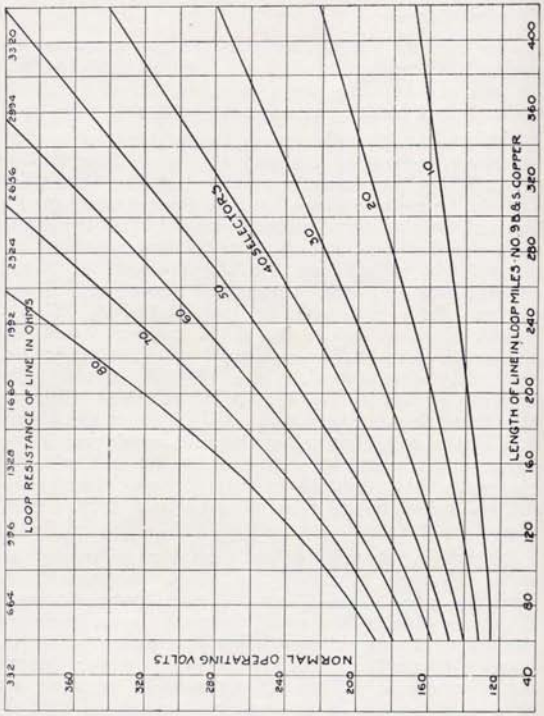

Fig. 4

Voltage-Line—Selector Curves
160 Type Selector Set

The rectifier consists of a fuse and switch block, 72-A repeating coil, F-11 relay, 20-21AA condensers, 212-A tube socket, which takes a Western Electric No. 214-A Vacuum Tube, and terminal block mounted in a black finished sheet steel box 15″ wide x 18″ high x 6″ deep. It weighs approximately 63 pounds.

The 110 volt—60 cycle—alternating current is connected through the fuse (6 amperes) and switch block to the primary of the repeating coil (see figure 6). The secondary of the repeating coil is provided with taps for supplying alternating current of 60 to 540 volts potential in 60 volt steps to the plate circuit of the vacuum tube. The steps permit of adjusting the D. C. output of the rectifier to the needs of the circuit as determined from figure 4. The tertiary winding of the repeating

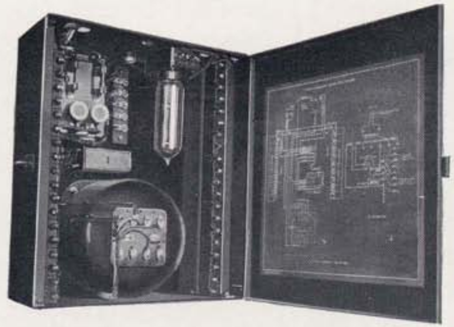

Fig. 5

60-A Vacuum Tube Rectifier

coil supplies current at 10 volts potential for lighting the vacuum tube filament, through the contacts of the relay. The condensers tend to hold up the voltage of the rectified current during the interval between the rectified half-waves. The terminal block is provided with five terminals as follows:

B1, B2 and B3 to be connected to B1, B2, and B3 and of one or two 60-A selector apparatus cases.

One K3 to be connected to K3 of one 60-A selector apparatus case and the other K3 to be connected to K3 of another 60-A selector apparatus case when required.

The filament of the vacuum tube lights only when the F-11 relay is energized as a selector key is operated to make a call. The filament circuit is closed a second before calling impulses are sent out. This allows the filament to heat sufficiently to rectify a full potential impulse at the start. The average life of the No. 214-A Vacuum Tube based

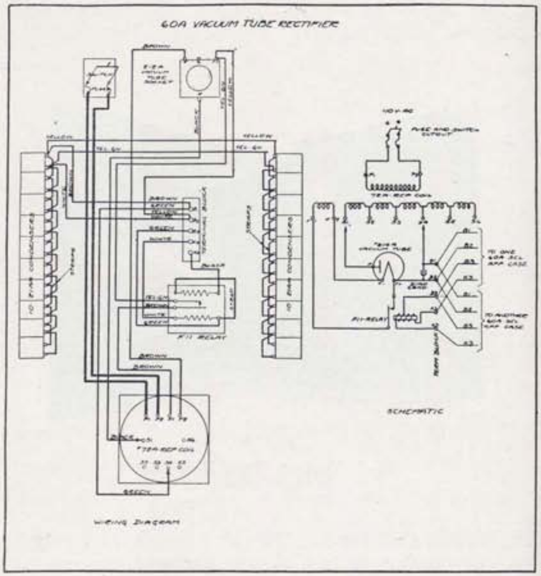

Fig. 6

Schematic Diagram of 60-A Vacuum Tube Rectifier

on 200 to 300 calls per day, is approximately two years but this figure is not guaranteed. This life is with a filament current of 3.3 amperes. If the current is increased the life of the tube is shortened.

The set rectifies only when the filament of the tube is lighted. This decreases the drain on the alternating current source and lengthens the life

of the tube. The drain during non-calling periods when the filament circuit is open is eight watts and on the average selector circuit the drain is approximately 90 watts while calling. At the rate of 300 calls per day (8 seconds per call) the rectifier would require 250 watt-hours per day.

The direct current voltage output of the tube equals the alternating current input to the tube with no load on terminals B1 and B2 and decreases from 10 to 35 per cent in proportion to the selector load. Under maximum load conditions, the maximum direct current output is approximately .400 ampere at 350 volts potential.

The F-11 relay in the filament circuit is provided with two windings so that it may be operated by the selector keys of either of two selector circuits separately or at the same time.

There is a 60 cycle tone from the rectifier, which interferes with telephone conversation on circuits using the Nos. 295 AJ and AK subscriber sets. This can be eliminated by connecting a filter per D-77800 between the rectifier and the selector apparatus case. This filter consists of a 5-AD retard coil and 20 No. 21AA condensers mounted in a black finished steel box 10″ wide x 18″ high x 6″ deep.

Ordinarily the 60 cycle tone from the rectifier does not interfere with telephone conversation on circuits using the 501-A and B and 502-A subscriber sets and the No. 12-A Loud Speaking Telephone Outfit; so the filter is not usually required on such circuits.

Note: Care should be taken to insure that the tube filament is not lighted during the non-calling period by a selector key sticking and causing its K1-K3 contacts to remain closed. An automobile wood dash lamp equipped with a 12, 16 or 24 volt, 2 C.P. bulb can be mounted on top of the selector key case and connected in parallel with the tube filament to notify the dispatcher when the tube is lighted.

Local Battery

The local battery at the dispatcher's station furnishes current for operating the 26-A and 122-EW relays. Eight dry cells or sufficient storage cells to give a voltage of 10 to 12 volts should be used. In no case should the voltage of this battery be allowed to decrease to less than 8 volts.

Way Station Battery

The way station battery furnishes current for operating the 60-C ringer. It may consist of primary or secondary cells. The voltage of this battery should be from 3 to 5 volts. The transmitter battery of the way station telephone sets may be used as a common battery for the transmitter and for the bell of one or two selector sets.

Calling Apparatus

No. 60-A Selector Apparatus Case

This case contains (see figure 1) all the calling apparatus at the dispatcher's station except the keys and the telephone set in ordinary installations. It is an oak cabinet approximately 32″ high x 16″ wide x 12″ deep, arranged for wall mounting. It is completely wired and provided with terminals for connecting the battery, lines, key case, and telephone set wires as shown in figure 2 or 3. The following is a short description of the apparatus:

No. 2-A Circuit Breaker

The function of the circuit breaker is to open the main current supply lead if an excessive amount of current flows from the source, 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 .6 ampere and non-operate on .4 ampere. These values can be increased or decreased by adjusting the air gap between the armature and the magnet by means of a knurled nut at the extreme end of the magnet. The best setting for the circuit breaker will depend somewhat on the local conditions for each installation.

On resetting the circuit 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 again to open the circuit.

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No. 122-EW Relay

The function of this relay is to connect the sending circuit to the line at the beginning of the operation of the calling key, and to disconnect the sending circuit again at the end of the operation of the calling key.

This relay is operated by the local battery through the K1-K3 contact of the calling key, the contact made between the steel contact spring and the impulse wheel or frame. This relay should remain operated during the whole operation of the key.

The air gap between the contacts of the inner and outer springs should be approximately 1-32″ when the relay is in an unoperated position.

The resistance of the relay is 100 ohms and it should receive from .075 to .100 ampere of current for operation.

CAUTION: Before attempting to adjust the relay the main battery switch should be opened.

No. 26-A Telegraph Relay (Pole Changer)

The function of this 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 operated by the local battery through the K1-K2 contact of the calling key, the contact made by the nickel silver contact spring and the steel contact spring as the latter passes over the teeth of the impulse wheel.

The resistance of the relay is 25 ohms. It should receive from .3 to .4 ampere of current for operation.

The air gap between the middle contacts and the front contacts should be approximately 1-32″ 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 contacts make or break at the same time, and also that the two back contacts make or break at the same time. Also, 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 the back contacts are made 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 center scale voltmeter or a zero center scale mil-ammeter with a resistance to limit the current. For this test the meter should be connected directly across the line wires. In either 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 center point. This shows, for example, 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 No. 26-A 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.

No. 5-AD Retardation Coils and 6 No. 21AA (1 M. F.) Condensers

The function of these coils and condensers is to smooth out the impulses of current used for operating the selectors while calling so as not to cause an objectionable sharp click in the receiver, but merely a slight dull thump that is not objectionable and does not interfere with the telephone transmission.

The resistance of these coils is 50 ohms each or a total of 100 ohms for the two coils.

It is important that the coils be connected non-inductively in the circuit as shown.

The two No. 21AA condensers not associated with the retardation coils are for spark "take-ups."

No. 58-B Protector

The function of the protector is to protect the inside apparatus against damage from high voltages by providing a shunt path from each side of

the line through an air gap between the copper blocks to a well established ground connection. It is important that this ground connection be well and permanently made. A fuse in each side of the line is also provided to guard the drop wires against abnormal currents. Seven ampere fuses are generally used.

The spacing between the copper blocks is such that 700 volts will not jump across the gap, but voltages over 700 will. Thus a low impedance path is provided to lead the high voltages off to ground rather than through the calling or telephone apparatus. Damage to the apparatus is thereby avoided.

The fuses should always be connected on the line side, and the copper blocks on the station side.

If the copper blocks become grounded by lightning or other high voltages, they should be replaced by new ones rather than an attempt made to clean the old ones.

Selector Keys

No. 60-A
No. 60-B
No. 61-A

General

The function of the calling key is to control the operation of the stick relay (No. 122-EW) and the pole-changer relay (No. 26-A), which in turn controls the main line current source and sends the sequence of current impulses necessary to operate the selector at the station desired.

The Nos. 60-A and 60-B 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. These springs are connected with the binding posts marked K1, K2, K3, at one 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.

When the key is not operating the end of the inner or steel 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 this steel spring and the impulse wheel control the operation of the No. 122-EW relay.

The outer or nickel silver contact spring should make contact with the steel spring only when the steel spring 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, that is, should be opened one-half and made one-half of the time while the steel spring is passing 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 K1-K2 in series with a voltmeter and battery or a mil-ammeter 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 short-circuited.

No. 60-A Selector Key

The No. 60-A (figure 7) selector key is for use with the No. 60-A selector when set for the code numbers given in Table No. 1 (at end of text). It may be set for any of the code numbers given in Table No. 1 by adjusting its segments as described in detail hereafter. In this series of settings the total number of current impulses for any code is seventeen.

The governor springs for the No. 60-A key are so adjusted that the impulse wheel will make one revolution in not less than 7½ seconds and not more than 8 seconds.

No. 60-B Selector Key

The No. 60-B Selector Key is for use with the

No. 60-A selector set for the code numbers in Table No. 2, and the No. 60-B selector when set for the code numbers given in Table No. 3. It may be set for any of the code numbers given in Table No. 2 or 3, by the adjustment of its segments in a manner similar to that explained in detail for the No. 60-A key, with the exception that a third flat segment is used, so that the total number of impulses is increased by 10 for the 27 step settings of the No. 60-A selector or by 2, 4, or 6 for the No. 60-B selector as shown in the table.

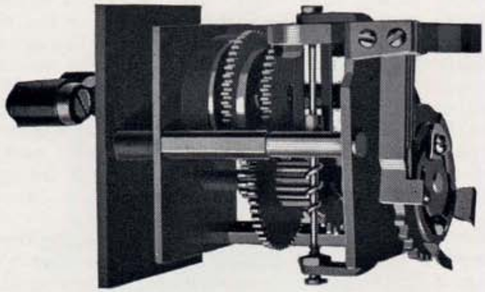

Fig. 7
No. 60-A Selector Key

The governor springs for the No. 60-B selector key are so adjusted that the impulse wheel will make one revolution in not less than 9 seconds and not more than 9½ seconds.

Method of Setting 60 Type Keys

In setting the key, each closure and each opening of the contacts count one. Two styles of segments are provided, one a flat segment which closes the contacts while the inner spring passes over it, the other segment with 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. If the first number in the code is odd, a flat segment is required, while a segment with the bent-up part is required if the first number is even. If the last number in the code is even, a flat segment is required, while a segment with the bent-up part is required if the last number is odd. Thus two like segments or one of each kind may be required to give the code setting. The first segment is sent so that the inner contact spring, in passing over the first set of teeth on the impulse wheel, gives the number of closures and openings of the contacts represented by the first number in the code. The other segment is set so that the contact springs, in passing over the third set of teeth on the impulse wheel, give the number of closures and openings of the contacts as represented by the last number in the code. Since the number of any impulses for any three digit code combination is always the same as in any other in the same table, it follows that if the first and the last digits are set the middle one will be automatically determined.

For example, to set the No. 60-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. As the last count was a space, take a segment with the bent-up part 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 contact 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. As the last count was on a tooth, set the edge of a flat segment on the center of this tooth. The number of closures and openings of the contact while the inner contact spring passes

between the two segments, is the middle number in the code (5 in this case).

To set the key so that all No. 60-A selectors will be advanced to their time receiving position, place a flat segment bridging from the center of first tooth to the center of the fourth tooth. This gives, after the first long impulse, 22 regular impulses in succession.

No. 61-A Selector Key

The No. 61-A Selector Key (see figure 8), is for

FIG. 8
No. 61-A Master Selector Key

use as a master key at test and switchboards; also at way stations on intercalling circuits. It may be set for any of the code numbers given in Tables No. 1 and No. 3 by moving the levers, extending through the cover, to the code desired. As in the case of the No. 60 type keys, the middle digit of the code is automatically determined by setting the first and the third digits.

The first lever on the left side is used only with the No. 60-B selector and normally is placed for station A and should be left in this position when used in connection with the No. 60-A selectors.

When used with the No. 60-B selectors it should be moved to the B, C or D position, corresponding with the code of the station desired.

The second lever is placed opposite the first number of the code of the selector desired.

The third lever is placed opposite the last number of the code of the selector desired.

The fourth lever is then moved down to the bottom of its slot and released. The key then operates the same as the 60-A key.

This key may be set to call all stations on the line

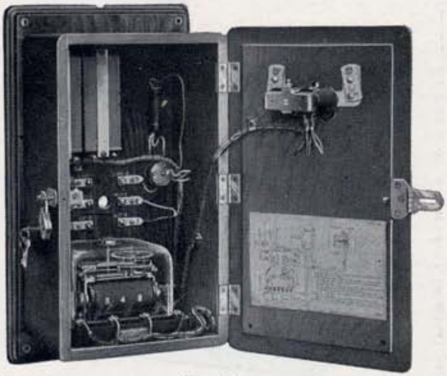

Fig. 9

No. 160-A Selector Set

equipped with No. 60-A (17 step) selectors and all stations connected to the A contact of the No. 60-B selectors by setting the second and third levers each on zero. The key then sends out 17 consecutive impulses to step all selectors to the first contact.

The key makes one complete operation in 7½ to 8 seconds. The speed is changed by bending the governor springs, at the right end, **in** to increase and **out** to decrease.

Three terminals on the bottom, designated K1, K2 and K3, connect to the corresponding terminals in the No. 60-A selector apparatus case. The contact springs connecting to K1 and K2 terminal

should be adjusted to be closed 50 per cent. of the time as the key is operated. This may be determined by the method explained under the 60 type key.

No. 160-A Selector Set

This set contains all the receiving apparatus at the way station, see figure 9, except the telephone set. It is an oak cabinet approximately 14″ high x 9″ wide x 6″ deep, arranged for wall mounting.

The set is completely wired and provided with terminals for connecting the line and local battery wires as shown in figure 10.

The following is a short description of the apparatus in the No. 160 Selector Set.

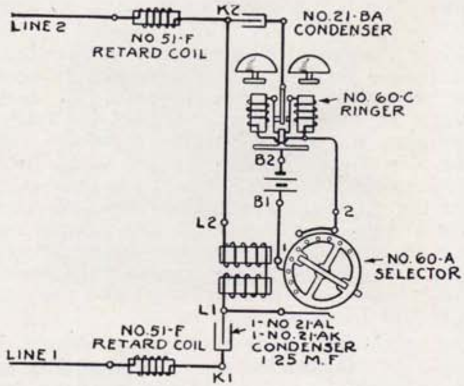

Fig. 10

Schematic Wiring of
No. 160-A Selector Set

No. 51-F Retardation Coils

The function of the two small retardation coils in the selector set, one connected to each line terminal, is to act as choke coils for high frequency voltages, as lightning, etc., and thus protect the more expensive apparatus in the set, even though the retardation coils may be opened by so doing. The resistance of these coils is approximately .5 ohm each.

No. 60-C Ringer

The function of the ringer is to call the way-station operator and also to give the time signals. This ringer is a vibrating, direct current ringer and is provided with contact springs for opening its own circuit intermittently.

When the selector operates and closes its local contact by advancing the code wheel so that the bronze spring on it makes contact with the first ringing terminal a local circuit through the local battery and the bell is completed, and the bell should ring for approximately 2 seconds until the selector is released from the ringing position. The ringer circuit may be tested at any time by making a connection between the terminals 1 and 2 on the selector.

While the bell is ringing, an answer-back or tone should be heard in the telephone receiver. This answer-back circuit is from L1 terminal through the retardation coil and the 1.25 M.F. condenser; through the contact on the selector made between the holding spring on the front of the selector and the code pin in the contact wheel when the selector is in ringing position; through the local battery; through the intermittent contact on the ringer, made between the right-hand contact spring and the contact on center stop-piece; and through the No. 21-BA condenser and the retardation coil to Line 2.

The right-hand contact spring should press against the rubber stud on the center stop spring with sufficient force to hold the left-hand contact spring back positively so that the answer-back contact is opened approximately 1-64″. To accomplish this the left-hand spring is adjusted to press against the contact on the extended arm on the armature with a force of approximately 20 grams, and the left-hand spring is adjusted to press against the contact on the other side of the extended arm on the armature with a force of approximately 12 grams.

The gongs are so adjusted that when the bell clapper strikes them there will be a perceptible air gap between the armature and the pole pieces. The corresponding operating contact shall then be open.

To insure the starting of the ringer on minimum current, the air gap between the armature and the pole pieces, on the side that the rubber stud is mounted on the center stop spring, should be slightly less than on the other side when the ringer is idle.

The resistance of each spool is 8 ohms, and the ringer is adjusted to give a fair ring on the current from one dry cell. However, two or three cells should be used. The same battery used for the telephone transmitter battery may be used for the ringer.

No. 60-A Selector

No. 60-A Selector

The function of this selector is to provide a quick and reliable means to call selectively one of a large number of way stations on the same telephone line without producing a signal at the other stations.

This is a step-by-step selector operated by a definite code or sequence of alternating or reverse current impulses. It consists of a mechanism unit mounted on a magnet unit with a bakelite base and a glass cover.

In general, the code wheels are set so that the same total number of steps is necessary to advance the code wheel to the ringing position on all selectors that are to be used on the same line.

With the number of holes provided in the code wheel this number of total steps may be any number from 8 to 32, which number would give a total of 6 and 378 code settings respectively. The No. 60-A selector, however, is set for a total of 17 steps, which number gives a total of 78 code settings, unless selectors are ordered for some other code setting than those given in Table No. 1. The selector is not stepped up by 17 consecutive impulses, however, when selecting a station, but by three sets of successive impulses as indicated in Table No. 1. (This is not counting the restoring impulses.)

The code pins on each selector are located so that, after the first set of impulses, the code wheel will be in position for the holding spring to engage with the first code pin. The second code pin is located so that after the second set of impulses, the code wheel will be in position for the holding spring to engage with the second code pin. The third set of impulses then advances the code wheel, so that the permanent code pin is in position to engage with the holding spring and, at the same time, the contact spring is directly over, and makes contact with, the first ringing terminal, thus completing the bell circuit. Each selector is capable of being set for any station number given in the Table No. 1 without any other change than the location of the two code pins in the code wheel.

The cycle of events in calling a station, 8-5-4 in Table No. 1 for example, is as follows:

(Refer to figures No. 2 or 3 and No. 10.) On operation of the calling key set for 8-5-4, the hold-up relay operates and puts battery on the line. This relay remains operated during the complete operation of the key. The first set of impulses from the impulse spring of the calling key operates the pole changer relay so as to give eight reverse impulses on the line. These eight impulses advance all the selectors eight steps. Then, although the battery is held on the line for approximately one second, the condenser in series with each selector bridge allows the rocker arms of all selectors to return to normal position. The code wheels on all selectors then

return to normal position, except those that have a code pin on the code wheel in position for the holding spring to engage them. All selectors are then advanced by the second set of reverse impulses, 5 in this case.

Of the selectors that were held in an advanced position before, only the one called will now have a code pin in position to be engaged by the holding spring. Also the selectors that returned to normal before, and have a code pin five steps from the normal position, will be in position to be held up by the holding spring. All other selectors will return to normal position during the second long period of approximately one second. The third set of reverse impulses, 4 in this case, advances all selectors four steps. Only the selector that had its code pins in the code wheel set for 8-5-4 (the selector called) will have been advanced to its ringing position—that is, a total of 17 steps from the normal.

In the ringing position the contact spring on the top of the code wheel will be directly over the first ringing terminal and making contact with it. Some of the other selectors may be held up on the first or second code pins, but will not have been advanced to the third or ringing code pin. During the ringing period of approximately two seconds, an answer-back or tone is heard in any receiver bridged across the line while the bell is ringing. After the ringing period, one impulse is delivered to the line by the calling key as before, and all selectors are advanced one step. All selectors then return to the normal position. A similar sequence is followed in the operation of a selector arranged for a different code setting.

In order to take care of special cases where a greater number of code settings are required than those given in Table No. 1, the code settings for a No. 60-A selector set for 27 total steps in each code setting are given in Table No. 2, which gives a total of 253 code settings.

Time Sending Set D-14386

In addition to the operation of selecting a station just described, the selector is provided with a second or time ringing terminal for receiving time. For this purpose a time sending set is used with the 60-A Selector Apparatus Case connected as shown in figure 2 for sending the time signals over selector circuits. The set consists of a 60-A selector (set for one step per D-16647), a D.P.D.T. switch, condensers and a resistance. For normal operation of the circuit the D.P.D.T. switch is thrown to the "calling position."

When it is desired to send time signals, a 60-A Selector Key set to send 22 consecutive impulses is operated. This steps all the 60-A selectors on the circuit around to the time-receiving position (code wheel contact within one step of closing the second or time contact) where it is retained by an insulated "time arm." The D.P.D.T. switch is then thrown to the "time position." This closes the circuit between K1 and K3 and connects K2 to terminal 2 of the 60-A selector in the time sending set. Closing contacts K1 and K3 operates the 122-EW relay which connects the main battery to the line. Then as a time repeating relay in the telegraph circuit operates and completes the circuit between T1 and T2, the 60-A selector in the time sending set advances one step and is held there by a code pin. The closing of the selector contacts operates the No. 26-A relay. This sends an impulse of one polarity out over the line to momentarily advance all the No. 60-A selectors one step. This momentarily closes the time contacts and causes all bells to tap. The selectors on the line then fall back to a position within one step of closing the time contact and are held there as before by the "time arm" engaging with the holding spring.

Then as the time repeating relay operates again, the 60-A selector in the time sending set advances another step and as it is not retained by a code pin, it falls back to the normal position within one step of closing its contact. The 26-A relay releases as the contacts on the time sending selector open and sends out an impulse of the opposite polarity over the line, operating all the 60-A selectors and causing all bells to tap as before. This series of operations is repeated for each two operations of the

time repeating relay, thus causing the bell to tap once each time the time repeating relay operates.

The 4 MF condenser, shunting the time sending selector, prevents it from sending impulses fast enough to cause the 60-A selectors on the line to step off the "time arm" if the selector circuit is connected to the time repeating relay when telegraph impulses are being sent. The 1-H resistance (200 ohms) limits the current through the winding of the time sending selector when a high main battery is used.

After the time signals have been sent, the D.P.D.T. switch is thrown to the calling position. The selectors on the line are then stepped off the "time arm" by turning any selector key. The circuit is then in condition for regular calling.

The time sending set functions on a main battery of any voltage between 100 and 350 volts. The "time arm" of the 60-A selector is insulated from the bell circuit to prevent the answer-back tone from interfering with telephone conversation while time signals are being sent.

No. 60-B Selector

This selector is known as the multiple contact selector and differs from the No. 60-A selector only in that it is equipped with four selective ringing terminals instead of one, so that any one of four local signal circuits can be closed by the same selector independently. This selector is not equipped with a terminal for receiving time signals.

The method of setting the code numbers and the method of operation is the same as described in detail for the No. 60-A selector. The terminals on the No. 60-B selector are known by the letters A, B, C, D. Terminal A is the first terminal engaged by the contact spring on the code wheel as the code wheel is advanced. The last group of impulses in the code setting for selecting the first or A contact is increased by two impulses to select the B contact, four impulses to select the C contact and six impulses to select the D contact. The numbers pasted on the selector spool indicate the code setting for the A contact. For example, a selector having a code setting 8-5-4 for the first contact will be marked 8-5-4, and the contacts will be known as 8-5-4 A, 8-5-4 B, 8-5-4 C, 8-5-4 D.

The impulses required to select the four contacts on selector number 8-5-4 will be A contact 8-5-4, B contact 8-5-6, C contact 8-5-8, D contact 8-5-10.

Table No. 3 gives all the code settings for the 17 step code which can be used for the No. 60-B selector without interference with any of the other regular 17 step code settings for the No. 60-A selector.

This selector functions in all other respects in the same way as the No. 60-A selector.

No. 60-B Selector

No. 127-J Extension Bell

This bell is used as an extension signal in connection with the multiple contact No. 60-B selector. The ringer in the No. 160-A selector set in which the selector is mounted gives the signal for the first or "A" ringing terminal. One of these extension bells is required for each signal in addition to the one in the No. 160-A selector set.

It consists of a No. 60-CG ringer and a No. 38-A resistance mounted in an oak box.

These sets are arranged to be connected directly to the terminals in the No. 160-A selector set as follows: Terminal K2 of the extension bell to be connected to terminal K2 in the No. 160-A selector

Western Electric

set. Terminal B2 of the extension bell to be connected to terminal B2 in the No. 160-A selector set. Terminal S of the extension bell to be connected to the binding posts 3 or 4 or 5 on the base of the No. 60-B selector as desired. These connections are shown plainly on a circuit label furnished with the No. 60-B selector.

The No. 60-C ringer has been previously described.

Operation of Selector Circuits Through 70-A Repeating Coils

Circuits equipped with 60 type selectors may be operated through 70-A repeating coils to allow:

1. A low simplex resistance in the simplex telegraph circuit.
2. One or more branch selector circuits to be operated from a main selector circuit without any metallic connection to it.
3. Two or more simplexed selector circuits terminating at one point to be operated from a common main current supply.
4. Two selector circuits to be used as side circuits for obtaining a composited or simplexed phantom with the physical and phantom telephone and the telegraph circuits terminated at the same or different points. Figure 14 shows a general way of obtaining these conditions.

No. 70-A Repeating Coil

The 70-A repeating coil is a toroidal type coil mounted on a wood base. The complete coil is approximately 8½" wide x 11" deep x 5" high, and weighs approximately 26 pounds.

The coil is provided with four windings brought out to separate terminals. The two inner windings (3-4 and 7-8) each have a resistance of approximately 40 ohms, and the two outer windings (1-2 and 5-6) each have a resistance of approximately 45 ohms. These windings are balanced from a resistance, inductance and capacity standpoint to within 200 crosstalk units to permit the coil to be used on simplexed telephone circuits arranged for duplex telegraph without interference from the telegraph.

The coil is especially designed for repeating the low frequency (3½ cycle) selector impulses and also talking frequencies (200 to 2,000 cycles). The loss in telephone transmission due to inserting a repeating coil in the center of a long line of No. 9 B & S gauge—non-loaded open copper wire is approximately 0.7 miles. The impedance at 890 cycles of two windings of the coil connected in series aiding is approximately 10,000 ohms and of four windings approximately 40,000 ohms. The loss due to bridging the coil on a telephone line as a simplex bridge is, therefore, negligible.

(1) When the 70-A Repeating Coil is used as an end simplex bridge, two or four windings connected in series aiding are bridged across the selector circuit. If the selector circuit is operated standard (condensers in each selector set) a resistance of 300 to 500 ohms should be connected on each side of the coil. If the selector circuit is operated through repeating coils the simplex coil windings should be bridged directly across without any resistance.

When the 70-A repeating coil is used as a simplex bridge for intermediate telegraph stations, the selector circuit is divided; one section is connected to the two primary windings (1-2 and 5-6) and the other section connected to the two secondary windings (3-4 and 7-8) of the 70-A repeating coil. When used for this condition the selector circuit should be operated through repeating coils at the Dispatcher's Station. The simplex resistance of the coil added to the telegraph circuit is approximately 20 ohms for two windings and 40 ohms for four windings. (See figure 11.)

(2) The 70-A Repeating Coil is used for operating one or more branch circuits from a standard selector circuit (condensers in selector sets) by connecting the primary of the 70-A repeating coil for each branch to the main circuit in series with a bank of condensers. The capacity of this bank of condensers is 10 MF plus 1 MF, for each selector on the branch. A 10,000 ohm resistance is connected in parallel with this bank of condensers to prevent oscillatory discharges of the condenser

from interfering with the operation of the selectors on either the main or branch circuits. (See figure 12.)

If the main selector circuit is operated through repeating coils the primary of the 70-A repeating coil for each branch is bridged directly across the main circuit without any condensers or resistance in series.

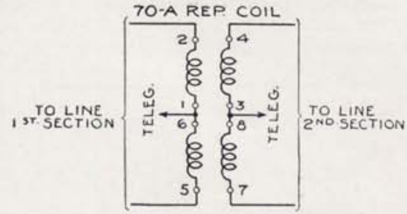

Fig. 11

Intermediate Telegraph Station

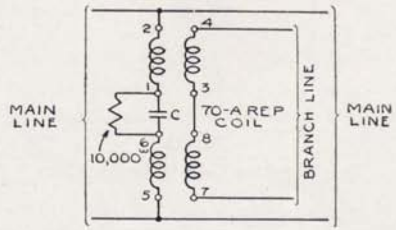

Fig. 12

Branch Line Operated Through Repeating Coil

(3) The 70-A repeating coil is used for operating two or more simplexed selector circuits terminating at one point from a common main current supply as follows:

Each selector circuit is connected to the secondary winding of a 70-A repeating coil. The primary of each repeating coil is connected in series with a bank of condensers to the line terminals of its associated 60-A apparatus case. The capacity of the bank of condensers is 10 MF plus 1 MF for each selector on the circuit. When a dry or storage cell battery or motor-generator set is used as a main current supply a resistance of 2,000 ohms (Ward-Leonard DM-2,000) is connected in parallel with the condenser bank to prevent oscillatory discharges of the condensers from interfering with the operation of the selectors. When a 60-A rectifier is used this resistance is changed to 5,000 ohms, if two selector circuits are operated from one rectifier, and no resistance is needed, if only one selector

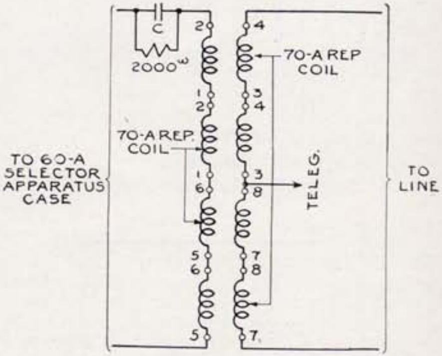

Fig. 13

Two Repeating Coils in Series Aiding

circuit is operated from one rectifier. The tube in the rectifier set in this case prevents the oscillatory discharges from interfering.

When the number of selectors on a circuit require a bank of condensers over 30 MF capacity, two 70-A coils should be used with the primaries connected series aiding and the secondaries connected series aiding. (See figure 13.)

(4) The 70-A Repeating Coil when used for operating selector circuits which form side circuits of a composited phantom is connected at the Dispatcher's Station, as explained under (3) and at the intermediate and end points as explained under (1).

A general arrangement for operating four selector circuits from one point with a composited phantom in each direction is shown in figure 14.

The voltage of the main current supply source for operating selector circuits through repeating coils should be from 50 to 75 per cent higher than the voltage specified on the voltage-line-selector curves in figure 4 for similar conditions.

PERIODIC TESTS

It is recommended that regular periodic tests be made of the line and the apparatus in the calling circuit as follows:

Test 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 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.

Test 2. Test (every two weeks) the potential of the local and main batteries when the normal operating current is flowing. (See page 5.)

Test 3. Test (once a month) by operating each calling key, to 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 page 11. 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 not equal, then the No. 26-A relay should be adjusted by changing the magnetic air-gap. However, if a few keys give unequal results, the K1 and K2 contact on these keys should be adjusted to give the same results as the other keys. (See page 14.)

Test 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 14. If not, adjust the governor springs as described to make it so. A convenient way to

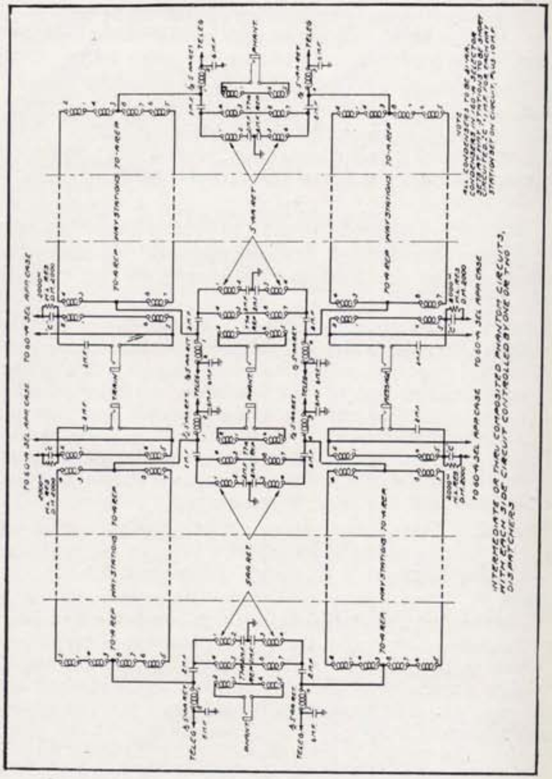

FIG. 14

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 and then test the remaining keys by winding this key up with one hand and the key under test with the other hand and then 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 1" 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 for the reason that heavier oils tend to become gummy.

Test 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 3 months) after the line tests and tests on apparatus in the calling circuit are made and each found O. K., is to reduce the potential of the main battery, say from 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 of operation 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 due to some unavoidable line or other trouble that may come in. This is a Safety First test.

Tests of this nature are maintenance tests and if carried out consistently may prevent cases of trouble and thus prevent interference of service.

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 operations of the relays in the calling circuit should be examined.

Then call the stations on each side of the station that failed and 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 O. K., 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 that calling key or else in the apparatus at that way station. This key should be tested as described under Periodic Tests 2 and 3. If the key is O. K., then 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 1 and 2 on the selector. If the bell then 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 1 and 2 on the selector, test the local battery and examine operation of the bell and the answer-back, see page 20.

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 O. K., 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 station.

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

If a voltmeter is used to measure the potential at that station, a high resistance meter, say not less than 15,000 ohms, must be used. A zero center 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 stepping impulses. However, the amount of the swing will depend somewhat on the damping of the meter and a definite value cannot be given. A minimum value can be obtained from trial.

As a general thing, adjustment of the selector in the field is not recommended inasmuch as the selectors are sealed. However, 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 easily corrected, we recommend that a spare selector be substituted in its place and this selector returned to the Western Electric Company for investigation. When 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.

EFFECT OF LINE OR WIRE TROUBLES

When a wire goes down or becomes open in any other way, the line as a rule becomes noisy and the stations beyond the break cannot be called. All stations can usually be called, however, up to the break.

When a short circuit occurs on the line near the dispatcher there may be considerable sparking of the contacts when a call is made and no selector can be called. When a short circuit occurs further out on the line some of the nearby selectors may be operated, depending upon the length of the line.

It frequently happens that telegraph wires break, swing or otherwise become crossed with telephone wires. If the telegraph battery is very high the operation of the selectors may be interfered with by telegraph impulses, especially if the telegraph impulses are reversed frequently.

If the insulation of the line is low but essentially the same for both line wires, there will be no effect on the calling system except, of course, that the selectors at the far end of the line will receive less current. The margin of the selectors should, however, be sufficient to take care of this. An unbalanced leak (that is, where the leak from one line wire is greater than from the other), will, as a rule, cause the line to become noisy, but should not affect the operation of the selectors.

TABLES OF CODE SETTINGS

Total Steps in Each Code—17 *TABLE NO. 1* *Total Code Settings—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	8-2-7	
2-9-6	3-8-6	4-7-6	5-6-6	6-5-6	7-4-6	8-3-6	9-2-6
2-10-5	3-9-5	4-8-5	5-7-5	6-6-5	7-5-5	8-4-5	9-3-5
2-11-4	3-10-4	4-9-4	5-8-4	6-7-4	7-6-4	8-5-4	9-4-4
2-12-3	3-11-3	4-10-3	5-9-3	6-8-3	7-7-3	8-6-3	9-5-3
2-13-2	3-12-2	4-11-2	5-10-2	6-9-2	7-8-2	8-7-2	9-6-2
10-2-5							
10-3-4		11-2-4					
10-4-3		11-3-3		12-2-3			
10-5-2		11-4-2		12-3-2		13-2-2	

Total Steps in Each Code—27 *TABLE NO. 2* *Total Code Settings—253*

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

TABLE NO. 3

For No. 60-B Selector

Total steps to "A" contact in each code 17
" " " "B" " " " " 19
" " " "C" " " " " 21
" " " "D" " " " " 23

Total Code Settings 28

		7-2-8 A, B, C, D	
		7-3-7 A, B, C, D	8-2-7 A, B, C, D
		7-4-6 A, B, C, D	8-3-6 A, B, C, D
		7-5-5 A, B, C, D	8-4-5 A, B, C, D
		7-6-4 A, B, C, D	8-5-4 A, B, C, D
		7-7-3 A, B, C, D	8-6-3 A, B, C, D
		7-8-2 A, B, C, D	8-7-2 A, B, C, D
9-2-6 A, B, C, D			
9-3-5 A, B, C, D	10-2-5 A, B, C, D		
9-4-4 A, B, C, D	10-3-4 A, B, C, D	11-2-4 A, B, C, D	
9-5-3 A, B, C, D	10-4-3 A, B, C, D	11-3-3 A, B, C, D	12-2-3 A, B, C, D
9-6-2 A, B, C, D	10-5-2 A, B, C, D	11-4-2 A, B, C, D	12-3-2 A, B, C, D
13-2-2 A, B. C, D			

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