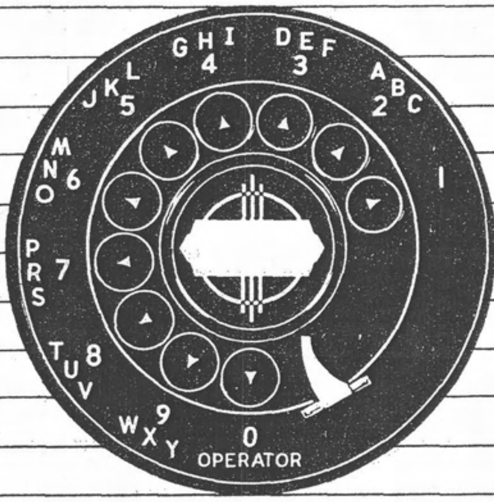
Electrical Princ les 800

AUTOMATIC ELECTRIC TRAINING SERIES | Bulletin **800**

ELECTRICAL PRINCIPLES OF TELEPHONY

STROWGER AUTOMATIC TELEPHONE SYSTEMS



AUTOMATIC ELECTRIC®

ORIGINATORS OF THE DIAL TELEPHONE

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STROWGER AUTOMATIC TELEPHONE SYSTEMS

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Modern dial telephone
(Automatic Electric Company type 80 Monophone)

ELECTRICAL PRINCIPLES OF TELEPHONY
PART 1
ELEMENTARY ELECTRICITY

1. ELECTRICITY AND ITS EFFECTS

"Electricity" is the name given to an invisible agent known only by its effects. The electrical effects with which we are most familiar are light, heat, power, voice transmission, and many others which we use and depend upon each day.

The laws which govern the flow of electricity in closed circuits are similar to those which determine the flow of water in a water circuit. Water flowing in a pipe transmits energy; similarly electricity flowing in a conductor transmits energy.

The exact nature of electricity is unknown. On the other hand, it is not necessary to know exactly what water is, to use the energy of falling water or water under pressure to develop power. It is, however, necessary to know how water acts and how it may be used to develop power. Similarly, in the study of practical electricity, the question of what electricity is, need not be considered; but how it acts and how it can be directed and controlled to do useful work are important.

Batteries and generators put electricity into motion or force it to move. An electric generator may be thought of as a pump which forces electricity to flow within a circuit.

2. ELECTRICAL UNITS

(a) Ampere

Electricity in motion is called an electric current. Therefore, a current of electricity in a wire is electricity in motion in that wire. There can be no steady current flow without a complete circuit to and from the source. In formulas, current-flow "intensity" is represented by the symbol "I". It is measured in "amperes". In telephone work, currents often are small fractions of an ampere and may be expressed in thousandths of an ampere, called "milliamperes".

(b) Volt

The force which causes electricity to move or to flow is known as electro-motive force (e.m.f.), pressure, potential difference, or voltage (symbol "E" in formulas). The electrical unit of pressure is the "volt". If an e.m.f. is applied to a closed or complete conducting circuit it will force electricity to circulate or flow around in that circuit. The flow of water through a pipe depends on the pressure forcing the water thru the pipe. Similarly, electrical pressure or e.m.f., measured in volts, causes electricity to flow through conductors.

(c) Ohm

Electrical resistance is the opposition offered by an electric conductor to flow of current . . . just as friction of flowing water against the inside of pipes tends to decrease the water flow in a hydraulic circuit. Current in an electric conductor will vary in accordance with the resistance offered to its flow. Resistance (symbol "R" in formulas) is measured in "ohms". After numbers, "ohms" often is abbreviated ω or more modernly Ω. It is evident that the amount of electricity that will flow through a given circuit will be determined not only by the voltage forcing the current, but also by the resistance offered by the conductors. With a specified voltage, the greater the resistance the smaller the current and vice versa.

3. OHM'S LAW

A simple but important relation exists between the e.m.f. (volts), the current (amperes), and the impedance (ohms) in any electric circuit. This relation was first discussed mathematically by Dr. Georg S. Ohm in 1827 as follows: The intensity of the current in a direct-current circuit is directly proportional to the voltage and inversely proportional to the sum of the resistances in the circuit. This is known as "Ohm's Law". The formula for it, and two other formulas derived from it, follow:

$$I = \frac{E}{R} \text{ or, Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

$$R = \frac{E}{I} \text{ or, Ohms} = \frac{\text{Volts}}{\text{Amperes}}$$

$$E = IR \text{ or, Volts} = \text{Amperes} \times \text{Ohms}$$

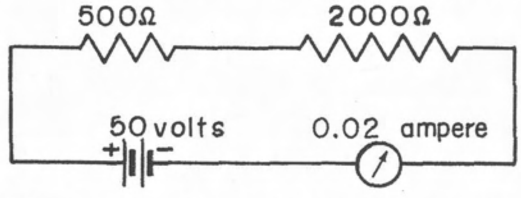
Examples in Ohm's Law

Assume that it is desired to ascertain the amount of current that will flow thru a coil having a resistance of 1300Ω and an impressed e.m.f. of 50 volts. Using the formula $I = \frac{E}{R}$; $E = 50$, $R = 1300$, $I = \frac{50}{1300} = 0.038$ ampere or 38 milliamperes. If the voltage and current are known, to find the resistance use the formula $R = \frac{E}{I}$. The resistance of a coil thru which 0.06 ampere flows when 50 volts is impressed on it is found as follows: $E = 50$, $I = 0.06$, $R = \frac{50}{0.06} = 833\Omega$.

Knowing current flow and resistance, voltage can be determined. A coil with 1200Ω resistance has a current of 0.04 ampere flowing thru it. Using the formula $E = IR$: $I = 0.04$, $R = 1200$, $E = 0.04 \times 1200 = 48$ volts.

4. RESISTORS IN SERIES

If a circuit has 2 or more parts in series, the resistance of the whole circuit is the total of the separate resistances.



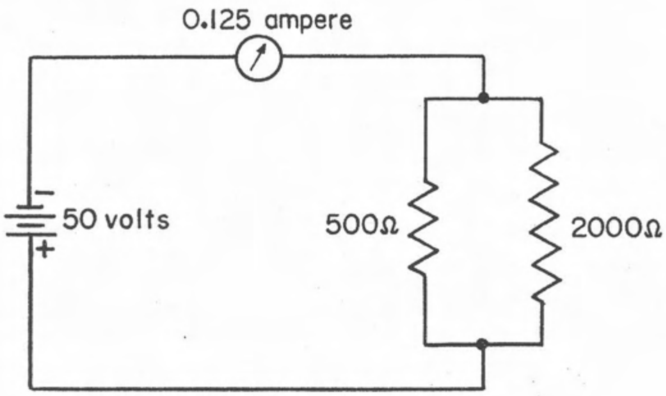
In the sketch above, 500Ω + 2000Ω = 2500Ω is the total resistance of the circuit. The current I = E/R = 50/2500 = 0.02 ampere or 20 milliamperes.

5. RESISTORS IN PARALLEL

If a circuit has 2 or more loads in parallel, the net resistance of the whole circuit is the reciprocal of the sum of the reciprocals of the separate resistances. Quite a mathematical mouthful? It looks much simpler, tho, in formula-form:

$$\frac{1}{R_{net}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots \text{etc.}$$

For example:

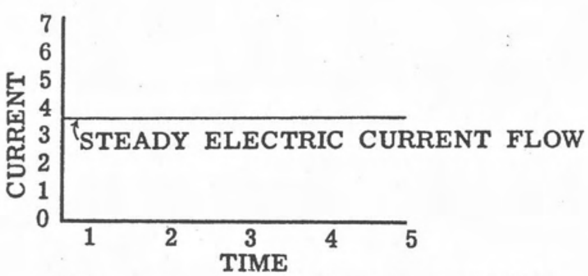


$$\frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{500} + \frac{1}{2000} = 0.002 + 0.0005 = 0.0025 = \frac{1}{400}$$

so the 2 loads together look to the battery like 400Ω. Together, the 2 loads draw $I = \frac{E}{R} = \frac{50}{400} = 0.125$ ampere from the battery.

6. ELECTRIC CURRENTS

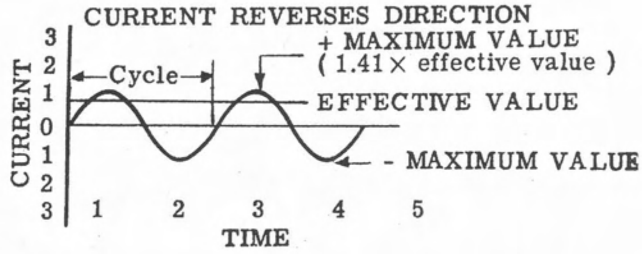
Of the various forms of electric current the four most commonly considered in telephone work are: direct current, alternating current, pulsating current, and undulating current.



This is a graphical representation of direct current

(a) Direct Current

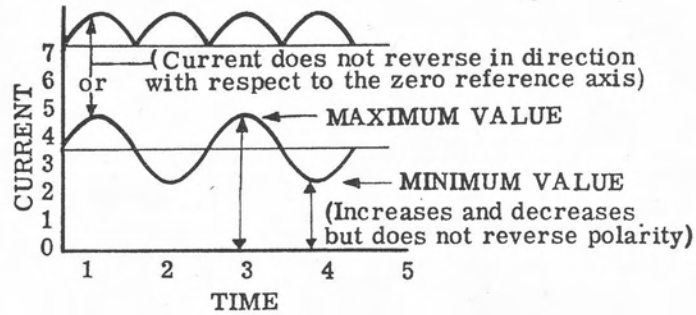
A direct current is one which always flows in one direction and when of constant strength is called a continuous current. The storage battery, the rectifier in various forms, and the direct-current generator are the most commonly known sources of direct current used in telephone practice.



This is a graphical representation of alternating current

(b) Alternating Current

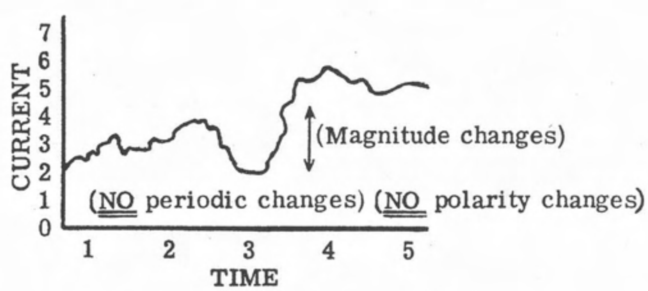
An alternating current is one which is constantly reversing its direction. A cycle is one complete reversal of current flow; that is, a current rising to maximum value in one direction and returning to zero, and then going to a maximum value in the opposite direction and returning to zero. The number of cycles per second (abbreviated ~) is known as the frequency. Alternating currents of frequencies from 16~ to 67~ are used to operate telephone ringers. Alternating currents of frequencies up to about 15,000~ are audible. Frequencies from 250~ to 3,000~ play an important part in telephone transmission.



This is a graphical representation of pulsating current

(c) Pulsating Current

Pulsating current is a current which always flows in one direction, but periodically varies in magnitude so as to flow with a series of pulsations.



This is a graphical representation of undulating current

(d) Undulating Current

Undulating current flows always in one direction but its magnitude changes aperiodically. The current flowing in a telephone transmitter is a typical undulating current.

7. A-C CIRCUITS

In alternating-current circuits and computations, one must consider not only the resistances in the circuit but also the reactances due to inductances and capacitances.

(a) Inductance (symbol: "L")

Electricity in motion always produces magnetic flux. When the current in an electric circuit varies, the amount of magnetic flux varies also, increasing when the current increases and decreasing when the current decreases. While changing, these flux changes induce voltage momentarily in any conductor the flux crosses. Thus, when current in a wire is changing, voltages proportional to the changes are induced in wires parallel to the current-carrying first wire. This effect is known as induction or inductance.

Because a coil consists of many turns of wire close to each other, when varying current flows through a coil, each turn of wire is coupled inductively to and affects every other turn. Thus, the coil has inductance. The inductance of iron-core coils is measured in "henrys" or "henries"; that of air-core coils in "millihenrys" or "millihenries" (thousandths of a henry).

(b) Capacitance (symbol: "C")

When two parallel conductive plates are close together, if voltage is applied to the plates, they receive and store an electric charge. The pair of plates has been called a condenser or more modernly a capacitor. The amount of electric charge the plates will hold per volt is expressed as the capacitance of the capacitor.

In calculations, the unit of capacitance is the "farad". A "farad" is quite large, however. Usually capacitors are rated in "microfarads" (millionths of a farad).

(c) Impedance (symbol: "Z")

Correct calculations of current flow in alternating-current circuits must take into account not only the resistances but also the reactances (symbol: "X") due to inductances and capacitances in the circuit. Together these make up the total or net opposition to a-c flow, called "impedance" and (like d-c resistance) measured in "ohms".

The calculation of reactance from frequency and inductance or capacitance, and the calculation of impedance from resistance and reactance are beyond the scope of this bulletin. Explanations will be found in any public library in books on physics (shelved under No. 530) or on electricity (shelved under No. 537). Having voltage and impedance, calculate current flow according to Ohm's law: $I = E/Z$.

(d) Effective or "Root-mean-square" Value

Alternating currents are defined so as to make applicable to them essentially the same laws that govern HEATING and transfer of power by direct current. An alternating current which produces HEAT in a given resistance at the same average rate as I amperes of direct current is said to have an "effective" or r.m.s. value of I amperes.

8. CONDUCTORS

A substance which offers little resistance to the flow of electricity is a good electrical conductor.

Most metals are good conductors, copper being one of the best. For this reason copper wire is used on relays and magnet windings. German silver wire is a fair conductor, but offers much greater resistance than copper. It is used in the windings of resistance coils.

Most metals increase in resistance when heated.

9. INSULATORS

Extremely poor conductors, such as rubber, cotton, silk, mica, enamel, and many others, are known as insulators, and are used to prevent flow of electricity.

PART 2
MAGNETISM

10. MAGNETS

Any substance which attracts iron and steel is said to be magnetized or to possess magnetism, and is called a magnet. The following paragraphs define some of the most common terms generally used in connection with magnets and explain the various types of magnets.

(a) Magnetic Poles

The two ends of a magnet where the magnetism is the strongest are called magnetic poles.

(b) Magnetic Field

The space immediately surrounding the magnet through which the magnetism acts is called the magnetic field.

Magnets are classified into two general classes; viz., natural and artificial magnets.

(c) Natural Magnets

Natural magnets are pieces of iron ore called magnetite or loadstone or lodestone, found in a number of places. The earth itself is a natural magnet with poles near the geographic north and south poles, and with a field covering the entire earth. This enables the compass, which will be explained later, to function to guide people about the earth. Natural magnets are not used very often, therefore it is not necessary to spend much time studying them.

(d) Artificial Magnets

Artificial or commercial magnets are divided into two general groups; viz., permanent magnets and temporary magnets.

A permanent magnet is any substance which will maintain indefinitely a magnetic field in the immediate space outside its own volume, without aid from any source. This is true of hardened steel which has been magnetized.

Temporary magnets are by far the most extensively used of any of the magnets. Temporary magnets generally take the form of an electromagnet.

An electromagnet usually consists of a soft iron core around which there is wound a number of turns of insulated copper wire. This wire is connected to a source of electric current such as a battery or direct current generator. While the current is flowing, the device becomes a magnet. As soon as the source of current is discontinued, the magnetism dies away rapidly. The relays used in Strowger Automatic Telephone equipment are electromagnets of this type and will be further explained later.

(e) Residual Magnetism

Residual magnetism is the magnetism retained by the core of an electromagnet after the circuit has been broken.

Magnetism, as previously indicated, may be set up more easily in some metals than in others. Temporary magnets use soft iron, instead of hardened steel as used in permanent magnets. Soft iron differs from steel in that magnetic lines are set up more easily in iron, and the number of lines set in iron are greater than in steel of the same volume. On the other hand, steel may hold its magnetism indefinitely while iron loses it almost instantly as soon as the current flow ceases. Where more complete absence of residual magnetism is desired, the iron is further softened by annealing. For this reason annealed or soft iron cores are used in the construction of relays for Strowger Automatic Telephone apparatus.

11. THEORY OF MAGNETISM

It is very difficult indeed to say just what magnetism really is. It is invisible, it has no weight, yet it manifests itself according to very definite and well known laws. Several theories have been advanced to explain magnetism and one of these, the molecular theory, is generally accepted as correct.

(a) Molecular Theory

The theory assumes that a bar of steel or iron, composed, like all matter, of small molecules, is made up of minute magnets. If the steel or iron is not magnetized, these molecules arrange themselves promiscuously in the body; therefore, there is no resulting external magnetism. Thus the steel is said to be demagnetized. When a bar of iron or steel is placed in a magnetic field, those tiny magnets arrange themselves in a systematic order, with all like poles pointing in the same direction and external magnetism is evident.

(b) Arrangement of Molecules

In order to understand this theory more clearly the case presented by a straight bar of steel should be considered. In its original state the bar is not magnetized, and the molecules are arranged in every conceivable direction. As soon as the bar is magnetized, however, the molecules are caused to rearrange themselves in systematic order with all of their north poles pointing in one direction, the south poles in the opposite direction. That pole of the magnet towards which the molecular north poles are pointed is called the north pole and the opposite is called the south pole.

If this bar is suspended from a string at its center point it will turn around until this north points north. If disturbed, it will always come to rest with the same pole pointing north.

(c) Compass

Such a permanent magnet supported at its center on a jeweled pivot point is commercially known as a compass. One end of the magnet, or needle as it is known in a compass, is distinctively marked, either by color or shape, and that end always points north.

If a magnet is dipped into some iron filings, it will be seen that the filings will cling to the ends of the magnet and not to the middle. This shows clearly the presence of the poles which are the points at which the magnetism is the strongest.

(d) Attraction and Repulsion

If the north pole of any magnet is brought near the north pole of a suspended magnet, the latter will turn away. If the south pole of the first magnet is brought near to the north pole of the suspended magnet, the latter will turn toward it. In other words like poles repel, and unlike poles attract each other. This is an important fact and should be remembered.

(e) Geographic Poles

The north and south poles of a compass and of a magnet have just been defined. Poles of the earth which are divided into two classes may be defined as follows:

Geographic poles are those points which represent the position of the north and south extremities of the earth's axis, the imaginary line around which the earth rotates.

Magnetic poles, located in a position not greatly distant from the geographical poles, are the points where the intensity of the earth's magnetic lines is greatest.

A north pole of a magnet has been defined as the pole which seeks the north pole of the earth. Since unlike poles attract each other, it follows that the magnetic pole near the earth's geographic north pole is the magnetic south pole, and the magnetic pole situated near the earth's geographic south pole is the magnetic north pole. In other words:

Earth's South Pole = Magnetic North Pole.
Earth's North Pole = Magnetic South Pole.

(f) Lines of Force

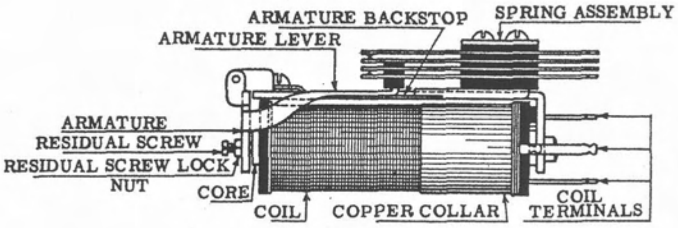
In the course of the explanation of the molecular theory, it was mentioned that when a bar is magnetized the magnetic circuit is completed both internally and externally. This may be proven.

The fact that the lines of force pass through the bar and form a complete loop, and do not start at the north pole and end at the south pole is proven by breaking the bar magnet into several pieces. Each piece becomes a separate magnet with a north pole and a south pole of its own, thus indicating that the lines of force form a complete loop. Lines of force which leave the magnet at the north pole enter the magnet at the south pole, pass through the magnet and return to the north pole, completing the loop. The space outside the magnet occupied by the magnetic lines of force is called the field. If a magnet is placed under a piece of glass on which iron filings have been sprinkled, the filings will arrange themselves along the lines of force, thus indicating the presence and position of the magnetic field.

12. ELECTROMAGNETS

Electromagnets are in common use in every branch of industry. The iron and steel industries use an electromagnet attached to a crane to hoist large quantities of iron or steel. Every motor has an electromagnet in it, that magnet being known as the field of the motor. Scores of other uses for electromagnets in equipment varying in size from the door bell to the largest electric locomotive could be mentioned. Strowger Automatic equipment would be impossible without them.

In 1820, H. C. Oersted, a European scientist, discovered that there is a magnetic field immediately around a wire through which an electric current is passed; that is, the electric current in the wire produces magnetism around it. This magnetic field lasts as long as there is a flow of current in the wire. Just why such a thing happens is not known, but it is definitely known that it does happen. The strength of this magnetic field, that is, the amount of magnetism present, depends upon the number of amperes flowing in the wire, and, when the wire is wound in a coil, the number of turns in the coil. The product of these two factors is known as the ampere-turns, a term about which a great deal will be said and which one should be thoroughly familiar with.



Horizontal Type Relay

13. RELAYS

The relays so extensively used by Automatic Electric Company consist of a coil, or electromagnet, with a mounting upon which a movable piece of metal called an armature is attached; also an assembly of springs operated by the movement of the armature. When the relay is not connected to a battery supply, the relay is said to be de-energized, or at normal. When in its normal position, the armature which is hinged, is away from the core; and there is an air gap between the armature and core. When the relay is connected to a battery supply, a magnetic field is set up in the coil and core which attracts the armature to the core. The movement of the armature from its normal position toward the core causes the relay springs to be forced into an operated position. The operation of the relay springs brings about the necessary circuit conditions, which will be explained in detail later. The removal of the battery supply from the relay causes a great reduction of the magnetism which permits the armature to return to normal.

Relays could be made to work by having a single turn of wire around the core, but the current consumed would be so great that trouble would result. In order to cut down the number of amperes required, the number of turns of wire is increased. Relays are wound with numbers of turns ranging from a few hundred to about ten thousand. The current consumed by such relays varies from about one ampere down to a few thousandths of an ampere.

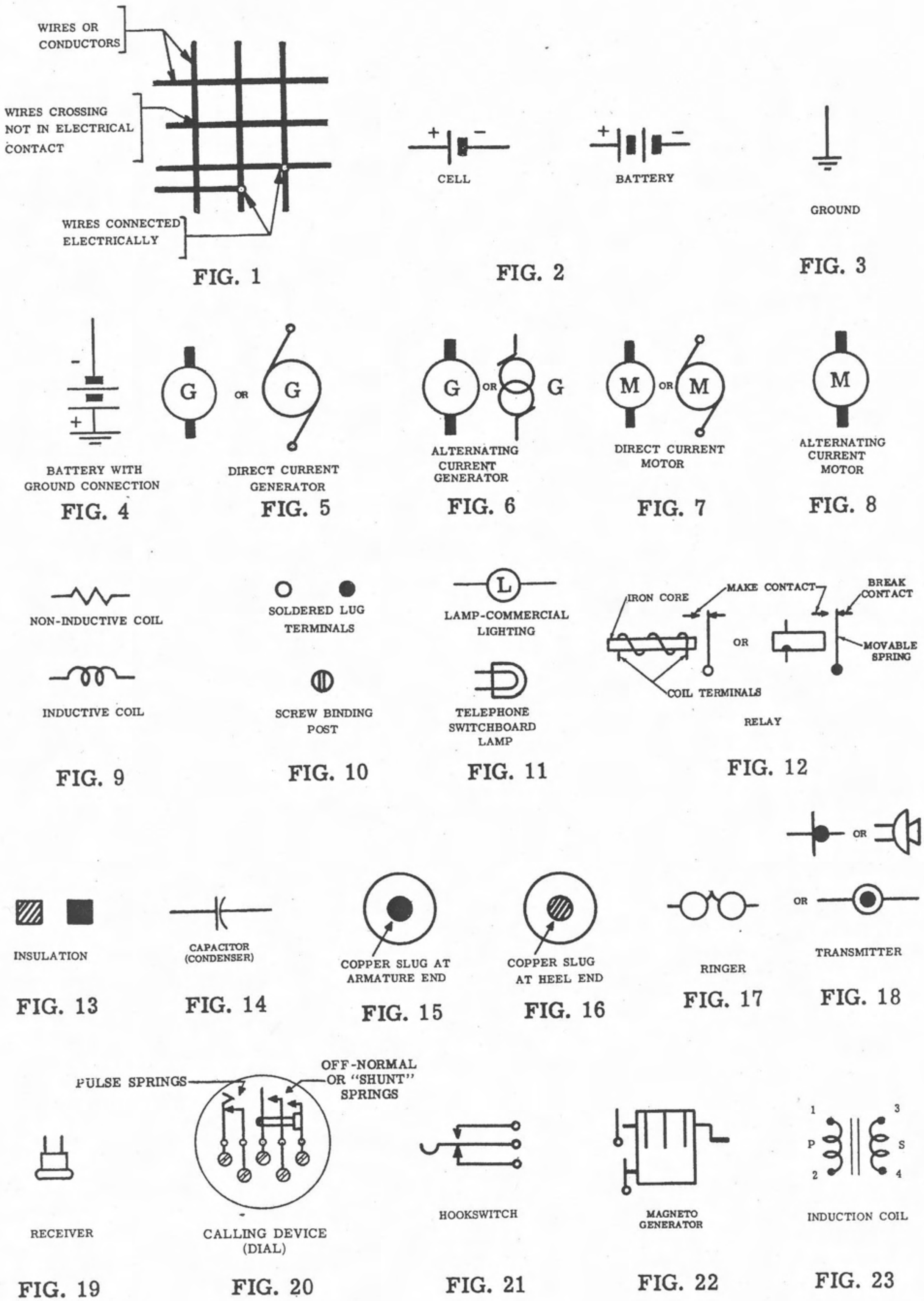
(a) Slow Acting Relays

Slow-acting relays play an important part in the circuit design of the present day Strowger Automatic Switches. They are used to delay momentarily certain circuit operations.

Slow acting relays may be divided into two classes; viz., the slow operating relay and the slow releasing relay. This slow acting feature is accomplished by the use of a copper collar mounted on the relay, which delays momentarily the operation of the relay armature.

(b) Slow Operating Relay

The slow operating relay is slow to attract its armature after the circuit has been completed. The copper collar being mounted on the armature end of the relay causes a delay in the attraction of the armature. The action that takes place may be more easily understood when the relay winding is considered as the primary of a trans-



Figs. 1 to 23. Elementary Symbols

former and the copper sleeve as a short circuited secondary winding consisting of a single turn having a very low resistance. When a voltage is first applied to the terminals of the winding, the current tends to build up and establish the magnetic field in the relay core. The instant the lines of force cut through the copper collar a voltage is induced in the latter causing a current to flow in it in the opposite direction from that in the winding. This current in the copper collar sets up a field in the same magnetic path, which opposes the field which is being built up by the current in the relay winding. Gradually the field in the copper collar dies away, and the magnetism due to the winding builds up until it reaches a maximum value and attracts the relay armature.

(c) Slow Releasing Relay

The slow releasing relay holds its armature, momentarily, after the circuit to the relay has been opened. In this case, the copper collar is mounted on the heel end of the relay. When the circuit to the coil is broken the magnetic field in collapsing sets up a current in the copper collar. This current is in such a direction as to try to maintain the existing magnetism. But since this current itself depends upon the decreasing magnetism, both the field in the copper collar and the relay gradually die away. This action delays the release of the armature.

14. NON-INDUCTIVE COILS

The direction of the magnetic field about a wire depends on the direction of the current flow in that wire. Therefore, the magnetic fields of two currents flowing in opposite directions oppose each other and will neutralize each other if they are of equal strength and if the wires are near enough together. Use is made of this fact by winding two wires into a single coil so that the current in one wire flows in the opposite direction to the current flowing in the other wire, around the coil. Such a coil has no perceptible magnetic field and is said to be non-inductively wound.

15. INDUCTORS ("impedance coils", "retardation coils", "choke coils")

Alternating current finds it more difficult to pass through an inductively wound coil than it does through a non-inductive coil of equal resistance. A different effect is produced when an inductively wound coil is placed in an alternating current circuit than when placed in a direct current circuit. In an A.C. circuit a counter e.m.f. is set up which acts as a "choke" to the impressed electromotive force. This effect is known as inductive reactance and the combination of reactance and resistance is known as impedance. Impedance coils are often used in telephone practice to prevent the flow of high frequency currents. The action which takes place in an impedance coil may be described as follows: the magnetic field around the coil, rapidly changing in direction at each cycle, causes a counter electromotive force (c.e.m.f.) to be set up, which opposes the impressed e.m.f. The effect of this c.e.m.f. coupled with the resistance of the coil jointly limits the flow of current.

PART 3

SYMBOLS--CIRCUITS--FAULTS

16. SYMBOLS

Electrical circuits are explained by a form of writing which employs symbols arranged in such a way as to tell the reader the electrical conditions and relations which exist. These records are valuable because they enable people to duplicate past work, to study the action of electrical apparatus, and to make easier the detection of troubles. The symbols were derived from rude pictures of the apparatus, which have in course of time been simplified to their present form. Many times the present symbol does not look at all like the object which it represents, but it usually suggests the original form of the apparatus. The apparatus has developed into modern form and the symbol has developed toward simplicity. (Figs. 1 to 23.)

17. COMBINATIONS OF APPARATUS

Some of the most common combinations of apparatus are explained in the following paragraphs.

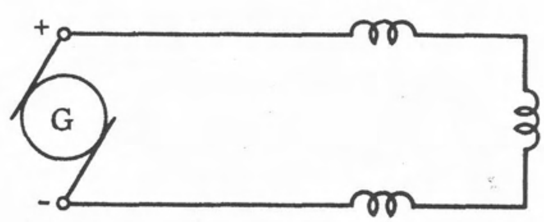


Fig. 24. Series Combination

(a) Series Connection

A series connection is a method of connecting the parts of an electric system so that the same current passes through each device in the circuit, one after the other in direct succession. (Fig. 24.)

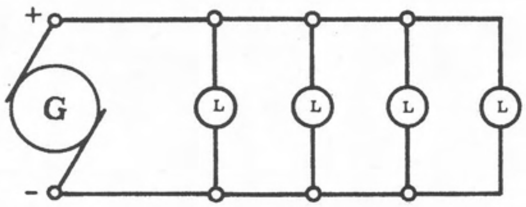


Fig. 25 Parallel Combination

(b) Parallel Connection

A parallel connection is a method of connecting the leads of an electric system in which all the positive terminals are joined to one conductor, and all the negative terminals to the other. When the pieces are thus connected the current is divided between them, and they are said to be in parallel with one another. Multiple or shunt are other names for this combination. (Fig. 25.)

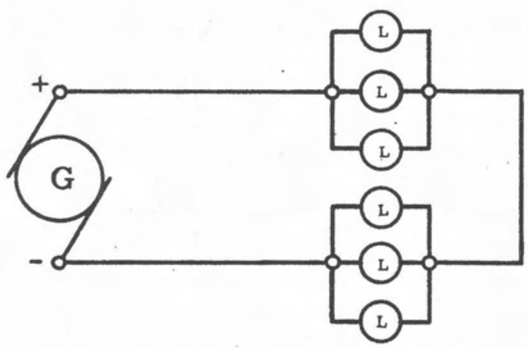


Fig. 26. Parallel Groups Connected In Series

(c) Series Parallel Connection

When devices such as lamps, in an electric circuit, are arranged in groups and connected in parallel in each group, these groups in turn being connected in series, the arrangement is known as a series parallel connection. (Fig. 26.)

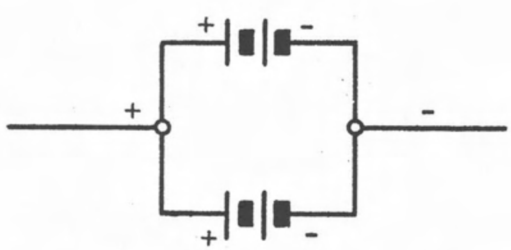


Fig. 27. Series Groups Connected In Parallel

(d) Parallel Series Connection

The parallel series connection is a method of connecting groups of devices such as cells, in an electric system so that these cells are in series in each group and the groups in turn are connected in parallel. (Fig. 27.)

18. METHODS OF CIRCUIT CONTROL

There are many methods of circuit control. A few of the most common are described briefly below.

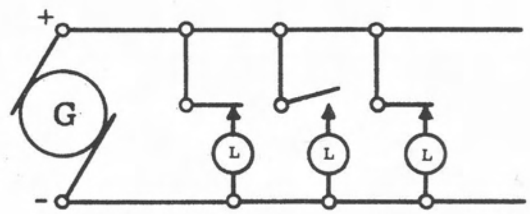


Fig. 28. Break Control

(a) Break Control

As an illustration of break control assume that three lamps are arranged to be lighted by one generator and each lamp is controlled by a switch. Any one lamp could then be cut off by breaking or opening its circuit at the switch without interfering with other lamps of the circuit. (Fig. 28.)

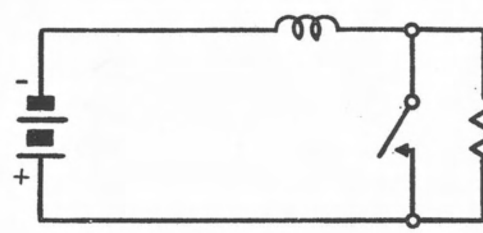


Fig. 29. Short-circuit Control.

(b) Short-circuit Control

A short-circuit control arrangement might, for example, consist of an inductive coil in series with a non-inductive coil. The latter could be removed from the circuit by short-circuiting it by means of the switch. This would not cut off the inductive coil. (Fig. 29.)

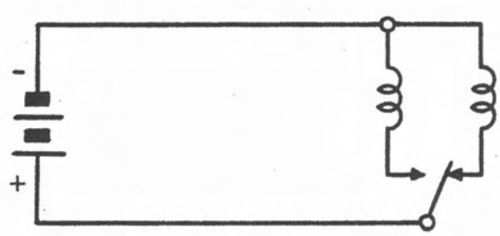


Fig. 30. Substitution Switching By Breaking

(c) Substitution Switching by Breaking

Switching by breaking may be illustrated by having two inductive coils controlled by a switch whose main spring may connect the battery circuit through either coil by breaking the circuit to the first coil. (Fig. 30.)

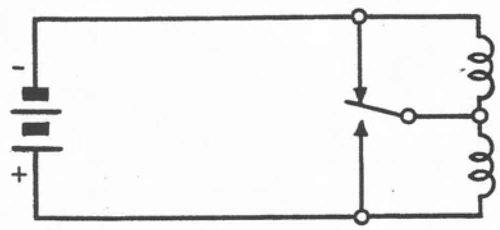


Fig. 31. Switching by Short-circuiting.

(d) Switching by Short-circuiting

If two coils are wired in series (Fig. 31), either coil may be short-circuited by the switch whose moving spring may touch either contact.

19. CIRCUITS

In order for electric current to flow there must be a complete path, that is, a closed circuit; and this closed circuit must include the battery or whatever source of current is used. A break in a wire, or other conductor, will prevent the flow of electricity past that part of the circuit in which the break occurs. When tracing a circuit, start at one terminal of the battery and follow the circuit through wires, connections, and apparatus until you reach the opposite terminal of the same battery.

(a) Wiring and Schematic Diagrams

Electric circuits are shown in two general classes, wiring diagrams and schematic diagrams. A wiring diagram shows the apparatus approximately in its relative location. It is used mostly for reference when wiring the apparatus and tracing connections. A schematic diagram is electrically the same as above, but the parts are rearranged in such a way as to show more clearly the paths of current flow, the relation of the apparatus, and the principles underlying the design of the circuit. A schematic diagram may contain all the circuits of a layout, or it may contain only one circuit path, rearranged to show itself more clearly.

(b) Circuits and Circuit Faults

In studying the descriptions of the following circuits and circuit faults, the illustrations should be referred to.

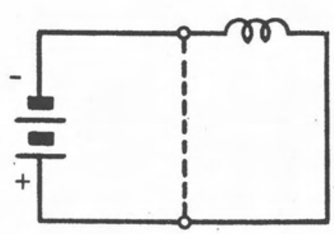


Fig. 32. Leak And Short Circuit

(c) Leak and Short Circuit

If there is an additional path in the circuit, Fig. 32, through which electricity can flow, as shown by the dotted line, some of the current will go through it. If the resistance of this path is high enough not to interfere to any extent with the operation of the coil, the path is called a "leak".

If the resistance is low enough to exclude practically all of the current from the coil, the fault is called a "short circuit".

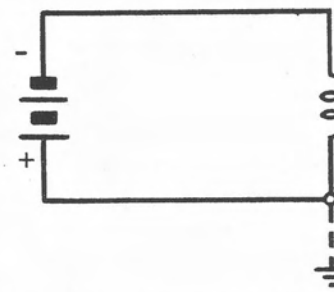


Fig. 33. Grounded Circuit

(d) Grounded Circuits

Fig. 33 shows a complete circuit with an accidental ground indicated by the dotted line. This ground would not affect the circuit and will not interfere with the current flow or the operation of the coil, because no other part of the circuit is grounded.

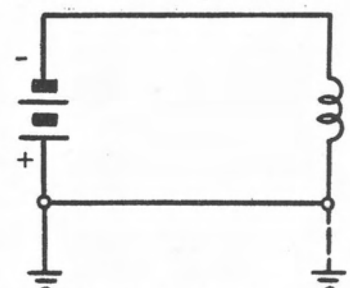


Fig. 34. Grounded Circuit

Fig. 34 shows a complete circuit with the positive side of the battery grounded. Should an accidental ground occur on the positive side of this circuit, as shown by the dotted line, it will not affect the current flow to the coil, or its operation.

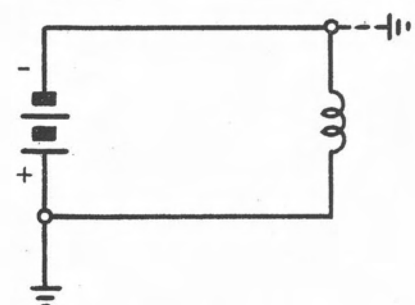


Fig. 35. Grounded Circuit

Fig. 35 shows a complete circuit with the positive side of the battery grounded. Should an accidental ground occur on the negative side of this circuit, as shown by the dotted line, the coil will be shunted out by having a ground on both sides of its winding. The battery will also be short circuited as the ground is on the negative side of the line.

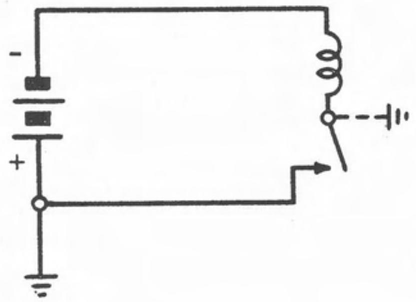


Fig. 36: Grounded Circuit

Fig. 36 shows an accidental ground on one side of the inductive coil. This would cause the coil to be operated at all times, regardless of the position of the switch, since there is a complete circuit from the accidental ground through the coil to negative battery.

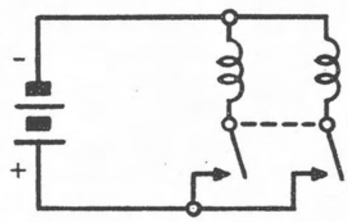


Fig. 37: Cross Circuit

(e) Crossed Circuit

The crossed circuit, Fig. 37, as indicated by the dotted line, would cause both coils to operate when either switch makes contact because a circuit is completed to both coils by the closing of either switch.

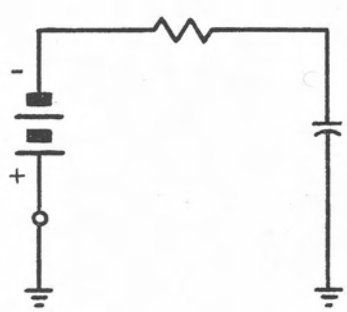


Fig. 38: Incomplete Direct Current Circuit

(f) Incomplete D.C. Circuit

A condenser in series with a coil in a direct current circuit, as shown in Fig. 38, will prevent the flow of current in the coil. The condenser in a D.C. circuit acts the same as an open conductor. A.C. but not D.C. will flow through a condenser.

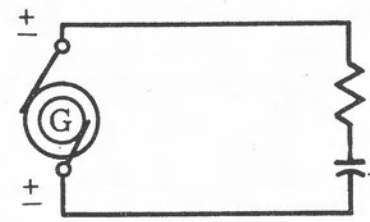


Fig. 39: Alternating Current Circuit

(g) Alternating Current Circuit

Since a condenser does not prevent the flow of current in an A.C. circuit, we can trace a complete circuit, Fig. 39, from one side of the generator, through the non-inductive coil, through the condenser, to the other side of the generator.

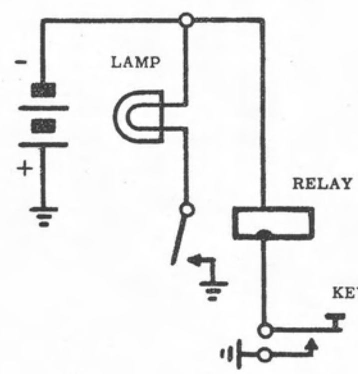


Fig. 40: Complete Relay And Lamp Circuit

20. DESCRIBING A CIRCUIT

In the description of a circuit, care should be used to state exactly what is meant. Always state which polarity of battery is referred to, and when speaking of any point in a circuit, define that point so that there will be no doubt as to what is meant. For example, Fig. 40 may be described as follows: By closing the key there is a complete circuit from negative battery through the relay, and through the closed key to ground (positive battery). This will cause the relay to operate, which completes the circuit from negative battery through the lamp, and through the closed relay contacts to ground, causing the lamp to light. The relay will remain operated and the lamp will remain lighted, as long as the key is closed.

PART 4
TELEPHONE PARTS

21. GENERAL

In order to bring out the principles underlying the transmission of sound waves in telephony, the following definitions are given:

A telephone transmitter is that portion of a telephone by means of which sound waves from the voice are converted into electrical energy which can be transmitted to another point on the line for reception by means of a receiver.

A telephone receiver is that portion of a telephone by means of which the electrical energy from the transmitter is converted back into audible sound waves.

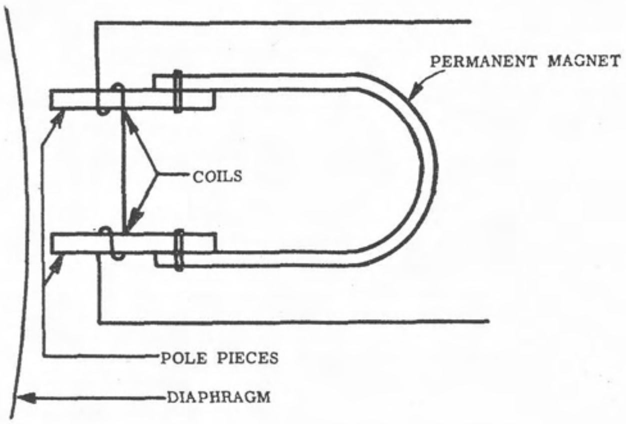


Fig. 41: Bi - Polar Receiver

22. PERMANENT MAGNET RECEIVER

The receiver, as shown in Fig. 41, includes a permanent magnet, magnet coils, and a diaphragm.

The permanent magnet attracts the diaphragm and places a certain tension upon it. One-half cycle of alternating current flowing through the magnet coils adds to the pull on the diaphragm that is exerted by the permanent magnets, and the other half cycle subtracts from their pull; therefore, the diaphragm makes one complete vibration or cycle during the period that one complete cycle of alternating current flows through the magnet coils.

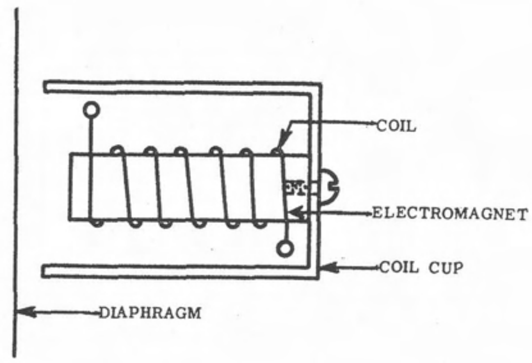


Fig. 42: Direct Current Receiver

23. DIRECT CURRENT RECEIVER

Fig. 42 shows a schematic drawing of a direct current receiver. In common battery systems where the direct current is fed from the central office to local stations, it has been found that the current which must flow through the line to furnish talking battery may be used for the additional purpose of energizing the receiver magnets so as to give them the necessary initial polarity. When the strength of the current flowing through the receiver magnet coils is varied, the tension on the diaphragm varies directly with the current and results in a vibration of the receiver diaphragm. When a voice through a telephone transmitter causes the variation of current; the receiver diaphragm responds and reproduces the sound of the voice.

This type of receiver was used to a considerable extent, however, present day practice favors the permanent magnet type of receiver. The newer designs are greatly improved and have a much smaller magnet than the earlier receiver had.

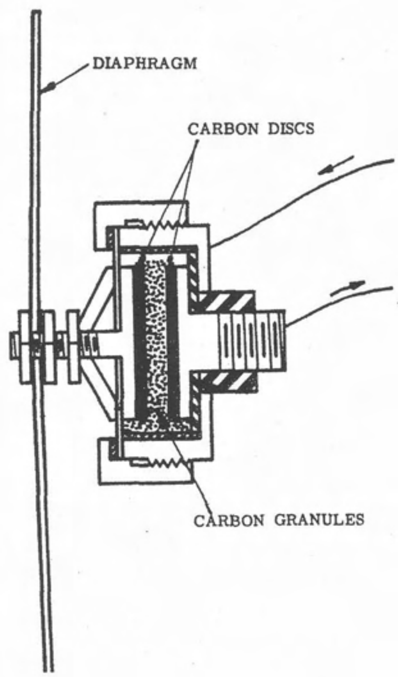


Fig. 43. Transmitter.

24. TRANSMITTER

The transmitter, as shown in Fig. 43, is made up of a diaphragm so mounted that its vibratory motion, caused by sound waves directed against it, will be transmitted to a mass of carbon granules in a cup, the granules being arranged in series with the transmitter circuit. This is known as the variable-resistance method of producing current undulations.

The carbon granules are contained in an insulated metal cup known as the electrode chamber in which are two carbon discs. These carbon discs, namely the front and rear electrodes, support the carbon granules. The movement of the diaphragm compresses and decompresses the mass of granular carbon between the two electrodes. In this way the resistance of the path from one electrode to the other through the carbon granules, is varied. The current is thereby varied in strength as the air pressure varies on the diaphragm. This varying current is sent out over the line to the connected receivers.

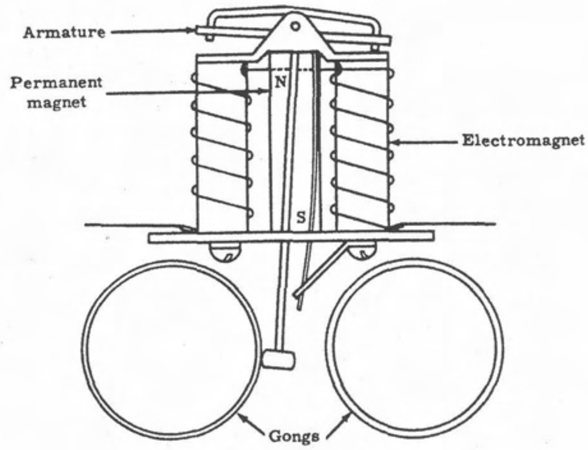


Fig. 44. Polarized ringer.

25. POLARIZED RINGER

The working parts of the polarized bell or ringer, as shown in Fig. 44, include an electromagnet, a permanent magnet, a pivoted armature carrying a bell clapper, and two gongs.

The armature is so pivoted that it vibrates in front of the poles of the electromagnet. The permanent magnet, usually in the shape of a broad "U", has one of its poles secured to the middle of the yoke of the electromagnet; while the other extends to a point just beyond the middle of the pivoted armature but out of contact with it.

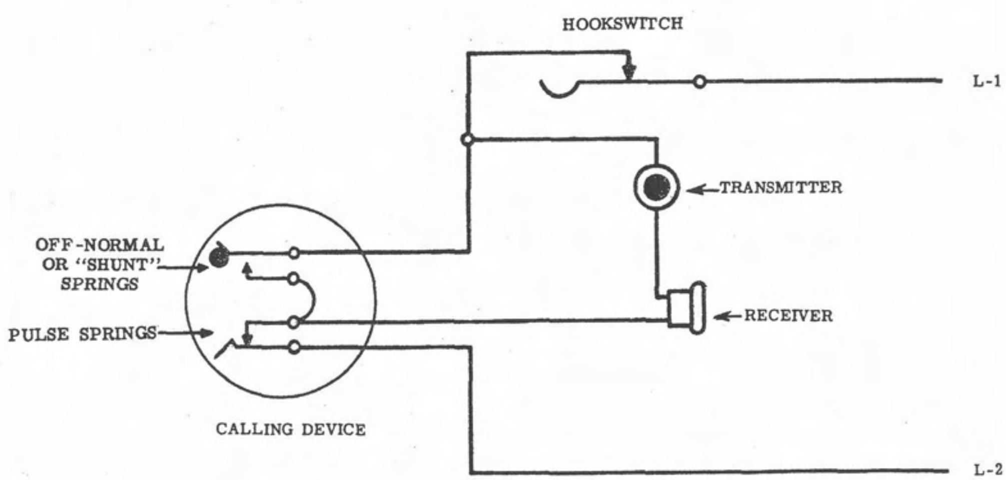


Fig. 45. Automatic Telephone Circuit Showing Calling-Device Connections

When there is no current flowing in the ringer coils, the ends of the armature are of south polarity and those of the electromagnet cores are of north polarity. With a current flowing in the electromagnet winding from positive to negative, the right pole will be additionally magnetized, due to the fact that the current is producing north magnetism and the left-hand pole subtractively magnetized, since the current is now producing south magnetism. Therefore, the magnetism of the right pole will be increased while that of the left pole will be decreased, causing the armature to be attracted more by the right pole than by the left, and the clapper will strike the right-hand gong. A reversal of current produces opposite action, the left-hand gong being struck. When the current ceases, the armature remains where last thrown.

26. DIAL

For the purpose of automatic operation, each telephone is equipped with a calling device or dial as shown in Fig. 45. The dial is essentially a circuit interrupter. When a finger plate of a dial is released after being turned from its normal position, it interrupts the line circuit in quick succession a number of times corresponding to the digit dialed. Each time the line is interrupted, what is known as a current pulse is transmitted to the automatic switchboard equipment. It is the current pulses that are sent over the line at the will of the subscriber, which start the automatic switches in motion and cause them to establish connections between subscribers.

PART 5
TELEPHONES--TELEPHONE SYSTEMS

27. GENERAL

Telephone systems are divided into two classes as to the source of transmitter current. One, in which the transmitter current for each subscriber is supplied from dry cells at the subscriber's station, is called the local-battery system. The other, in which the transmitter current for all subscribers is supplied from one battery at the central office, is called the common-battery system.

28. LOCAL-BATTERY TELEPHONE

A local-battery telephone has within itself all apparatus needed for talking and signaling (both sending and receiving)....including two 1.5-volt dry cells.

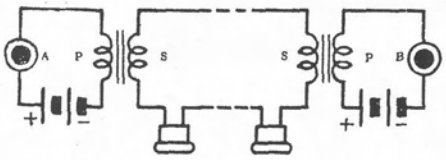


Figure 46A. Talking circuit of two local-battery telephones.

Figure 46A shows the talking circuits, only, of 2 telephones. "A" represents a telephone connected by two wires to another telephone "B". When the transmitters are quiet, steady direct current flows in each primary circuit and no current at all in the secondary or line circuit. When a person speaks into the transmitter, the transmitter resistance changes rapidly and causes the battery current to become stronger and weaker. This rapidly varying primary current induces in the secondary winding an alternating current which flows thru both receivers. Since both ends of the circuit are alike, B can talk to A as well as A to B.

Figure 46B shows the complete circuit of a magneto telephone.

Current for ringing the bells is generated by a magneto (hand generator), which when turned produces alternating current of about 20~. When the crank is at rest, the magneto is disconnected from the line, but when the crank is turned, a portion of the first revolution operates a switch which connects the magneto across the line.

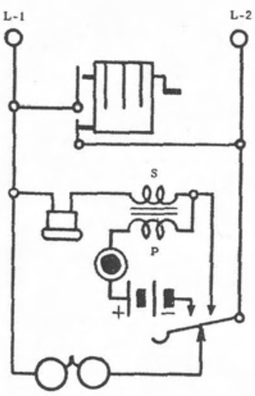


Figure 46B. Local-battery or magneto telephone (complete circuit).

The secondary circuit is kept open by one of the upper contacts of the hookswitch. When the receiver is taken off the hook, the line (L-2) is switched from the ringer to the talking circuit (receiver and secondary of the induction coil) at the same time the primary circuit is closed by the upper contacts, and there is a complete local-battery arrangement. The primary circuit is kept open when the instrument is not in use, so the battery won't run down.

29. LOCAL-BATTERY TELEPHONE INDUCTION COIL

An induction coil is merely a transformer consisting of two insulated wires wound around an iron core. One winding, called the primary (P), is in series with the transmitter and battery in a local circuit; the other winding, called the secondary (S), is in series with the receiver and the line.

If constant direct current flows in one winding, no voltage is induced in the other. However, if there is a change in the current in one winding, voltage will be induced in the other. Continual variation of the current in one winding results in alternating-current flow in the other winding.

With the transmitter circuit thus separated from the line, the transmitter itself is the principal resistance in the transmitter circuit, and has leverage to make large changes in the primary current (whereas it would have little effect on current in the total line [as long as we stuck with the 3-volt battery]).

The secondary winding has more turns than the primary winding, and the voltage in the secondary is correspondingly higher than in the primary. Since the induction coil doesn't create any watts, at this higher voltage the voice energy is transmitted with less current intensity, so there is less I^2R loss in the line resistance. Thus the induction coil serves two purposes: increasing the range of change in the transmitter current, and lessening loss in the line. The induction coil may also be regarded as a transformer whose ratio matches the transmitter-circuit impedance to the line impedance.

30. PARTY LINES

(a) Bridged ringing. One simple party-line scheme is simply to connect in parallel all telephones on the line (figure 47). Often every party hears all rings for any party, and "codes" (e.g., 1 long ring, 2 short rings, etc.) indicate which party is wanted.

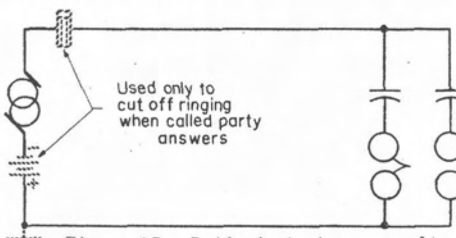


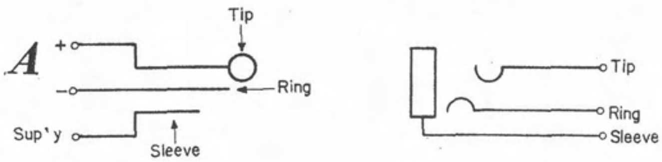
Figure 47. Bridged-ringing party line (shows ringer-circuits, only, of two telephones).

Or, the party-line telephones can have "harmonic" ringers, each mechanically tuned to respond to only one alternating-current frequency (such as 20~, 30~, 42~, 54~, or 66~); then the central-office sends the proper frequency to ring the desired party only. If there are not over 5 parties on the line, harmonic ringing calls the desired party privately, and is said to be "selective". (If there are more than 5 parties with harmonic ringers bridged on the line, those responsive to the same frequency ring together, and are distinguished by coded rings; ringing then is said to be "semi-selective".)

(b) Divided ringing. Another widely used party-line scheme uses the 2 line-wires for talking, but uses only 1 line-wire and earth return for ringing (figures 48B and 48C).

Some companies still use the old manual-switchboard names for the parties: "Party on tip" (+line) and "party on ring" (-line). Figure 48A shows the parts of manual-switchboard plugs and jacks from which these names came. Figure 48B shows ringing current going out thru the plug "ring" conductor...the word "ring" not referring to ringing current, but to the ring's shape (inside the plug, the tip's conducting stem passes thru the hole in the "ring"); in dial service we call this the -line. Similarly figure 48C shows ringing current going out thru the plug tip to call the "party on the tip" side of the line, or, as we say now, the +line.

Divided ringing is "selective" for 2 parties with untuned ringers....or for 10 parties if 5-frequency harmonic ringing is used. More parties can be rung, semi-selectively, if divided ringing is coded.



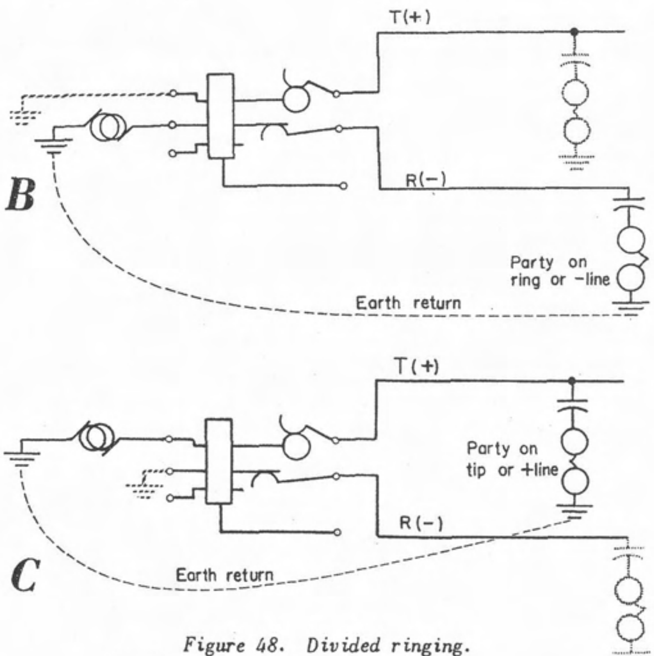


Figure 48. Divided ringing.
A – *Manual-switchboard plug and jack.*
B – *Ringing the party on "ring" or -line.*
C – *Ringing the party on "tip" or +line.*

31. REPEATING COIL

The "repeating coil" is a transformer, often of 1:1 ratio. It is used to couple inductively the voice currents in two circuits whose battery-feed and signaling paths are to be kept separate. When repeating coils connect two telephones, it is necessary sometimes to ring thru them as well as talk thru them. Therefore, the repeating coil is designed to transform ringing as well as voice currents. Ringing currents ordinarily have a frequency ranging from about 16~ to 67~, while voice currents have frequencies ranging from a few hundred up to about 3000~. Therefore, the best repeating coil for transforming voice currents is not the best for transforming ringing currents. Thus, when a coil is required to carry both ringing and talking currents, it has a compromise design so that it can reproduce both currents acceptably.

32. COMMON-BATTERY TELEPHONES

The common-battery telephone must have talking apparatus, signaling apparatus, and a means of controlling the circuits. The automatic telephone requires in addition a calling device or "dial". The ringing apparatus is used to attract the attention of the subscriber when someone desires to speak to him. The dial enables the subscriber to control automatic switches at the central office, to cause them to establish connection between two telephones. The talking battery and ringing current are received from the central office. Various types of common-battery telephone systems are described in the following paragraphs.

(a) Stone Common Battery System or Impedance Coil System

Fig. 49 shows the schematic wiring diagram of the Stone common-battery system. Current is furnished by a battery through two inductive coils called impedance coils, which are usually wound on the same iron core. The electric current divides, part going to one telephone (A) and the rest to the other (B) over a metallic circuit. Telephones A and B are of similar construction. When no one is talking the current flow is steady. If a person speaks into the transmitter it acts like a variable resistance and makes the current stronger and weaker. It is like a valve in a water pipe, but it is never wide open or tight shut. The undulating current (voice current) caused by the transmitter travels throughout the circuit composed of the two transmitters and the two receivers. Very little will pass through the impedance coils because they are inductive. The sound of the speaker's voice can be heard in both receivers. The impedance coil method

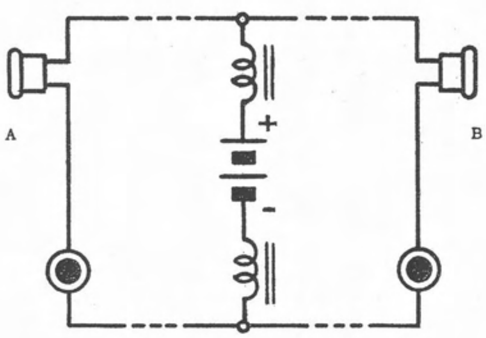


Figure 49. Stone's "inductor" common-battery system.

is used almost exclusively in private branch exchanges where the telephone loops are all of about equal length and resistance. When the loop resistance of two connected circuits is unequal, as in the case when one is longer than the other, the line having the higher resistance receives less than its fair share (i.e., less than half) of the current fed thru the inductor windings.

(b) Repeating-Coil Common-Battery System

In the Hayes or repeating-coil common-battery system, figure 50A, the battery supplies current thru a repeating coil which has four windings. All four windings are on the same iron core. Current is supplied thru two windings to telephone (A), and thru the other two windings to telephone (B). The battery is customarily grounded. When speaking into the transmitter, electric waves or undulating currents are created which induce an alternating current in the repeating-coil windings for that telephone. This alternating current is induced in the two repeating-coil windings for the other telephone. Any repeating coil possesses this property of repeating an alternating current from one circuit to another.

The repeating-coil method has an advantage over the impedance-coil method, because thru its use the two lines are practically divided except for the inductive link formed by the windings of the repeating coil. This method is used very largely in systems with longer loops. It has the disadvantage of having the alternating voice current pass thru the battery, with the resultant possibility of picking up battery noise.

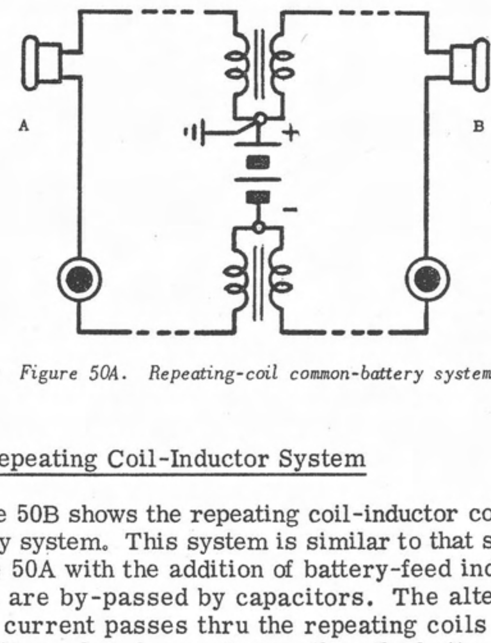


Figure 50A. Repeating-coil common-battery system.

(c) Repeating Coil-Inductor System

Figure 50B shows the repeating coil-inductor common-battery system. This system is similar to that shown in figure 50A with the addition of battery-feed inductors, which are by-passed by capacitors. The alternating voice current passes thru the repeating coils and the capacitors, but does not pass thru the battery. The battery-feed inductors serve the double purpose of keeping the alternating voice current from passing thru the battery, and of keeping battery noises from reaching the lines.

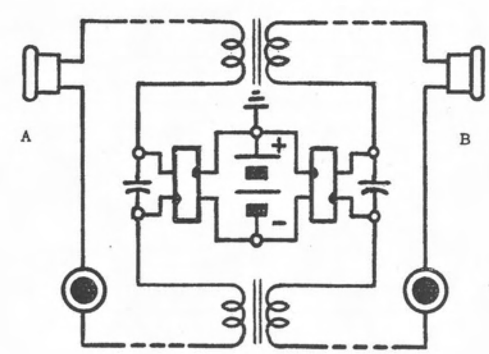


Figure 50B. Repeating-coil-inductor common-battery system.

(d) Capacitor-Inductor Common-Battery System

In the capacitor-inductor common-battery system shown in figure 51, each telephone receives its transmitter current thru an inductor in the central office. The two lines are coupled by the capacitors in the central office.

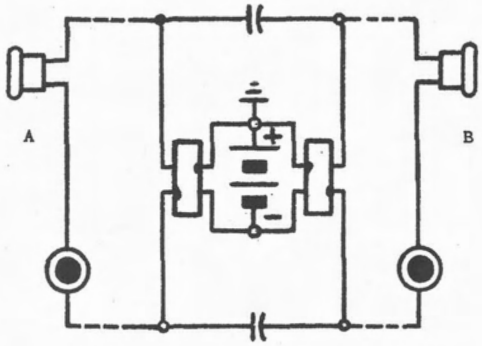


Figure 51. Capacitor–inductor common-battery system.

When a person speaks into the transmitter of telephone A, varying its resistance and the line current, the voltage drop across each capacitor varies, charging and discharging the capacitors in accordance with the speech waves. The charging and discharging currents through the receiver at B reproduce there the sounds spoken into the transmitter at A.

Thus, in effect, the voice current travels through a circuit consisting of the two telephones, the lines, and the capacitors. (Very little voice current leaks through the central-office battery-feed inductors because of their high impedance to voice-frequency currents.)

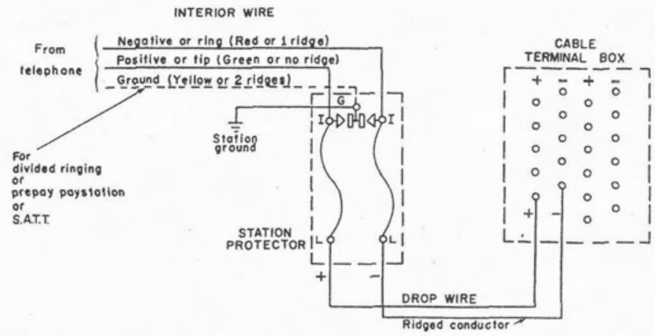
The battery feed shown in Fig. 51 is the one most commonly used in Strowger automatic central-office equipment.

In practice, the inductors usually are the coils of relays. The relays not only serve as battery-feed coils but also respond to the subscribers' hookswitch signals and dial pulses.

(e) Installation

Actual wire and cable connections between central office and subscriber pass thru various terminal, protective, and distribution devices; most are shown in figure 66.

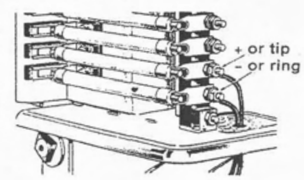
At divided-ringing party-line stations, at paystations, and in S.A.T.T. exchanges, line polarity is important. Tracers used thruout the United States to identify line polarities at subscriber installations are:



The R-alliteration "ring, red, right, ridged" will help you remember these standard tracers:

Ring (negative) line connects to:
Red (or 1-Ridge) interior-wire conductor
Right-hand station-protector terminal screw
Ridged (tracer) drop-wire conductor
Right-hand* cable-terminal stud

*The r alliteration ring=right applies at a strand-mounted or sheath-mounted cable terminal or at an unprotected pole-mounted or wall-mounted cable terminal. At a protected pole-mounted or wall-mounted cable terminal, use instead the t alliteration tip=top, and connect the +line to the upper terminal-stud of the pair.



PART 6

TYPES OF AUTOMATIC TELEPHONE

33. GENERAL

The automatic telephone differs from the common-battery manual telephone only in that it has a calling device or "dial".

34. SERIES AUTOMATIC TELEPHONE

Automatic telephones made some 30 or 40 years ago used the series circuit shown in figure 52. Although it is used rarely today, it is a simple circuit which it will be instructive to study. It divides naturally into four separate parts, shown in figures 55, 56, 57, and 58, discussed hereinafter.

Series-circuit telephones are no longer standard except for inexpensive special-purpose or toy telephones. For commercial telephone service they have been superseded by booster-circuit telephones.

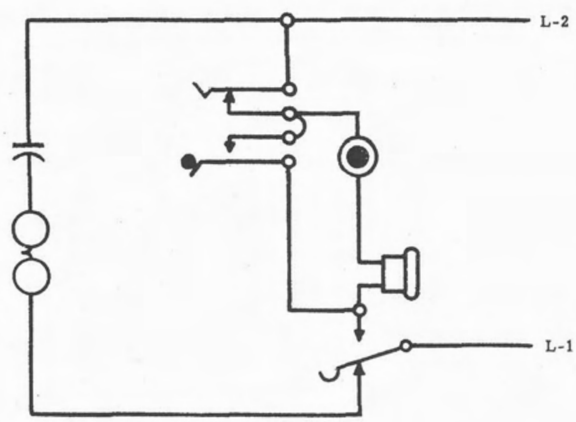
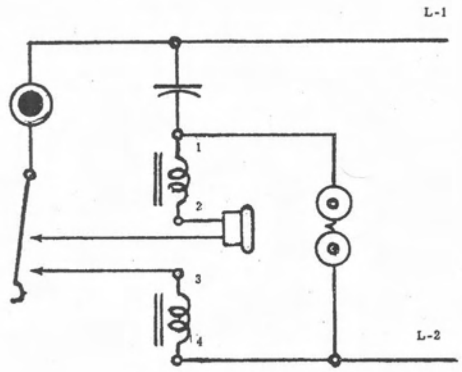


Figure 52. Series automatic telephone.



Schematic

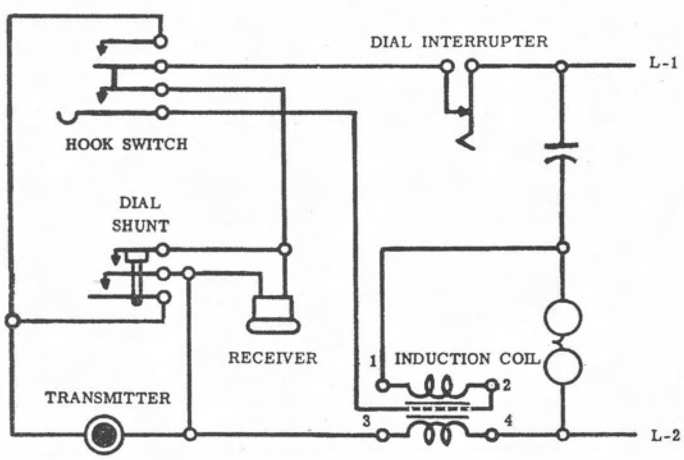


Fig. 53: Booster Automatic Telephone

35. BOOSTER AUTOMATIC TELEPHONE

The booster telephone circuit, shown in Fig. 53, is especially effective on long lines. It has an induction coil of the two winding type so connected in the circuit that it will assist the transmitter in sending. Fig. 53 also differs from Fig. 52 in that the ringing apparatus is bridged permanently across the line, and the receiver is of the permanent magnet type which requires no direct current to make it operative. Also, three dial shunt springs are necessary to short circuit the transmitter and receiver.

In order to understand the operation of the booster circuit during speech transmission, two distinct circuits must be kept in mind: (a) the main talking circuit which includes the two limbs of the line, L-1 and L-2, the transmitter, and the secondary winding (3-4) of the induction coil; and (b) the local talking circuit, purely local to the substation, which includes the transmitter, receiver, primary winding (1-2), and the condenser. It will be readily seen that when talking into the transmitter, two distinct sets of current undulations will be set up: (a) those directly produced in the line due to the variations in resistance of the transmitter; and (b) those produced in the local talking circuit by the charging and discharging of the condenser, due to the varying potential drop across the transmitter. The local talking circuit current undulations will be better understood if it be kept in mind that the condenser is connected across the terminals of the transmitter, directly on one side and through the receiver and primary winding (1-2) on the other side. The effect of the small direct current through the ringer is negligible, and it is evident from the above connections that the potential difference across the condenser will be varied by variations in potential across the transmitter. Alternating currents will then flow in the local circuit as the condenser adjusts its charge to the varying difference of potential across the transmitter and across its own terminals.

The alternating currents flowing in the primary winding (1-2) will induce currents in the secondary winding (3-4). Thus, if the two windings (1-2) and (3-4) of the induction coil are connected in proper relation to each other, the induced currents will reinforce or "boost" the currents which are directly produced in the line by the transmitter--hence the name "booster circuit".

During the reception of speech the action of the induction coil is that of an ordinary transformer. The line winding (3-4) becomes the primary, and what was the primary winding (1-2), during the transmission of speech, becomes the secondary. The incoming voice current flows from the positive line through the primary winding (3-4) of the induction coil, and the transmitter to the negative line and vice versa. There is a tendency for a very small portion of the incoming voice current to reach the negative line over the path composed of the receiver, the secondary winding of the induction coil, and the condenser, as well as through the transmitter; but it is prevented from flowing over this path, because the voice current, in passing through the primary winding (3-4), induces a stronger current in opposition to it, into the secondary winding (1-2). The induced current flows through the receiver over the local circuit embracing the transmitter, condenser, and secondary winding (1-2) of the induction coil.

36. ANTI-SIDE TONE CIRCUIT

The anti-side tone circuit has been designed to either eliminate or suppress sidetone. Sidetone is the sound reproduced in the speaker's receiver by his voice current acting through his own transmitter.

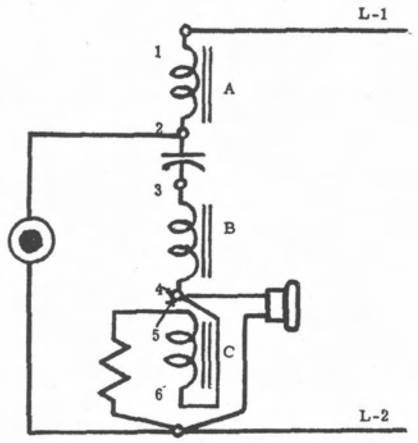


Fig. 54: Anti-Sidetone

Referring to Fig. 54, the windings "A" and "B" act like an auto-transformer. If the average of all the voice frequencies is taken as 1000 cycles per second, it will permit the matching of impedances at this frequency. The matching of impedances is the circuit condition necessary to get the maximum electrical power transfer from a generator to a connected load.

The condenser (blocks direct current) is employed to keep the talking current out of the receiver. The voltage generated in the winding "C" leads the current past the receiver instead of through it.

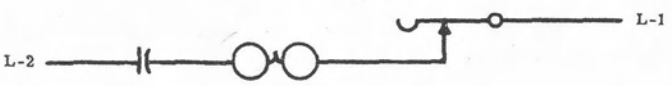


Fig. 55: Ringer Circuit

Fig. 55 shows the ringer circuit with the condenser and the bells in series. These permit the apparent flow of alternating current only.

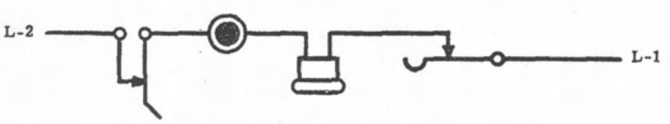


Fig. 56: Talking Circuit

Fig. 56 shows the talking circuit with the receiver, transmitter and impulse springs in series. The circuit shown is completed when the receiver has been removed from the hook and the dial is at normal.

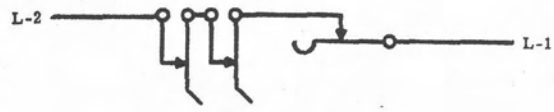


Fig. 57: Impulse Circuit

Fig. 57 shows the impulse circuit with impulse springs and shunt springs in series. The circuit completed to the impulse springs is interrupted a number of times corresponding to the number dialed. The opening of the circuit, or the impulses, which are sent out, cause the switches at the central office to operate to complete the connection to the called number.

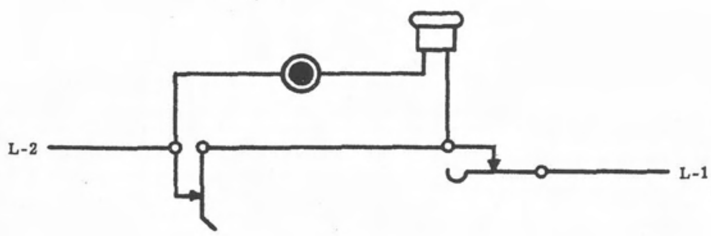


Fig. 58: Shunt Circuit

Fig. 58 shows the shunt circuit, completed whenever the dial is in an operated position. The shunt springs upon making their contacts shunt out the receiver and transmitter to prevent the impulses from being heard in the receiver of that telephone. This shunt circuit is completed only while the dial is other than in its normal position.

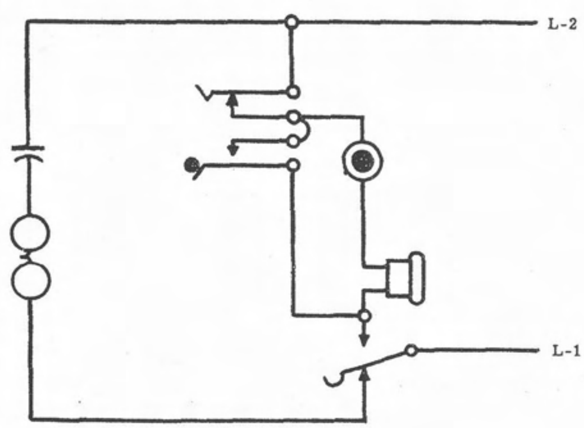


Fig. 52: (Repeated) Series Automatic Telephone

37. HOOKSWITCH

The hookswitch, as shown in Fig. 52, has a lever spring which touches the bottom contact when the receiver is hanging on the hook. When the receiver is removed from the hook, the lever spring leaves the bottom contact and touches the upper contact. The two line wires from the central office enter the telephone at L-1 and L-2. The receiver is non-polarized and requires direct current flowing through it to make it capable of operating.

When the receiver is on the hook, no battery current from the central office can get through the telephone. There is, however, a path through the capacitor and bell through which alternating current may flow. To signal the subscriber, the central office apparatus sends out alternating current, which passes through the capacitor and the bell and rings the latter. If a subscriber wishes to make a call, he first takes the receiver off the hook. This cuts the bell out and cuts the talking apparatus into the circuit. Battery now flows from L-2, through the calling device, transmitter, receiver, upper contact of hook lever spring to L-1. To operate the switches, the subscriber operates the calling device, which causes the circuit tobe interrupted at the impulse springs at the rate of approximately ten per second. To prevent these interruptions from making a disagreeable noise in the receiver and to provide a uniform resistance in the impulsing circuit, the shunt springs come together and short circuit both transmitter and receiver.

The plunger-actuated cradle-switch of a Monophone corresponds to a hookswitch.

PART 7
TELEPHONE SWITCHBOARDS

38. MANUAL SWITCHBOARDS

Although dial-controlled switchboards complete most telephone connections nowadays, manually-operated switchboards still switch many calls, including:

(a) person-to-person, collect ("reverse charges"), and other toll ("long distance") calls.

(b) calls to private branch exchanges in business houses, hotels, etc., where a P.B.X. switchboard (figure 59) connects each "outside" caller to the desired department or individual.

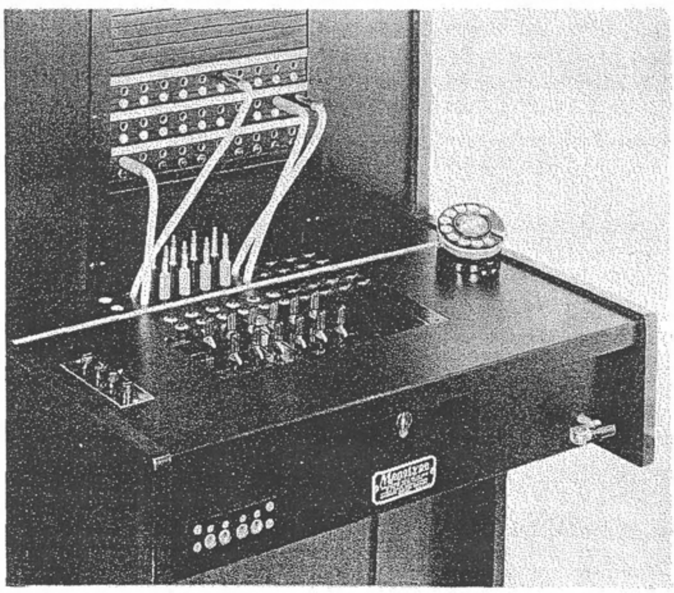


Fig. 59. One-position non-multiple private branch exchange switchboard.

On calls from automatic telephones to manual telephones, and vice versa, and on toll calls, manual-switchboard operations affect dial equipment, and dial equipment affects manual-switchboard lamp signals. Therefore let's learn the usual basic manual operations and lamp signals.

Your first look at a manual switchboard may bewilder you. Of course the upright field of lamps and jacks contains the many lines which the operator can interconnect. But what of the horizontal keyboard, with its array of plugs, lamps, and keys? These are not really complex—it's just that there are perhaps 15 or 17 repetitions or duplicate sets of equipment, each laid out in this simple pattern:*

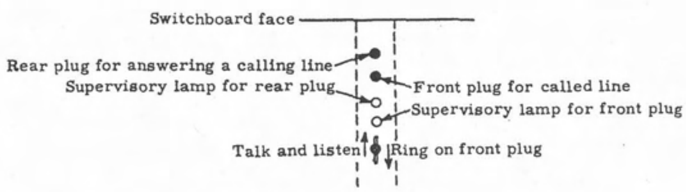


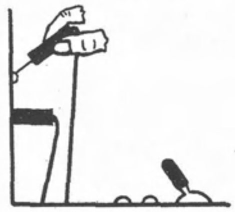
Fig. 60. Cord-circuit equipment for one connection.

This is all the equipment needed to complete one connection—two plugs and cords, of course, plus for each cord a lamp which lights when the telephone on the line plugged into is on the hook, and a lever-switch or "key" with which the operator talks and listens and rings. A typical switchboard keyshelf consists of 15 or 17 such sets of equipment, all alike. The operator can use ANY of the plug pairs to connect any two telephones.

*Figure 60 and the five small diagrams on page 20 depict a public-exchange switchboard for non-coin local service with no party lines. Public-exchange switchboards for jack-per-line party lines, etc., have additional keys. P.B.X. switchboards have ringing keys for both plugs, and their lamp signals behave somewhat differently, etc.

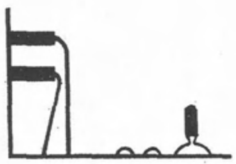
When anyone lifts his handset to make a call, the lamp lights beneath his jack. The operator throws the talking key of any idle plug pair, puts the rear plug in the jack (this turns off the line lamp), and asks "Number, please?"

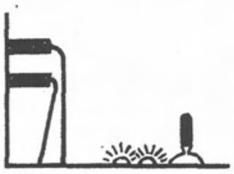
If this is a large switchboard with 3 or more operators, in front of every second or third operator there will be a jack for the called line—i.e., the called-line jack is repeated or "multipled" several times throughout the switchboard. At such a "multiple switchboard" our operator touches the front-plug tip to the sleeve of the called-line jack nearest her. If there is a plug in one of the line's other jacks, our operator hears a click and says "The line is busy". If she hears no click, she plugs in.



When the operator puts the front plug into the called-line jack, the cord-pair front supervisory lamp lights. The operator pulls the ringing key back momentarily. The front supervisory lamp remains lighted, and the operator rings from time to time, until the called party answers.

When the called party takes his handset off the cradle, the front supervisory lamp goes out, and the parties converse.





When the conversation has been finished, both parties hang up, and the supervisory lamp for each plug lights. The two lamps remain lighted until the operator takes down the connection.

Notice that dark lamps mean the operator need do nothing; a lighted lamp means the operator should do something.

When a lamp in the switchboard vertical face lights, it is an "off hook" signal, telling the operator to plug in to answer a new call.

When a lamp in the switchboard horizontal keyshelf lights, it is an "on hook" signal, telling the operator to do something, such as to keep ringing a called party who has not answered, or to take down a connection because both parties have hung up. A flashing rear supervisory lamp indicates the caller is jiggling the hookswitch and wants to talk with the operator to give her additional instructions, to ask for information, etc.

39. AUTOMATIC SWITCHBOARDS

The automatic switchboard differs from the manual in that connections are set up automatically through a series of switches located in the central office, and controlled from the dials at the subscribers' telephones.

The central-office equipment or switchboard, in a simple automatic system, consists of linefinders (or lineswitches), selectors, and connectors. All cooperate in establishing a connection between two lines.

40. THE LINESWITCH*

In the first automatic switchboards each subscriber's line had its own connector switch (§43). In larger switchboards, each subscriber's line had a selector switch (§42). Each connector or selector had several relays and 300 bank contacts and was used only a few minutes each day; it stood idle most of the time.

In 1906 a smaller and less expensive switch, the "lineswitch", was introduced. In a lineswitch system (figure 61), each subscriber's line has a lineswitch. When the caller lifts his handset from the hook to make a call, the lineswitch automatically connects the line to an idle selector or connector. This reduces the number of more expensive selectors and connectors. Since each selector or connector is used by more than one line, it is in use for a larger percentage of the time, and therefore the more expensive equipment is used more efficiently.

Both lineswitches and linefinders are in use to-day. As a general rule nowadays lineswitches are used in P-A-X's and P-A-B-X's, and linefinders are used in central offices which serve the public.

41. THE LINEFINDER SWITCH*

The "linefinder", used since 1928, minimizes the equipment individual to a line. The linefinder is analogous to a manual-switchboard operator's arm and rear plug; it reaches up to find the calling line. In this system the equipment individual to the line has been reduced to one, two, or three relays (usually two). A small pool of linefinder switches is common to a group of lines, and when the handset is removed from the hook of a telephone in the group, the linefinder switch automatically finds the calling subscriber's line. The calling subscriber's line is now extended directly to the succeeding switch (selector or connector).

42. THE SELECTOR*

The selector is a 2-motion switch. The caller's dial controls the first or vertical motion, which selects the equipment group having access to the called line. Then the switch shaft rotates automatically, hunting idle equipment within the chosen group.

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*For further information, see:

Lineswitch bulletins 805, 806, and 809
Linefinder bulletin 821
Selector bulletin 808

Typically, all but the last two or terminal-selecting digits of a telephone directory number operate selectors. Thus, a 1000-line central office uses selectors for hundred-selection—for example, if you call telephone 234, when you dial "2" a selector selects the 200-group. A 10,000-line central office uses two ranks of selectors, one for thousand-selection and another for hundred-selection.

43. THE CONNECTOR*

The connector, a 2-motion switch, is analogous to a manual-switchboard operator's arm, front plug, ringing key, etc. The typical connector has access to 100 lines. The last digits the caller dials control the connector. Because automatic switchboards are inherently "multiple" switchboards, the connector tests whether the called line is busy. If the called line is busy, the connector sends busy tone to the calling party. If the called line is idle, the connector rings out on the line. When the called party answers, the connector cuts off the ringing, and supplies transmitter current to both the calling and the called parties. When both parties hang up, the connector releases itself and other equipment used during the conversation.

The connector, supplying busy tone, ringing current, transmitter current, disconnect control, etc., is virtually a self-sufficient switch. If (fig. 62) the exchange does not require selectors, a complete central office can be built of just linefinders and connectors.**

(b) The lineswitch associated with his line selects and connects him to an idle connector switch. "Dial tone" is sent back to the calling subscriber as a signal to start dialing.

(c) The subscriber dials the first digit of the called number, causing the connector to select the desired "tens" group.

(d) The subscriber dials the other digit of the called number, causing the connector to select the desired line.

(e) The connector tests the called line. If the line is already engaged, the connector sends "busy tone" back to the caller. If the line is not engaged, the connector sends ringing current to signal the called party.

(f) The called subscriber answers, and conversation takes place.

(g) Both subscribers hang up. All switches in the connection release, and are ready to be used for another call.

The selectors and connectors may be used by any subscriber. The lineswitch alone is individual to the subscriber.

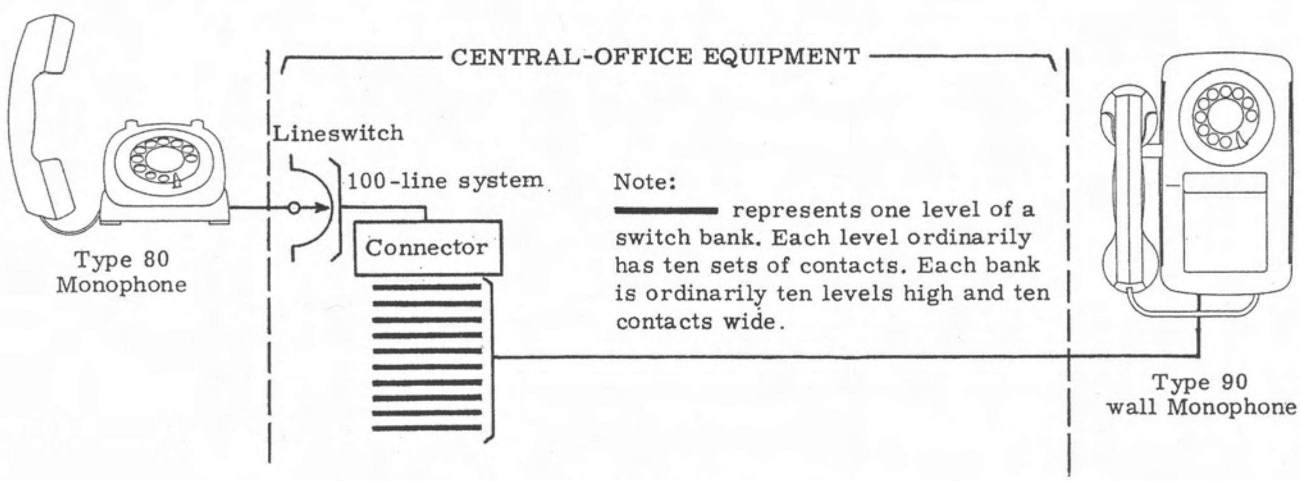

Fig. 61. 100-line system using lineswitches.

44. LINESWITCH HUNDRED-LINE SYSTEM (FIG. 61)

The hundred-line system shown in Fig. 61 consists of lineswitches (one for each telephone line) and connectors. The process of setting up a call is briefly as follows:

(a) The calling subscriber removes his Monophone handset from the cradle.

*For further information see Connector bulletins 807 and 813.
**Plus outside-line protectors, power equipment, etc.

45. LINEFINDER HUNDRED-LINE SYSTEM (FIG. 62)

In the system discussed in §44 the lineswitch found an idle connector. In the linefinder system (Fig. 62), when the handset is lifted, line relays start an idle linefinder, and it finds the calling line and extends it through to the connector. Dial tone tells the caller to dial. The connector functions as described in §44.

The linefinders, selectors, and connectors may be used by any subscriber.

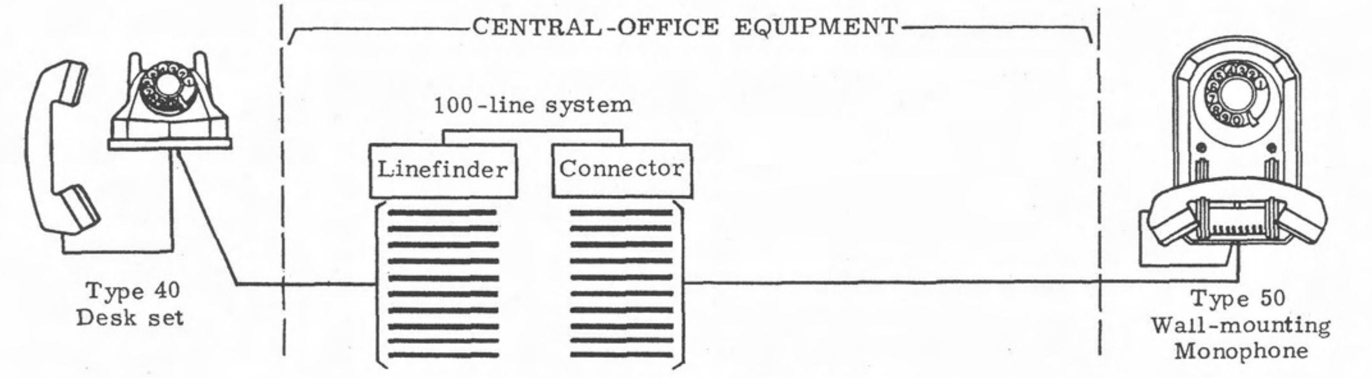

Fig. 62. 100-line system using linefinders.

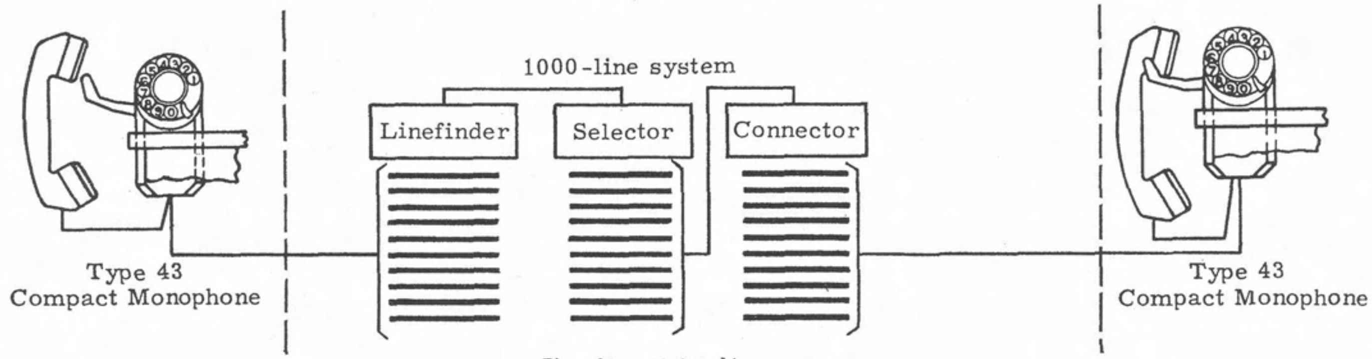

Fig. 63. 1,000-line system.

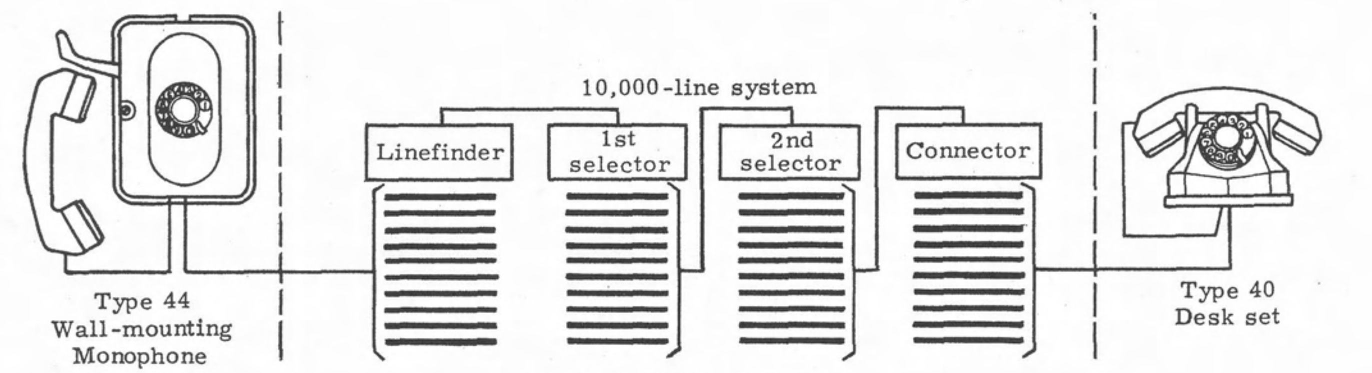

Fig. 64. 10,000-line system.

46. THOUSAND-LINE SYSTEM (FIG. 63)

The thousand-line system shown in Fig. 63 is similar to the one-hundred-line system in Fig. 62, except for the addition of selector switches between the linefinders and the connectors. The selector selects the particular hundred-group being called. For example, if 345 is the number to be called, the selector extends the calling line to an idle connector in the three-hundred group. The call then proceeds as in a one-hundred-line system.

47. TEN-THOUSAND-LINE SYSTEM (FIG. 64)

The ten-thousand-line system shown in Fig. 64 is made up of ten groups, each having one thousand lines. It requires "first selectors" to select any one of the thousand-line groups. In each thousand-line group, "second selectors" select the desired hundred-line group in that thousand. It differs from the thousand-line system only in the addition of a second group or rank of selectors to choose the desired thousand group.

48. MULTI-OFFICE SYSTEM

Usually a telephone exchange larger than ten thousand lines is divided into more than one "central office"; that is, instead of one huge switchboard concentrated in just one building, there are several switchboards of perhaps 10,000 lines each in various parts of the city. The multi-office-exchange area is so subdivided that the average length of the subscribers' lines will be as short as possible. This saves cable.

Of course an additional rank of selectors is needed for ten-thousand or office selection. In addition, pulse repeaters (bulletin 810) are used to minimize the number of wires required in the trunks between central offices (two wires per trunk are usual), etc.

A diagram showing the interlinking of a large multi-office exchange is too complicated for our present study (see bulletins 802, 811, and 819).

PART 8
BASIC SWITCH-STEPPING CIRCUIT

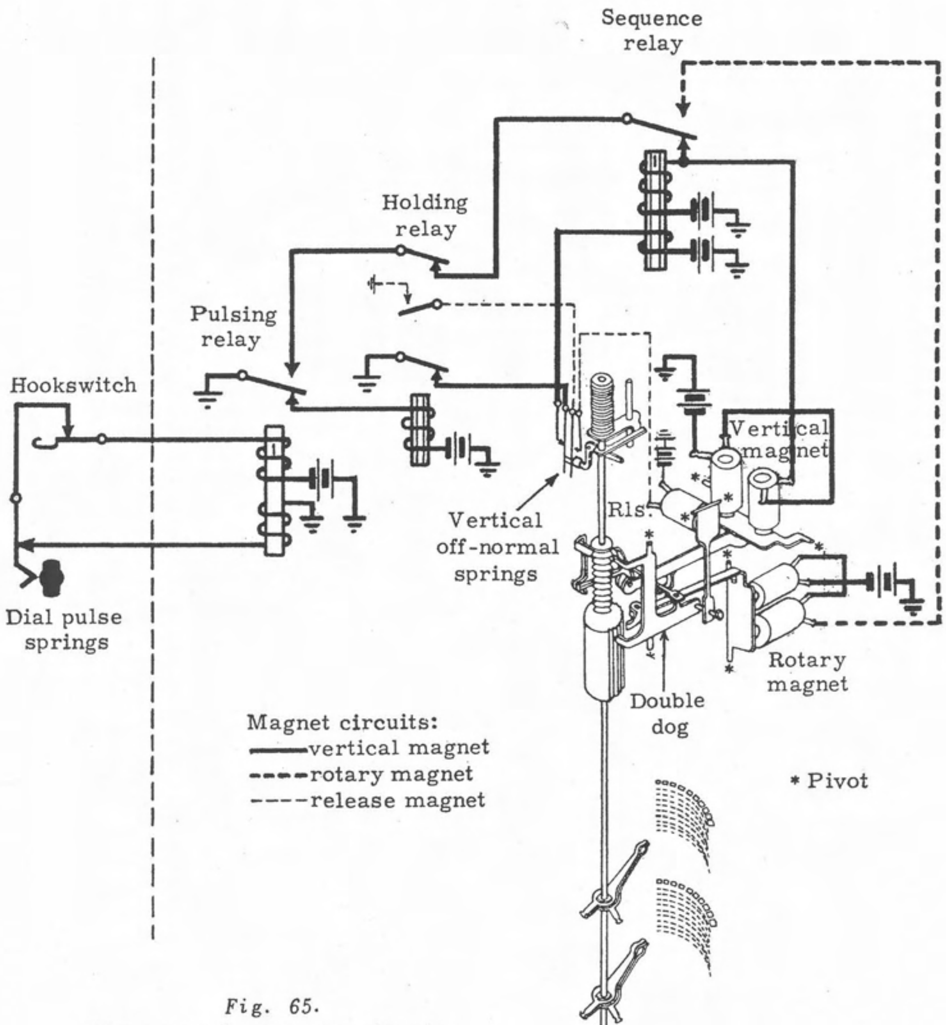

Fig. 65.
Basic switch-stepping circuit.

49. SLOW RELAYS SORT DIAL PULSES

Subscribers' dial pulses (§26 and Fig. 57) are used to step selecting switches in automatic central offices and thereby establish connections between calling and called telephones. Fig. 65 is a partial schematic circuit showing a typical* use of fast and (§13c) slow relays to channel dial pulses to the proper stepping magnet.

When the caller lifts his handset, the hookswitch closes the line circuit and operates the pulsing relay. The pulsing relay operates the holding relay, which in turn operates (through winding 2) the sequence relay.

Let's assume the caller wishes to step the switch wipers to bank-contact position 34.

He dials "3". The dial opens the line circuit 3 times in quick succession.

The pulsing relay, a quick-acting relay, responds to the dial pulses. For each "pulse", the dial opens the line circuit about 1/16 second, releasing the pulsing relay. Although the released pulsing relay opens the circuit of the holding relay, the holding relay has a copper sleeve to delay** its release about one-third of a second; thus the holding relay stays operated until the dial pulse-springs reclose and the pulsing relay reoperates.

Each time the pulsing relay restores, it sends a pulse of current through sequence-relay winding 1 and the vertical magnet in parallel. The first vertical-magnet pulse raises the switch shaft so that the vertical off-normal springs open the circuit of sequence-relay winding 2; however, the pulsing-relay pulses through sequence-relay winding 1 and the induced currents in the sequence-relay sleeve** keep the sequence relay operated throughout the string of dial pulses—3 in our example. The 3 pulses into the vertical magnet cause it to raise the switch shaft and contact wipers up opposite the third bank-contact level.

*Connector.

**See §13c in this bulletin, or look up "Lenz' Law" in any public-library physics book.

After the last pulse, the dial pulse-springs remain closed, the pulsing relay remains operated, and, after about a tenth of a second, the sequence relay restores.

In our example, we have assumed the caller wants to connect to the bank contacts of line 34. Now, with the sequence relay released, when the caller dials "4", his dial opens the line circuit quickly 4 times, and the pulsing relay restores 4 times and sends 4 pulses of current into the rotary-stepping magnet. This turns the shaft and wipers to line 34.

Figure 65 is of course a simplified and incomplete circuit. In a complete circuit the rotary magnet, too, might have another slow-to-release sequence relay of its own to detect the end of the second digit dialed, and prepare the path for or actually start the next operation.

50. RELEASE

When the call has been concluded and the connection is no longer required, the caller hangs up. This time, instead of a brief dial pulse, we have the hookswitch opening the line circuit for a long time. The pulsing relay restores immediately, and opens the circuit of the holding relay. The holding-relay sleeve* keeps it operated for another third of a second; then the holding relay restores. (Just as we have said that the pulsing relay responds to dial** pulses, we might say that the holding relay responds to the caller's hookswitch, or that the holding relay distinguishes brief breaks [dial pulses] from prolonged open-circuits [hookswitch signals].)

The released holding relay closes the release-magnet circuit. The release-magnet armature withdraws the "double dog" teeth which had held the shaft and wipers in place. The helical spring atop the shaft turns the shaft and wipers back to the left and off the bank contacts. Then gravity pulls the shaft down to its "normal" position. A shaft extension operates the "off-normal" contacts, which open the release-magnet circuit.

51. APPLICATION

Such a combination of one fast relay and two slow relays, etc., recurs in all dial-controlled equipment.

PART 9
GLOSSARY OF TELEPHONE TERMS

The following conform, in part, to American Institute of Electrical Engineers "American standard definitions of electrical terms" (A.S.A. C42-1941).

- A -

"A" SWITCHBOARD is a manual-central-office local switchboard at which calls from subscribers are answered, and connections are completed either directly at the same switchboard or via trunks to other switching equipment.

A-B TOLL calls (originally manual-system calls which an A operator completed through a B operator in another but nearby town) are calls to nearby towns, handled in a manual central office by an A operator or in a dial central office by a DSA operator (as distinguished from calls to long-distance points handled by a toll operator).

ANSWERING PLUG AND CORD are used to answer a calling line. Known also as "rear" plug and cord.

ANTI-SIDETONE TELEPHONE includes a balancing network to minimize reproduction, in the user's receiver, of the sound of his own voice when he speaks, and of surrounding room-noises picked up by his transmitter.

ATTENDANT is the "operator" at a private-branch-exchange switchboard.

AUDIBLE RINGING SIGNAL is connected to the calling line to indicate that the called station is being rung. Known also as ring-back tone, ring tone, etc.

AUTOMATIC means "doing by a machine that which formerly was done by hand".

AUTOMATIC SWITCHBOARD is a telephone switchboard in which the connections are made by using remotely controlled switches.

AUTOMATIC TELEPHONE SYSTEM or dial system is a telephone system in which telephone connections between customers are ordinarily established by electric and mechanical apparatus controlled by pulses produced by a calling device.

- B -

"B" SWITCHBOARD is a manual local switchboard, to complete connections from other central offices.

BANK is an assemblage of fixed contacts over which one or more wipers move in order to establish electric connections.

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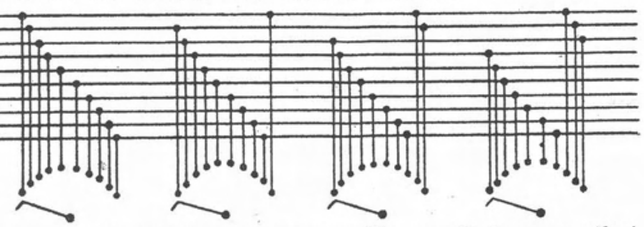
*See §13c in this bulletin, or look up "Lenz' Law" in any public-library physics book.

**Of course the pulsing relay also responds to the caller's hookswitch.

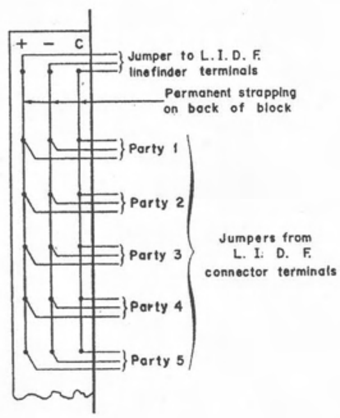
BANK SLIP is varying the sequence of the multiple connections of a number of bank-contact-level outlets



to an equal number of succeeding switches, so that different succeeding switches are first choice to different selectors.

BATTERY is a combination of two or more galvanic cells electrically connected to work together to produce electric energy. (Common usage permits this designation to be applied to a single cell used independently.) In telephone literature, "battery" commonly means the NEGATIVE (-) terminal of a central-office d-c power supply.

BUNCHING BLOCK at a distributing frame in a terminal-per-station central office is a terminal strip whose terminals are strapped in groups, thru which jumper wires from connector terminals of the parties of a party line are connected together. (They obviate messy piles of several jumper wires soldered to single terminal lugs).



BUSY TEST is a test made to find whether or not certain facilities which may be desired, such as a subscriber line or trunk, are available for use.

- C -

CALLING DEVICE is an apparatus which generates the pulses required for establishing connections in an automatic telephone switching system. See "dial" and "key pulsing".

CALLING PLUG AND CORD are used to connect to the called line. Known also as "front" plug and cord.

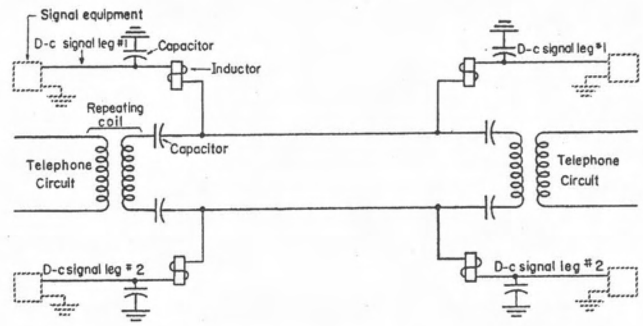
CENTRAL OFFICE is where orders for or signals controlling telephone connections are received and connections are established.

CLR (combined line and recording). See "recording-completing".

CODE RINGING is party-line ringing wherein the number of rings, or the duration, or both, indicate which station is being called.

COMMON-BATTERY CENTRAL OFFICE is a central office which supplies transmitter and signaling currents for its associated stations, and current for the central-office equipment, from batteries located inside the central-office building.

COMPOSITED CIRCUIT is a repeating-coil telephone circuit with inductors and capacitors as filters to permit



simultaneous conversation and d-c signaling over the same line wires. Often used to derive dialing legs for a phantom group.

CORD CIRCUIT is a connecting circuit terminating in a plug at one end or both ends and used at switchboard positions to establish telephone connections.

CUT-OFF RELAY, associated with a subscriber line, disconnects the line relay from the line when the line is called or answered.

- D -

DIAL is a type of calling device, which, when wound up and released, generates the pulses required for establishing connections.

DIRECTOR (Automatic Electric Company registered trade-mark) is an automatic-telephone-system register-translator-sender manufactured by Automatic Electric Company. A register receives and stores pulses. A translator converts information about a call into a new form to perform the desired subsequent operation. A sender transmits pulses to a distant office.

DISCONNECT or RELEASE means to disengage the apparatus used in a telephone conversation and to restore it to its condition when not in use.

DISTRIBUTING FRAME is a structure for terminating permanent wires of a central office, and for permitting easy change of connections between them by means of cross-connecting wires called "jumpers". (See figure 66.)

DIVIDED RINGING provides partial ringing selectivity by connecting half the ringers from one side of the line to ground, and the other half from the other side of the line to ground.

DRY CONTACT is one through which no direct current flows.

DSA (dial-system "A" or assistance) OPERATOR is the operator reached when "0" is dialed in a large exchange where there is one code (0) for "operator" and another code (e.g., 110, 211, etc.) for "long distance". She renders miscellaneous assistance, completes A-B-toll calls, etc.

- E -

EXCHANGE is an assemblage of telephone stations, lines, and switching arrangements for their interconnection, together with all accessories to provide telephone communication service in a specified area which usually embraces a city, town, or village and its environs.

EXTENSION STATION is a telephone station associated with a main station through connection to the same subscriber line and having the same call-number designation as the associated main station.

- F -

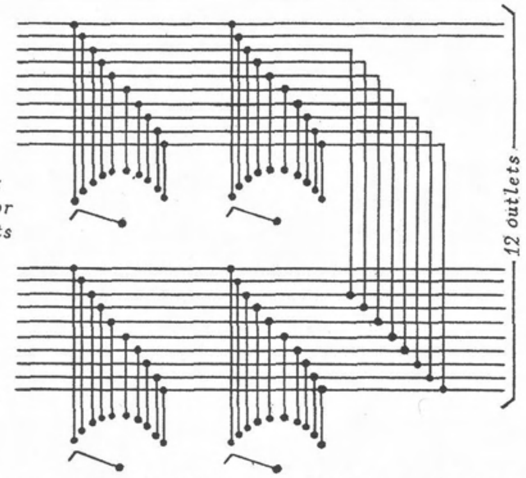
FOLLOW is the yield or bending of a relay front-contact spring during operation, or of a relay back-contact spring during release. Follow holds the contact points together firmly and rubs the contacts together to improve their conductivity.

- G -

GAUGING is positioning relay stationary springs so their contacts make, break, and follow properly.

GRADING is the method of connecting level multiples together so that a group of selectors is given access to individual trunks on the early choices, but on the later choices shares access to trunks with other groups.

Example: Grading for 12 outlets



This increases the efficiency of later choices by progressively combining on subsequent choices the traffic offered to several groups, with the last common trunk carrying the residual traffic of all groups. Also, the selector-groups together have access to more succeeding switches than there are bank-contact positions on a level of any one selector.

GROUND sometimes actually refers to an earth connection. For protection and electrolysis reasons, the positive terminal of a telephone central-office storage battery or power system always is earth-connected; hence in relay-circuit explanations the word "ground" usually means simply "+ battery"

GROUND-RETURN CIRCUIT is a circuit which has a conductor (or two or more in parallel) between two points, and which is completed through the ground or earth.

- H -

HARMONIC RINGER is a telephone ringer which responds to alternating current within only a very narrow frequency band. A number of such ringers, each responding to a different frequency, are used for the various stations on a harmonic-ringing party line.

HARMONIC SELECTIVE RINGING is selective ringing which employs currents of several frequencies, and ringers each tuned mechanically to the frequency of one of the ringing currents, so that only the desired ringer may be actuated.

HOUSE CABLE is a distribution cable within the confines of a single building or a series of related buildings but excluding cable run from the point of entrance to a cross-connecting box, terminal frame, or point of connection to a block cable.

- I -

INDIVIDUAL LINE is a subscriber line arranged to serve only one main station, although additional stations may be connected to the line as extensions. An individual line is not arranged for discriminatory ringing with respect to the stations on that line.

INSULATION RESISTANCE of an insulated conductor is the resistance offered, by its insulation, to an impressed d-c voltage tending to produce a leakage of current through the insulation.

INTERCEPTING TRUNK is a trunk to which a call for a vacant number or changed number or a line out of order is connected for action by an operator.

INTERMEDIATE DISTRIBUTING FRAME (IDF) is the frame where subscriber lines or directory numbers are cross-connected to line equipments. (See figure 66.)

INTERTOLL TRUNK is a trunk between toll offices in different telephone exchanges.

- J -

JUMPERS are semi-permanent but easily changed electric connections between terminals at distributing frames, etc.

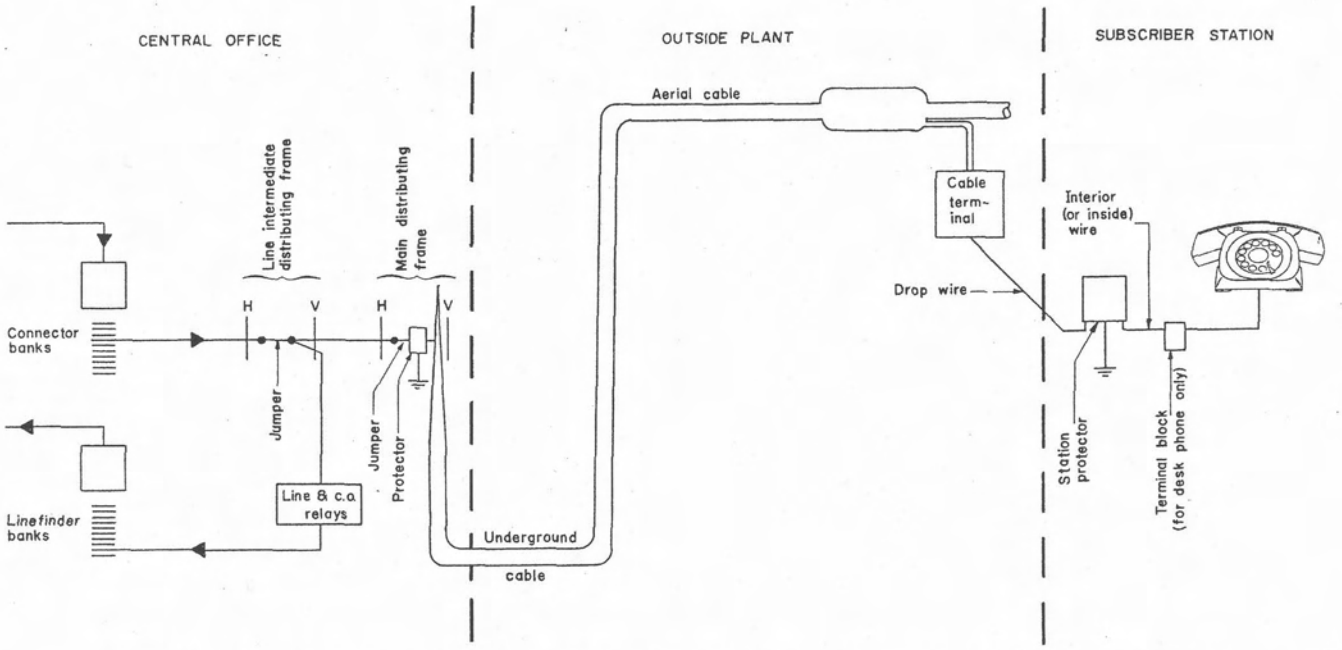
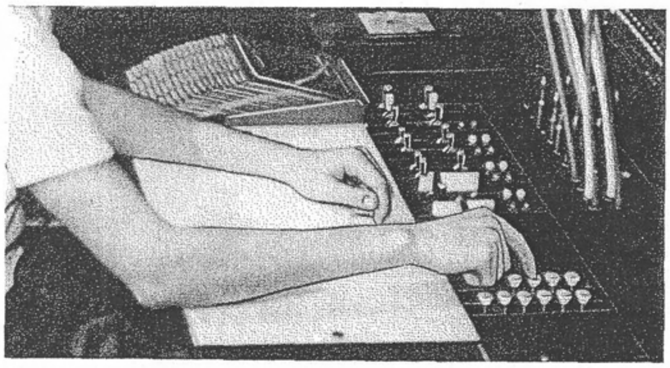


Figure 66. Some of the actual wire and cable connections, and distribution, protective, and terminal devices, between central office and subscriber.

- K -

KEY is a hand-operated switching device ordinarily comprising concealed spring contacts with an exposed handle or push button, capable of switching one or more parts of a circuit.

KEY PULSING is sending control pulses (digits, including digit-equivalents of letters) by a keyset* instead of a dial. Used mostly by toll-board operators.



*Often the question is asked: "Does the keyset send pulses while a button is being pressed down, or while it is coming back up?" Neither. The keyset by itself cannot replace a dial. The keyset merely enables the operator to mark the numbers quickly into a GROUP OF NUMEROUS RELAYS, where they are stored temporarily. Pulse-generating and counting relays then do the actual pulse-sending at the normal, slower, rate of a dial.

- L -

LEAKAGE CURRENT is a stray current of relatively small value which flows through insulation when voltage is impressed across the insulation.

LOCAL-BATTERY TELEPHONE SET is a telephone set for which the transmitter current is supplied from a battery individual to the telephone set. Current for signaling by the telephone station is supplied from a local hand generator.

LOOP is a telephone line between a central office and a telephone station, private branch exchange, or other end-equipment.

- M -

MACHINE RINGING is ringing which is started either automatically or by an operator, after which it continues automatically until the call is answered or abandoned.

MAIN DISTRIBUTING FRAME (MDF) is a distributing frame, on one part of which terminate the permanent outside lines entering the central-office building and on another part of which terminate the subscriber-line multiple cabling, trunk multiple cabling, etc., used for associating any outside line with any desired terminal in such multiple or with any other outside line. It usually carries the central-office protective devices, and functions as a test point between line and office. (See figure 66.)

MAIN STATION is a telephone station with a distinct call-number designation, directly connected to a central office.

MANUAL SWITCHBOARD is a telephone switchboard in which the connections are made manually, by plugs and jacks or by keys.

MARGINING is adjustment of relay armature-spring tension.

MEASURED SERVICE is telephone service for which charge is made according to the measured amount of usage.

METALLIC CIRCUIT is a circuit of which the ground or earth forms no part.

MONOPHONE (registered trade-mark) is an automatic telephone manufactured by Automatic Electric Company.

MULTIPLE is a system of wiring so arranged that a circuit, a line, or a group of lines are accessible at a number of points, to any one of which connection can be made.

MULTIPLE SWITCHBOARD is a manual telephone switchboard in which each subscriber line is attached to two or more jacks, so as to be within reach of several operators.

- N -

NIGHT ALARM is an electric bell or buzzer for attracting the attention of an operator to a signal when the switchboard is partially attended.

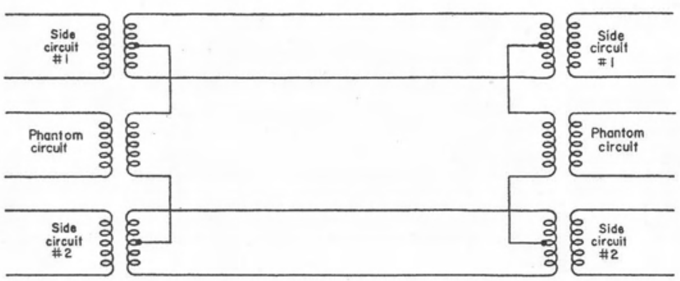
NON-NUMERICAL ACTION of a switch is that action which does not depend on the called number (such as hunting an idle trunk).

NUMERICAL ACTION of a switch is that action which depends on at least part of the called number.

- P -

PARTY LINE is a subscriber line arranged to serve more than one main station, with discriminatory ringing for each station.

PHANTOM CIRCUIT is a superposed circuit derived by center-tapping repeating coils in two pairs of wires,



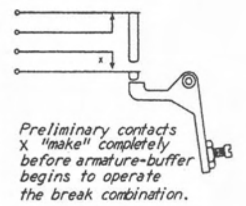
called side circuits. For the phantom circuit, the two wires of each side-circuit pair are effectively in parallel.

PILOT LAMP is a switchboard lamp which indicates a group of line lamps, one of which is lit.

POLARIZED RELAY is a relay in which the movement of the armature depends upon the direction of the current in the circuit controlling the armature.

POSITION is that part of a switchboard designed for the use of one operator.

PRELIMINARY CONTACTS are combinations which operate completely before any other combinations on the relay operate. (Usually marked "X" on A. E. Co. circuit blueprints.) The magnetization required to operate the preliminary contact is less than the non-operate magnetization for the other combinations.



PRIVATE BRANCH EXCHANGE (PBX) is a manual telephone exchange serving a single organization and having connections to a public telephone exchange.

PROTECTOR usually consists of fuses in series with the line and lightning arrester paralleled across telephone equipment (see figure 66). It protects the subscriber, equipment, and telephone-company employes from high voltage due to lightning or a cross with a power line.

PULSE is a sudden change of brief duration, produced in the current or voltage of a circuit in order to actuate or control a switch or relay. The typical dial pulse is about 0.0615-second open circuit.

PULSE REPEATER is used for receiving pulses from one circuit and retransmitting corresponding pulses into another circuit. It may also correct the wave form of the pulses and perform other functions such as supplying transmitter current to stations.

- R -

RECORDING-COMPLETING TRUNK is a trunk for extending a connection from a local line to a toll operator, used for recording the call and for completing the toll connection.

REPEATING COIL is a term sometimes used in telephone practice to designate a transformer.

REVERSE-BATTERY SUPERVISION is a form of supervision in which supervisory signals are furnished from the terminating end to the originating end by reversing the direction of current flow over the trunk.

REVERTING CALL is a telephone call between two subscriber stations on the same party line.

RING side is that conductor of a circuit which is associated with the ring of a plug or the ring spring of a jack; i.e., the negative (-) wire of a telephone line.

RINGDOWN is that method of signaling an operator in which telephone ringing current is sent over the line to operate a drop or a self-locking relay and a lamp.

RINGER is an electric bell designed to operate on low-frequency alternating or pulsating current and associated with a telephone station for indicating a call to the station.

- S -

SATT is an abbreviation of "Strowger automatic toll ticketing".

SELECTIVE RINGING is party-line ringing which rings the bell of the desired station only.

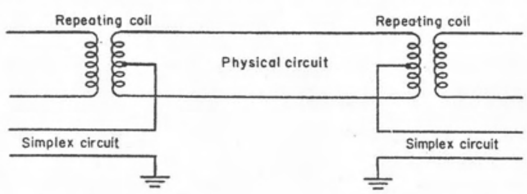
SEMI-SELECTIVE RINGING is ringing on a party line of more than two parties wherein the bells of two stations are rung simultaneously, differentiation being by number of rings, one or two.

SHORT CIRCUIT is a condition in which, through fault or intent, essentially zero resistance or impedance is connected in parallel across a device or apparatus, diverting essentially all current from it, and reducing the voltage drop across it essentially to zero.

SHUNT is a device having appreciable resistance or impedance, connected in parallel across another device or apparatus, and diverting some (but not all) of the current from it. Appreciable voltage drop of planned usefulness exists across the shunted device or apparatus, and appreciable current flows through it.

SIDE CIRCUIT is a circuit arranged for deriving a phantom circuit. Sometimes called "physical" circuit.

SIMPLEX CIRCUIT is a circuit derived from a pair of



wires by using the wires in parallel, with ground return.

SLEEVE wire is that conductor of the circuit which is associated with the sleeve of a plug or jack. In automatic central offices, formerly the "private" or now the "control lead", an intra-office third wire which does not go outside the central-office building.

SUBSCRIBER is a customer of a telephone system who is served by the system under a specific agreement or contract.

SWITCH TRAIN is a series of switches in tandem.

- T -

TANDEM CENTRAL OFFICE is used primarily as a switching point for traffic between other central offices within the same exchange and nearby exchanges.

THROUGH SUPERVISION, in a manual telephone system, is the automatic transfer of supervisory signals through one or more trunks.

TIP side is that conductor of a circuit which is associated with the tip of a plug, or the tip spring of a jack; i.e., the positive (+) wire of a telephone line.

TOLL CIRCUIT connects two exchanges in different towns. "Toll" is charged for its use.

TOLL SWITCH TRAIN is a switch train which carries a connection from a toll board to a subscriber line.

TRUNK is a telephone line or channel between two central offices* or switching devices**, which is used in providing telephone connections between subscribers generally.

TRUNK HUNTING is the operation of a selector or other similar device, to establish connection with an idle circuit of a chosen group. This is usually accomplished by successively testing terminals associated with this group until a terminal is found which has an electrical condition indicating it to be idle.

TWO-STEP RELAY: a relay with preliminary contacts in a circuit where after its preliminary contacts operate it remains for a time with the armature partially operated, and awaits additional magnetization to complete its stroke and operate the other combinations.

- U -

UNIVERSAL NUMBERING is a multioffice-area numbering and switching plan which permits the same number to be dialed to reach a given telephone, regardless of the location of the station originating the call.

- V -

VOICE FREQUENCY is a frequency lying within that part of the audio range which is employed for the transmission of speech. Voice frequencies used for commercial transmission of speech usually lie within the range 200 to 3,500 cycles per second.

- W -

WET CONTACT is one through which direct current flows. (Significant because of the healing action of direct current flowing through unsoldered contacts.)

*The typical trunk or telephone line between two central offices consists of TWO wires (or fewer if phantom circuits, carrier channels, etc. are used).

**The usual trunk between two local-switchtrain switching devices consists of THREE wires. Toll switchtrains often use four wires.

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