

RAILWAY SIGNALLING AND COMMUNICATIONS

CHAPTER XI: TELEPHONY – PART 2

TRAFFIC-CONTROL SYSTEMS.

To control effectively the movement of trains it is a very general practice to centralise the control at an office or offices and connect all the essential signal boxes, etc., on the route to an omnibus circuit. A special selective circuit is used so that each point can be rung individually, this circuit usually incorporating a rotary switch or “selector” at each station, such switch being stepped by a series of impulses from the control office. A typical circuit is shown in Fig. 172. The rotary selectors, known as type No. 60A, at each station are connected, with a series condenser, across the line wires, being stepped by the condenser charges and discharges, the result of a series of battery reversals from the control station.

The contacts on the selector are so arranged that a local bell circuit is completed when the selector receives the correct combination of impulses, and its own bell, and no others, will be rung, no two combinations being alike. These combinations usually consist of three sets of impulses, the total number of which always amounts to seventeen. Thus station numbers could be 4, 3, 10 or 5, 7, 5, etc. Arrangements can be made for a group of stations to have a common call. Two or three groups can be provided for on one control circuit. In these cases it is usual for all stations of any one group to have the same first digit, and they may all be called together, when the dial system is in use, by dialling that digit only.

The local bell circuit is completed on step number 17, but the rotary portion of the switch will not reach this step if the first two digits are not appropriate to the station. This is accomplished by the insertion of two pins on the circumference of the selector “wheel”, e.g., if the station number is 4, 3, 10, a pin will be inserted to prevent the wheel restoring after the receipt of four impulses, and similarly the second pin will be inserted to prevent the wheel restoring after a further three impulses, and the selector will then step to position 17 on receipt of the last digit of ten impulses. As other selectors on the control circuit will have, at least, the second pin in a different position, these selectors will restore after the second digit and will not reach position 17. The code of a station can be easily changed by altering the position of the pins. Contacts are arranged on the bell to send a tone to line to indicate to the control officer that the station is being rung.

The control-office equipment for setting up the codes may consist of a bank of keys, each key having a mechanism to send the appropriate code for each station, or the codes may be “dialled” by using a standard automatic dial, this now being the standard arrangement. Where the dial system is employed, the selectors shown in Fig. 172 may be employed, but the third train of impulses is sent automatically and only two digits are required for dialling. All stations on one control circuit may be called at once by sending a complete train of seventeen impulses.

It may be desired to connect a control circuit of one section to that of another for inter-communication between control offices. This is usually provided by having a selector arranged to complete a local relay switching circuit, upon receipt of a continuous train of sixteen impulses. In some traffic-control systems the three-stage selectors are replaced by rotary switches similar to those used in automatic telephony.

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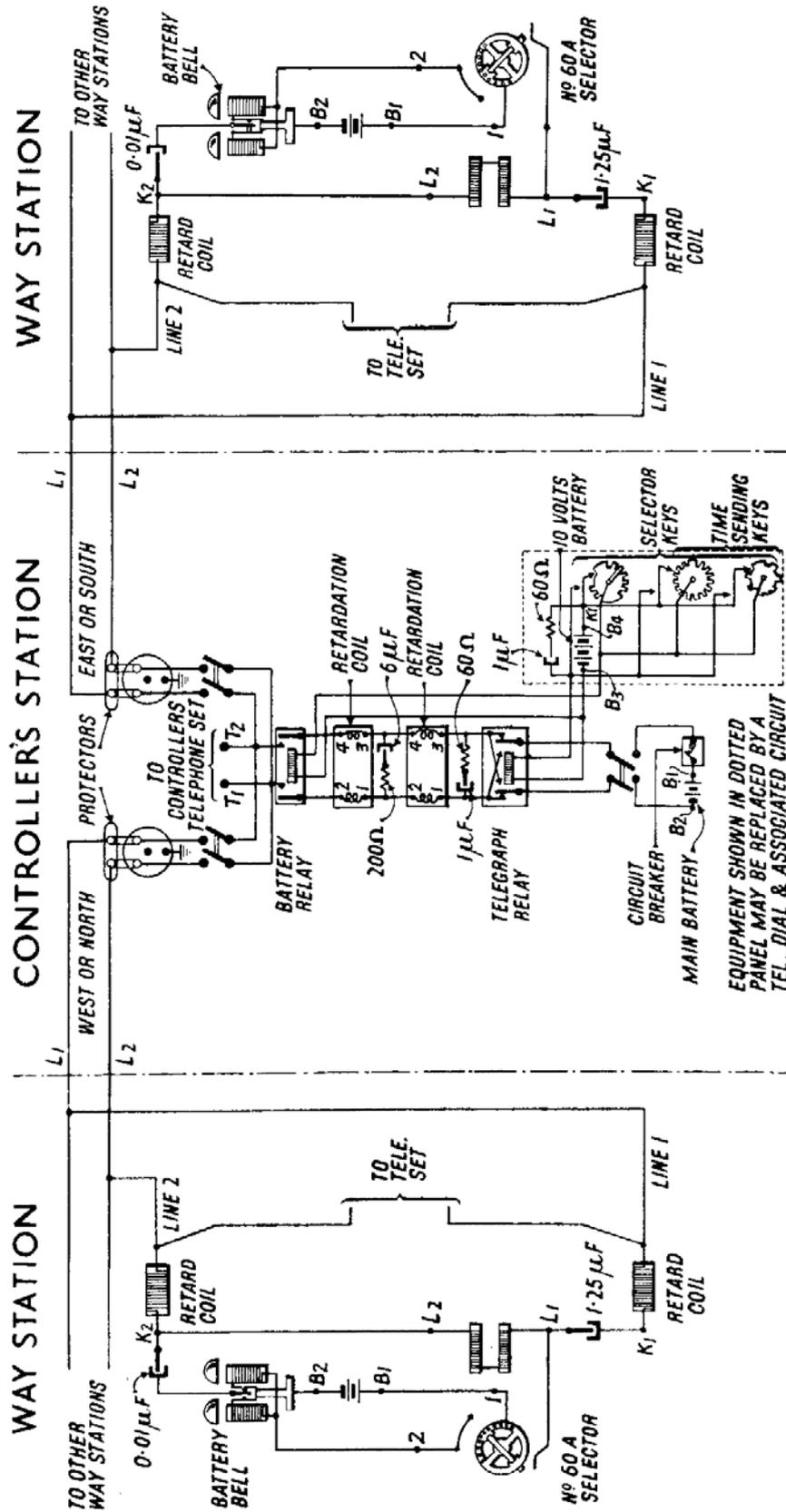


FIG. 172. Selective Traffic Control Telephone System

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LINE WORK.

In railway working the connecting lines are usually run on overhead-pole routes, terminating in a cable where entry is required to the exchange or telephone. The lines are carried on insulators mounted on the arms of the poles, and for good transmission the insulation resistance must be kept high, by renewing broken insulators, etc., and keeping the wires clear of trees or buildings. On long lines the resistance of the wires seriously weakens the transmitted currents, and heavier gauge wires are therefore used on these routes. On long lines trouble is also caused by inductive and capacity effects causing noisy and faint transmission and overhearing. In the case of the two pairs of wires run on one route, as in Fig. 173 (a), if the varying speech current in B is at the moment of consideration in the direction shown by the arrow, then the varying magnetic field surrounding this wire will induce an E.M.F. in C and D in the opposite direction. As C is closer to B than D, these E.M.F.s will be of different strength, e.g., higher in C than in D, and the current will therefore flow round the telephone circuits of C D, with consequent noise in the receivers. As the induced current will be of the same characteristics as the original current in B, overhearing will result. This effect is still further enhanced by the "capacity effect" shown in b. The wires being run parallel, they may be considered as the plates of a condenser. Therefore, if the voltage in B produces a negative charge on its surface, a similar but positive charge will be induced on C, which in turn will induce a negative charge on D. The charges on C and D, being opposite, will neutralise themselves via the telephone circuits, with consequent noise and overhearing.

These effects can be largely overcome by crossing the wires, as in c ; the induced E.M.F.s are then in opposite direction in each half of C and D, as shown by the arrows, and therefore neutralise themselves in the line without travelling via the telephones. With several pairs of wires on one route, this crossing of wires has to be carefully planned, and a standard arrangement is employed to obviate interference as much as possible. This arrangement is shown in Fig. 174, the crossings usually being introduced by the fitting of four insulators at the cross-over points, as in Figs. 175 and 176.

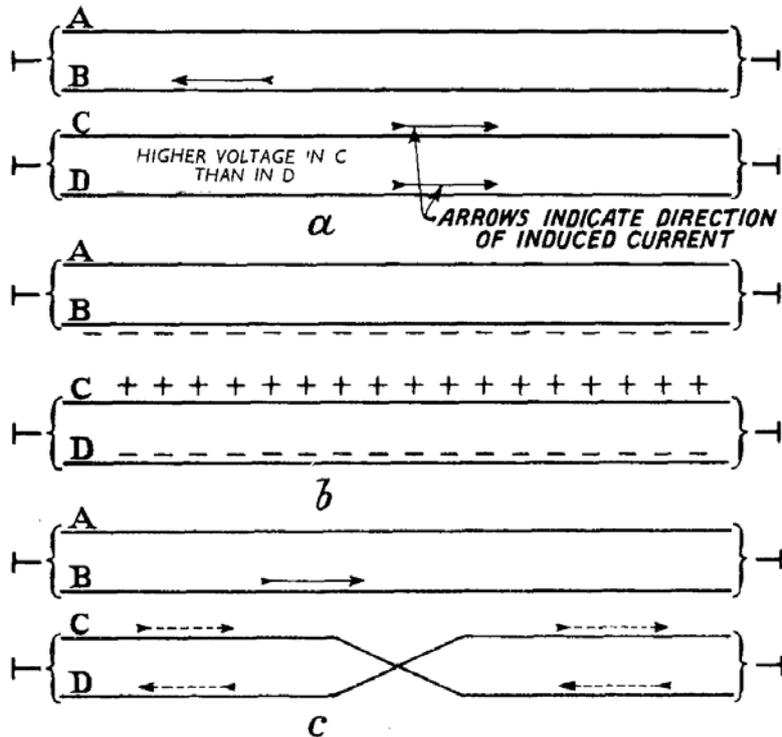


FIG. 173. Inductive and Capacity Effect.

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On overhead routes protection has to be provided against the wires being struck by lightning or making accidental contact with power wires. The latter is provided for by terminating the line wires on fuses, usually designed to blow at 1 ampere. As a steady current of 0.5 ampere would not blow the fuse but would damage the apparatus, a further protection is provided by means of a "heat coil", fitted in each line wire circuit. This consists of a coil of wire C (Fig. 177) on a short metal tube T. The tube is held in position by a special soft solder to the centre pin P. The heat coil is provided with a cover D, and it is normally clipped between a pair of holding springs, serving also to make contact with the coil. A prolonged current of not less than 0.25 ampere will heat the coil sufficiently to melt the solder. Under the tension of the holding springs the tube T will move on the pin P sufficiently to open the spring contacts and disconnect the line. This type of heat coil is usually fitted at the exchange end of the line, the springs also serving as a convenient point for the insertion of a testing clip.

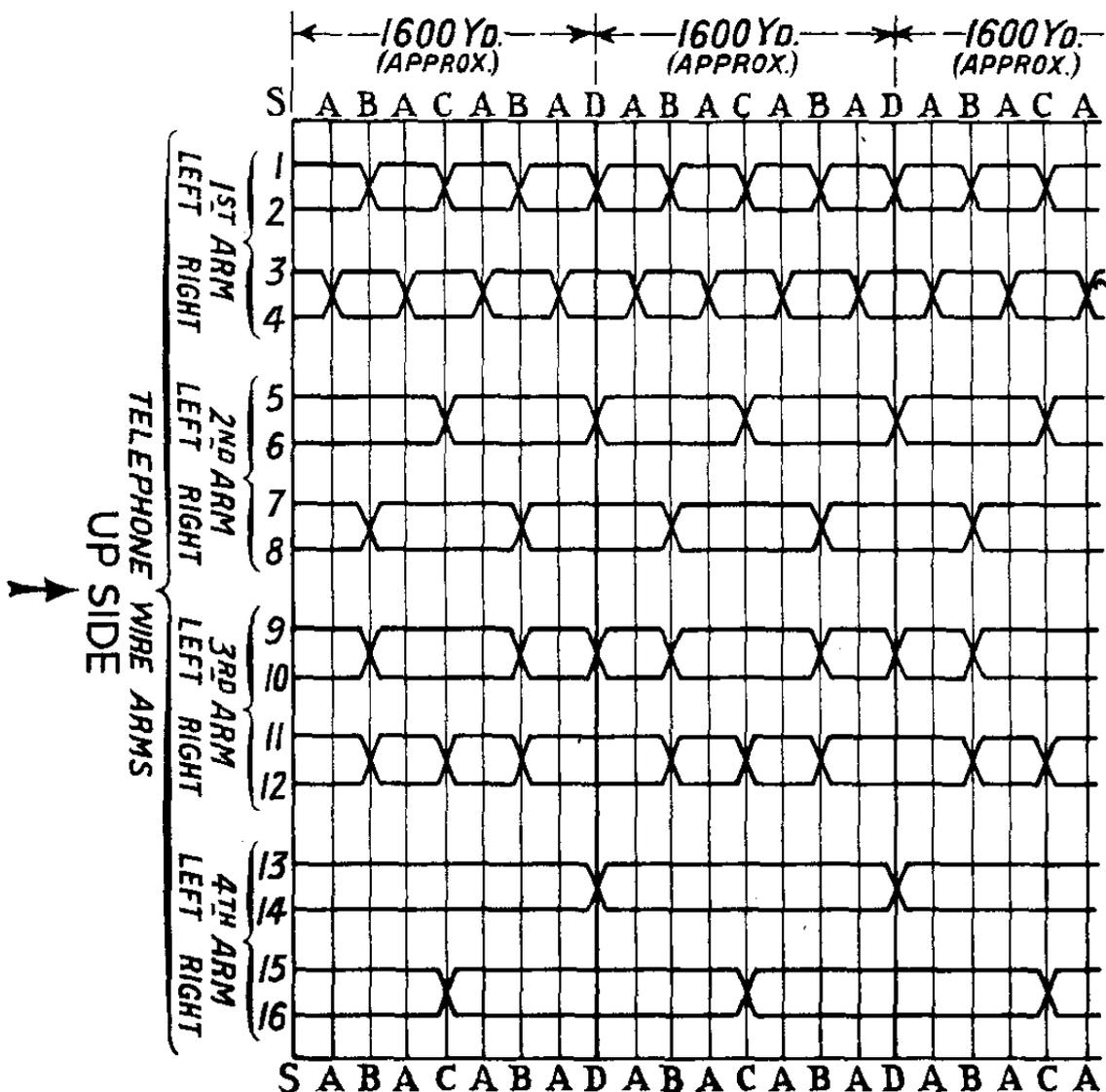


FIG. 174 Transposition of Wires.

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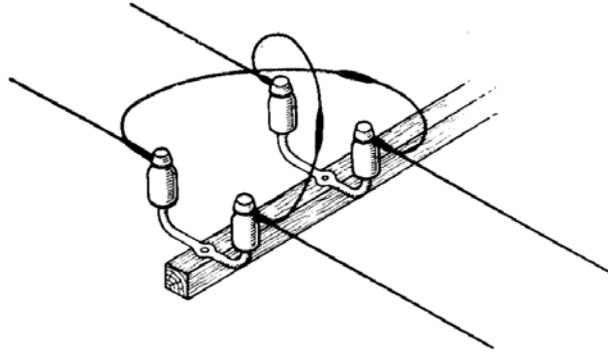


FIG. 175 Transposition Point.

For lightning protection an easy path to earth has to be provided for the extremely high voltages produced by a lightning flash. This is accomplished by providing a small air gap to earth across which the flash will easily jump. As the lightning discharge consists of alternating current it will take this path of least inductance to the alternative of the apparatus circuit, which usually presents a comparatively high inductance. The air gap is usually an arrangement similar to Fig. 178, consisting of two metal plates, one of which is connected to line and the other to earth. Earth wires leading from lightning arresters to earthing devices should be kept as short and straight as possible. The minimum size of copper conductor between earth plates and arresters should be 7/.029 in.

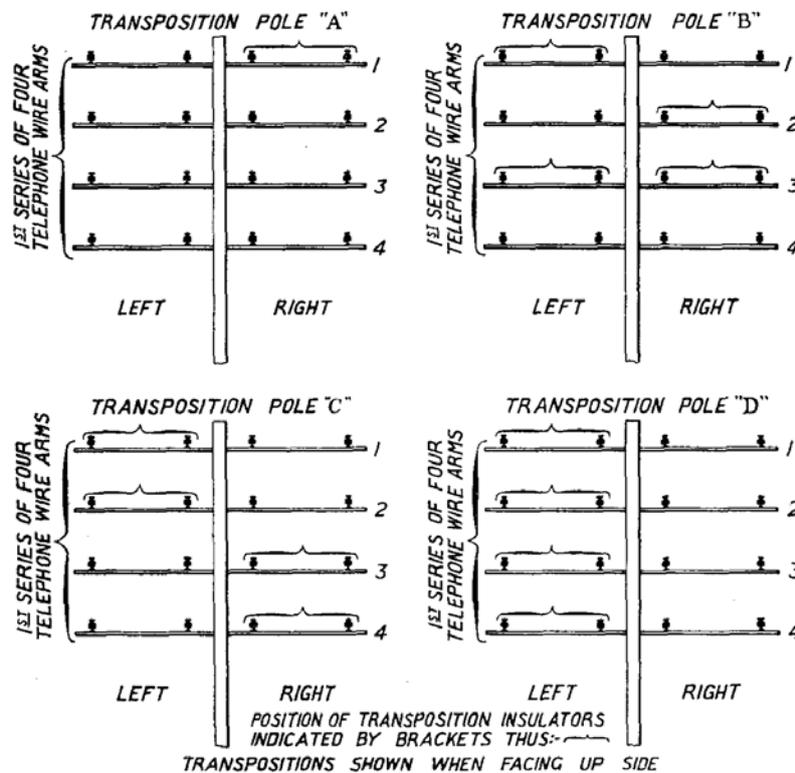


FIG. 176.-Positions of Transposition Insulators.

A form of protector used in exchanges consists of two carbon or metal plates X1 and X2 (Fig. 179) separated by a mica plate R. Holes are drilled in the mica, thus producing a small air gap between the carbon plates. It is essential to keep these assemblies free from

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dust, as a layer of dust across the carbons will lower the insulation of the line. Some present-day carbons are treated with a special varnish, the mica plate being then omitted.

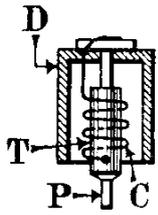


FIG. 177. Heat Coil.

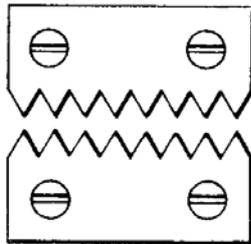


FIG. 178. Serrated Lightning Protector

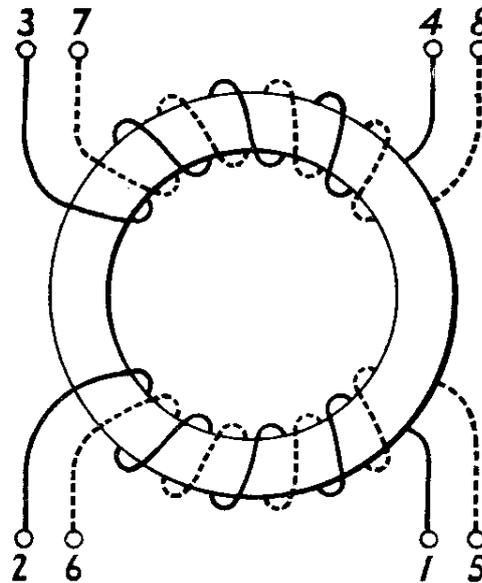


FIG. 180 Repeating Coil

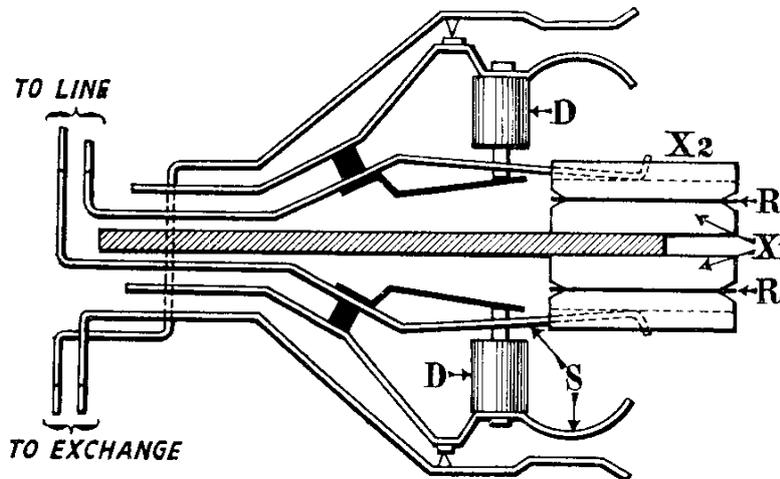


FIG. 179.-Carbon Protector and Heat Coils.

SUPERIMPOSING.

The number of wires on a pole route being limited, and the cost of erection fairly high, it is economical to use one wire or pair for more than one connecting circuit. This, of course, must be achieved without mutual interference, and in simple circuits of this nature a repeating coil is usually incorporated. This consists essentially of four coils fitted upon a circular soft iron ring, as in Fig. 180. It will be seen that a pair of coils are wound together, and the ends are connected to numbered terminals. The normal action of the coil is that of a transformer, with a ratio of 1 : 1. It is very important to note that these numbered connections must be made as shown in Fig. 180, as incorrect wiring may cause inefficient operation of the circuit.

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Considering now some applications of this device to superimposed circuits, the case of a telegraph circuit superimposed on a telephone circuit is shown in Fig. 181. The normal telephone speech is transmitted to line via the repeater coil R 1 and from the line to distant station at R2. The telegraph line is joined to the centre connections of the repeating coil, as shown, and the current in the telegraph circuit divides equally through the coils and line wires. There is thus no interference with the telephone circuit. It will be seen that the metallic telephone circuit forms one leg of the telegraph circuit, the current dividing equally at the centre of each repeating coil.

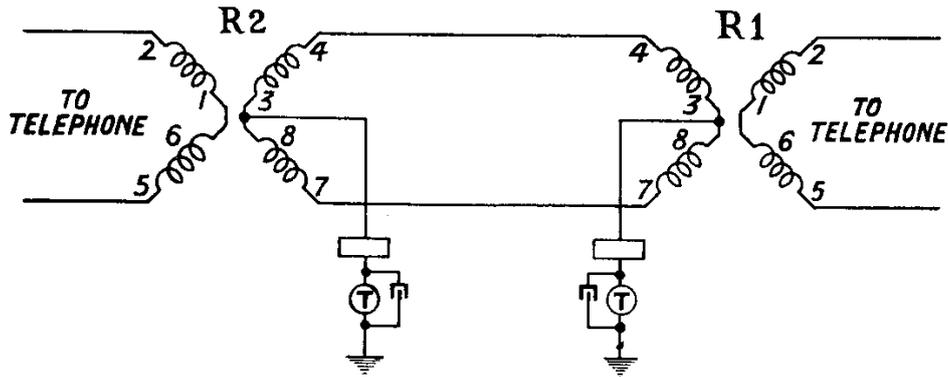
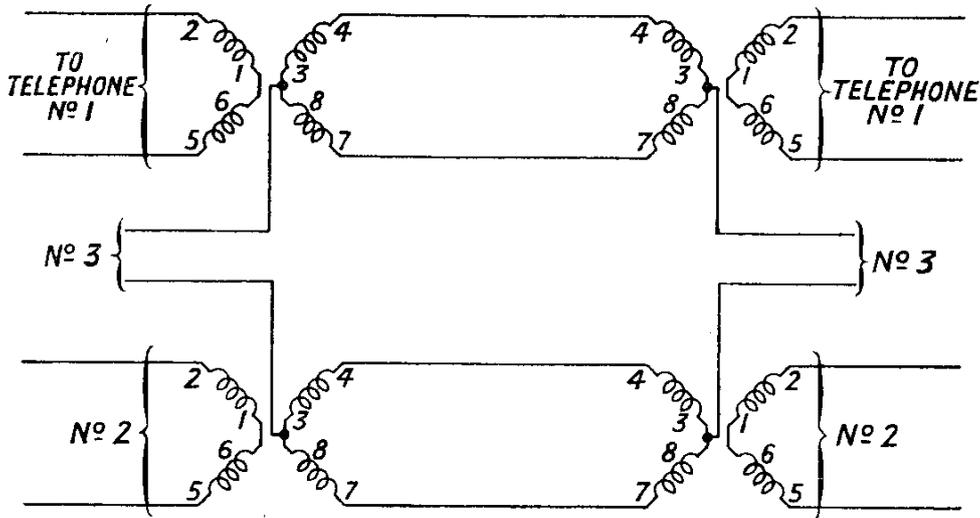


FIG. 181.-Telegraph Superimposed on Telephone Circuit.



FIG, 182 . -Two-wire "Phantom" Circuit.

If another superimposed circuit be provided on another pair of wires a two-wire "phantom" circuit, as shown in Fig. 182, becomes available, the diagram showing a telephone circuit superimposed on two physical circuits. It is possible to carry the system still further and superimpose a fourth circuit, with earth return, on circuit No. 3. For the successful operation of superimposed circuits the individual coils of the repeating coil must be well balanced and the line wires of the physical circuit must be of the same gauge and of similar material. Maintenance of good insulation is particularly important in the case of these circuits. It will be obvious that if there is a greater amount of leakage from one wire than from the other, telegraph currents will be different in each wire and thus cause the telegraph signals to be heard in the telephones.

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BUZZER TELEPHONES.

Buzzer telephones employ a method of calling by emitting a buzzing sound from a hooter at the called station. The required calling current is produced by using the induction coil as a vibrator. Contacts are fitted on the end of the coil similar to the well-known "shocking" coil. Upon battery being supplied to the primary the contact is attracted and breaks the primary circuit, and an action is produced similar to a buzzer. The induced currents in the secondary are sent to line and actuate the receivers. Buzzer telephones are generally superimposed. It would, for example, not be possible to connect a battery ringing telephone to a signal repeater circuit, as both positive and negative battery polarities are required to operate the repeater. Buzzer currents, however, do not affect the repeater. Also, it is necessary to prevent current from the repeater battery leaking through the telephones, and this is arranged by inserting condensers between the latter and the line.

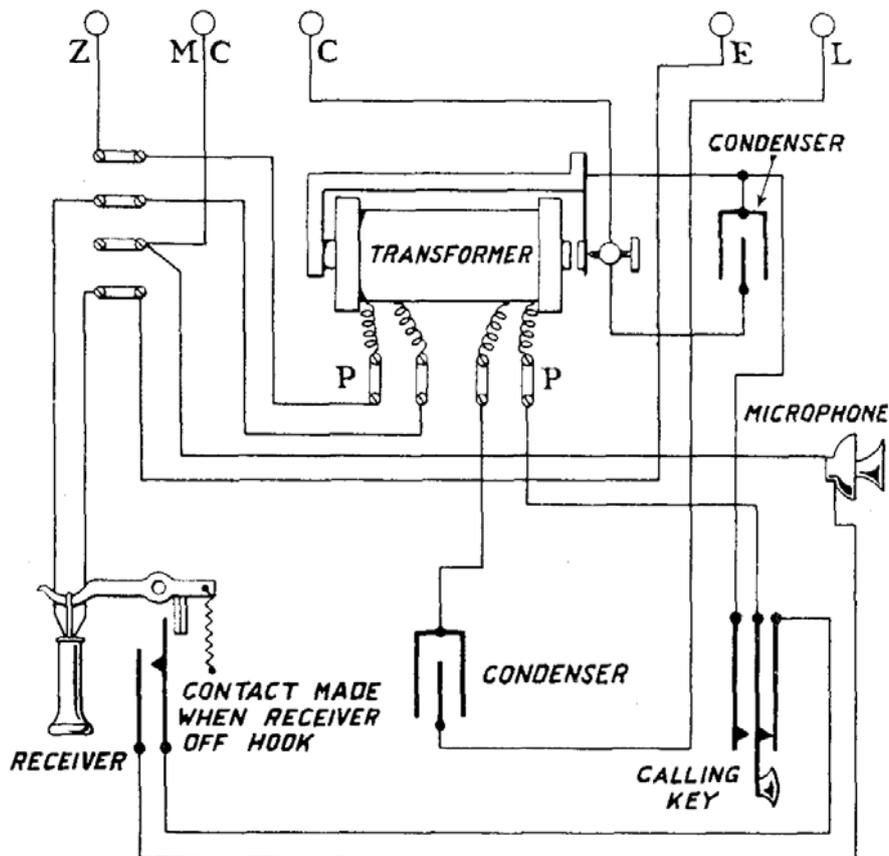


FIG. 183.- Buzzer Telephone Circuit.

The buzzer current, being alternating, passes freely through these condensers if of suitable capacity, i.e., 0.5 to 2 mF. It is important that the contacts of vibrators be adjusted so that a clear musical note is produced, otherwise an early failure to operate is probable. Fig. 183 shows a buzzer telephone circuit. These telephones are frequently superimposed upon signal repeater circuits, as shown in Fig. 184.

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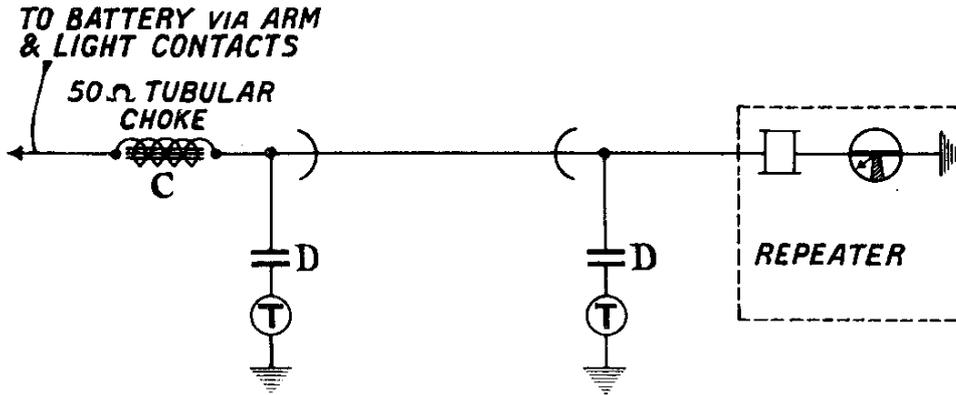


FIG. 184. - Buzzer Telephone on Signal Repeater Circuit.

The choke coil C prevents the speech currents leaking to earth via the repeater battery, and the coil of the repeater indicator acts as a choke to prevent leakage at that end of the circuit. The condensers D prevent the direct current of the repeater circuit from passing through the telephones. Similarly a telephone may be superimposed on a block bell circuit, as shown in Fig. 185.

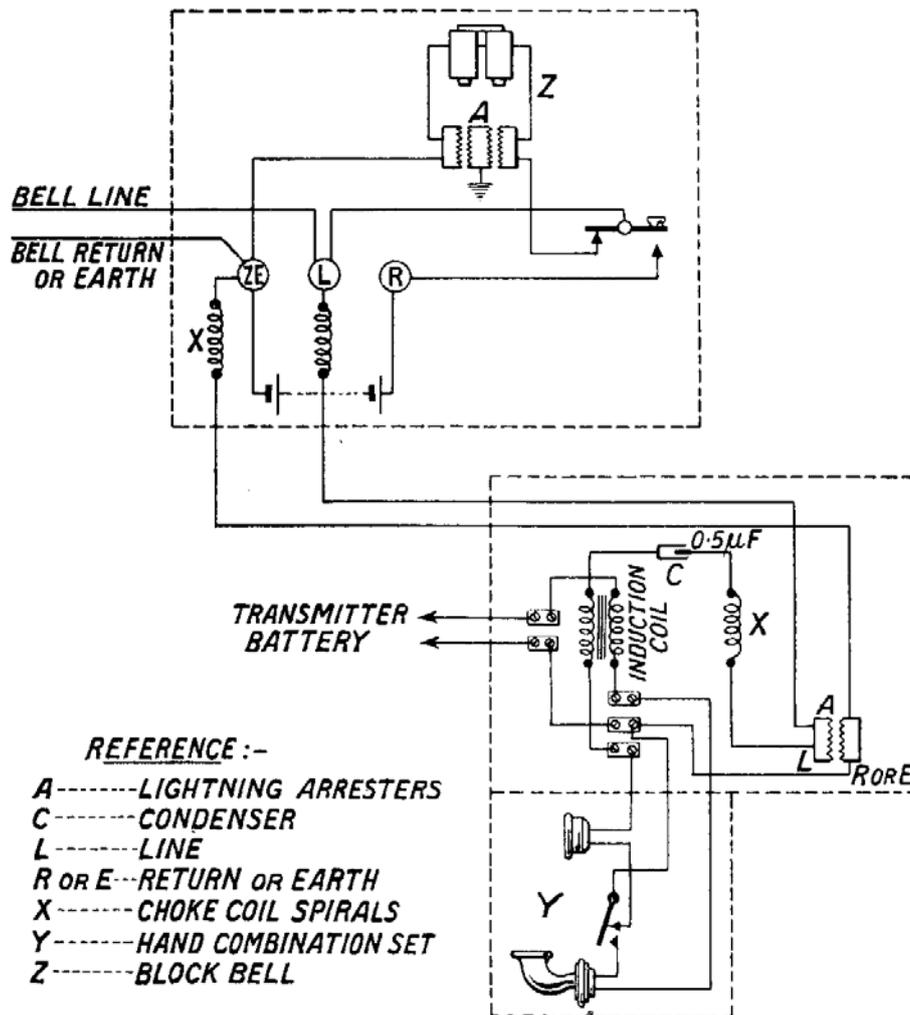


Fig 185. – Telephone on Block Bell Circuit

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CARRIER TELEPHONY.

Carrier telephony permits of two or more telephone conversations taking place simultaneously without mutual interference on a single pair of wires. Each conversation is said to be carried by a "channel"- to be exact, a "duplex" channel - because it transmits speech in both directions. The system is similar to wireless transmission, the channels operating on different wave-lengths or frequencies, a line wire instead of the ether being used to convey the electrical energy. Increasing use is being made by railways of this method of conveying speech, which permits of increasing the trunk telephone facilities at a much lower cost than could be done by running new lines. It also has the additional advantage of much improved speech efficiency, due to the fact that amplifiers are included in the apparatus to eliminate the effect of line losses. The circuits used in the apparatus are somewhat complicated, but the following description of general principles is included to give a general conception of the subject.

Normal speech currents have a frequency range, or band, as it is called, of approximately 300 to 2,800 cycles per sec. The average overhead line, however, is capable of transmitting much higher frequencies than 3,000 c.p.s. If, therefore, the speech band can be shifted for transmission purposes, to, say, 3,200 to 6,000 c.p.s., a channel can be provided in addition to the normal circuit. Similarly further channels can be transmitted by using still higher frequency bands. The maximum number on open lines in addition to the voice frequency channel is four. Experiments are in progress for transmitting up to possibly 400 channels over specially constructed cables.

For each telephone channel additional to the ordinary voice frequency channel a separate carrier frequency is generated, generally by means of a valve oscillator. Each carrier frequency is then modulated by the speech frequency, the resulting output from the modulator circuit being a complicated wave which contains three frequencies, viz., carrier frequency, carrier plus modulator frequency and carrier minus modulator frequency. If, for example, the carrier frequency is 6,000 c.p.s. and the speech frequency at the moment happens to be 2,000 c.p.s., then the modulator output will consist of (1) 6,000 c.p.s., (2) $6,000+2,000=8,000$ c.p.s., and (3) $6,000-2,000=4,000$ c.p.s. Thus for a normal speech band of 300 to 3,000 c.p.s. the resulting bands from the modulator, in addition to the 6,000 c.p.s., will be (1) $6,000-(300 \text{ to } 3,000)=5,700 \text{ to } 3,000$ c.p.s. (2) $6,000+(300 \text{ to } 3,000) =6,300 \text{ to } 9,000$ c.p.s. These two bands are referred to as the lower and upper side bands respectively.

The modulator output is now transmitted to line, and at the receiving end demodulation takes place. The band of frequencies occupied, however, using the example above, would be from 3,000 to 9,000 c.p.s. - a band width of 6,000 c.p.s. It is found that each side band contains practically all the characteristics of the incoming speech, and therefore one side band only need be transmitted. The carrier frequency in modern installations is not transmitted, as it is found that less interference is experienced and much less power is required. It is therefore only necessary to transmit one side band, with a width of 2,800 c.p.s. The unwanted side band and carrier frequency are suppressed by means of filter circuits. A filter circuit consists of an arrangement of inductances and condensers with values such that heavy attenuation is given to all frequencies outside a particular band.

Referring now to Fig. 186, the audio frequencies incoming at A are passed through T to the modulator M. The filter circuit F1 then suppresses all but the required side band, which is passed to the valve amplifier A1, the output of which passes through filter F3 to line. A similar apparatus is fitted at the distant end, with the possible exception of the difference in oscillator frequencies, to be explained later.

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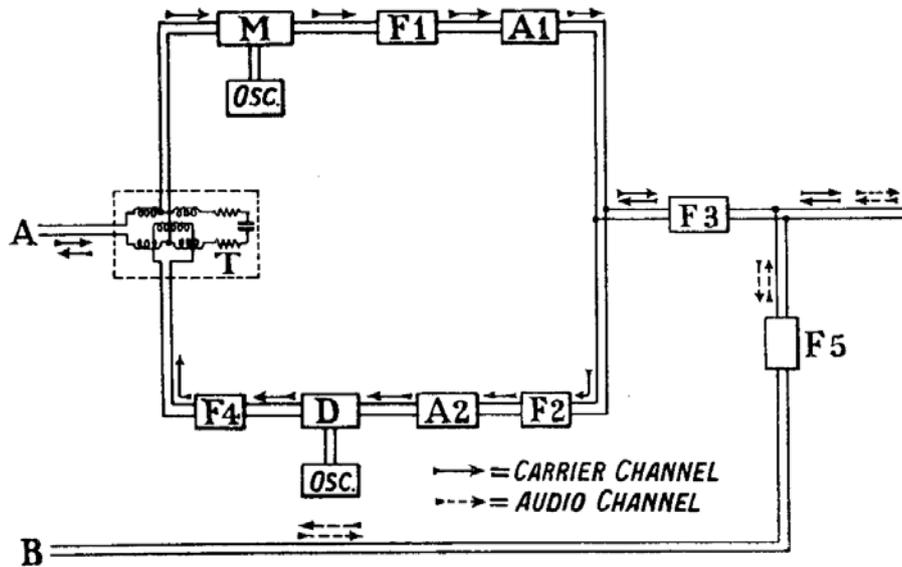


FIG. 186.-Single Channel Carrier Circuit.

When a side band of frequencies is received from the line these pass the filter F3 to the receiving filter F2 and thence to the receiving amplifier A2. Filter F3 is a "high pass" filter, and will only pass frequencies above the normal audio circuit, whilst filter F5 is a "low pass" filter and will only pass those below, the combination thus serving to separate the carrier channel from the normal audio channel B.

In a "single" channel carrier system, the upper side band is sometimes employed for transmission in one direction and the lower side band for the other. Filter F2, therefore, is designed to pass only that side band required for reception. The output from the amplifier A2 is passed to the demodulator I), where the reverse action takes place to that in the modulator, the output being the audio frequencies and the carrier frequency. The audio frequencies only are passed through T to A by the action of the low pass filter F4. As the carrier is suppressed at the transmitter, it has to be re-supplied to the demodulator by an oscillator. Usually a different carrier frequency is used for transmitting and reception, one side band being used in each case. If a four-wire circuit is employed, two for sending and two for receiving, then the same frequency can be used in each direction for each channel.

The transmitting frequency at one station will be the receiving frequency at the other, and therefore on a two-wire circuit the oscillator frequencies are reversed at one station. Additional channels, with associated modulators, demodulators, etc., and appropriate filters, can be applied to one line, each channel having a different carrier frequency. The transformer T, known as a hybrid coil, is designed to pass speech from A to the modulator, and from the demodulator to A, but not from the demodulator to the modulator.

Various methods are used for signalling over the channels. In one case the normal magneto ringing current of 17 c.p.s. is converted by a relay circuit to a frequency of, say, 500 c.p.s., this frequency being applied to the modulator for a comparatively long period. An alternative method is directly to lower or raise the oscillator output by 500 c.p.s. The receipt of either frequency by the demodulator at the distant end is to give an output of 500 c.p.s. and a proportion of the demodulated received current is taken to a valve rectifier. A relay is incorporated in the anode circuit of this rectifier, the grid circuit of the latter being arranged to give an excessive anode current upon the receipt of a 500-c.p.s. signal.

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The anode relay will only operate if this excessive current is prolonged, and in operating will apply a normal 17-c.p.s. signal to line. The prolonged period is required to prevent the relay from operating to normal 500-c.p.s. speech currents, these being of short duration.

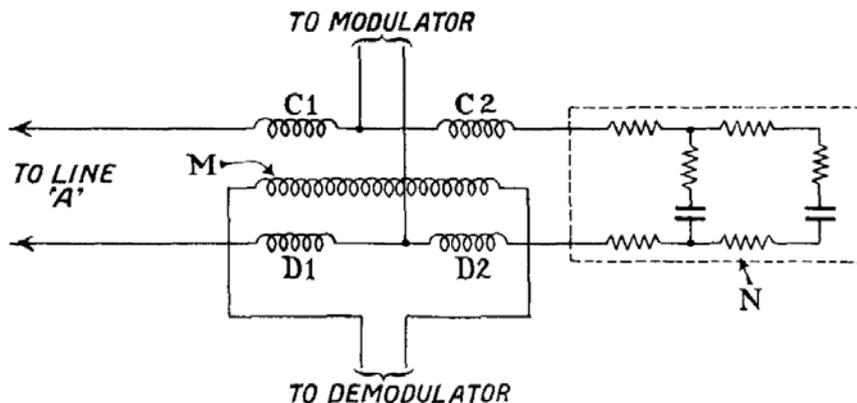
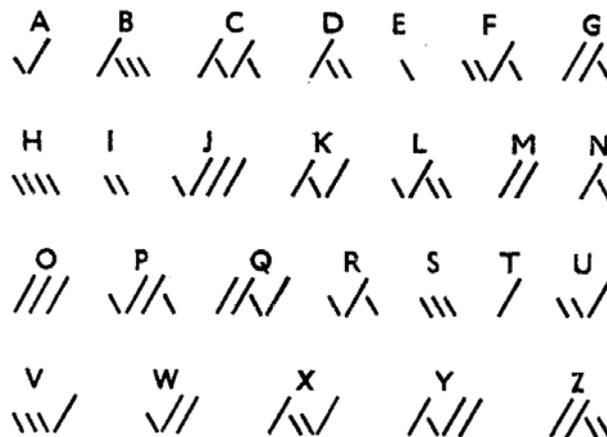


FIG. 187.- "Hybrid" or Differential Transformer.

The hybrid transformer T is shown in detail in Fig. 187. The coils C1 C2, D1 D2 are connected to the line as shown and to the network N. The latter is a combination of inductances and condensers, designed in this instance to have the same characteristics as the line to be connected at A in Fig. 186. Coil D1 is connected to the demodulator circuit.

Outgoing speech currents will divide between the modulator circuit and the network circuit. Incoming speech from the demodulator circuit in M, however, will induce an E.M.F. in C1 C2 and D1 D2; the E.M.F. in C2 D2 will be dissipated in N, and that in C1 D1 around the line circuit. If N provides a correct balance the points of connection of the modulator circuit will be at equal potential, and no current will flow in the modulator circuit.



EXPLANATION OF ALPHABET

THE LONG STROKES REPRESENT POINTING THE NEEDLE TO THE RIGHT, THE SHORT STROKES TO THE LEFT; THUS A ✓ IS MADE BY POINTING THE NEEDLE ONCE LEFT AND ONCE RIGHT; C ↘↘ IS MADE RIGHT, LEFT, RIGHT, LEFT; F ↘↘↘ LEFT, LEFT, RIGHT, LEFT; Y ↘↘↘ RIGHT, LEFT, RIGHT, RIGHT

Single Needle Telegraph Alphabets