TELEGRAPH AND TELEPHONE

THE TELEGRAPH, TELEPHONE AND WIRELESS TELEGRAPH ILLUSTRATED AND DESCRIBED. CONTAINING A MANUAL OF PRACTICAL LESSONS FOR STUDENTS AND OTHERS.

SUPPLEMENT TO

THE SCIENCE OF RAILWAYS

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The telegraph is an essential part of a railway and it is probable that a great majority of the managing officials of railroads who deserve to be called great because of their achievements, commenced business life in telegraph offices at obscure stations on some railroad. And it is probable that this will continue to be the case so long as railways are operated. For very few men have a genius so profound and assimilative qualities so great that they can learn the railway business thoroughly from headquarters; from the house-top.

It is along the line of a railway, in touch with its every day phases, that the intricacies of the business are to be acquired and mastered. And there is no other initial position that offers such great advantages in this direction as the telegraph office. The operator is the hand of the superintendent. All the trains pass under the former's observant eyes, and, in many cases, it is through him that their movements are directed. Before his window all the vast paraphernalia of business passes. He thus becomes familiar, by observation and contact, with this, the essential feature of railway enterprise and life.

He also comes in hourly contact with the forces engaged about the station, where all activity originates. In this way he learns station work and obligations by observing what is done and how it is done. And in his leisure hours he assists, in every way he can, in selling tickets, way-billing freight, writing up the records, rendering returns, and so on. Thus the duties and responsibilities of the agent and his assistants are, little by little, and all unconsciously, acquired, so that he soon has them at his fingers' ends.

And so he not only learns the practical features of railroad business, but becomes imbued with the instincts of its life so that when he is promoted, if it happily falls out that way, he possesses a great fund of definite knowledge and practical experience to draw from in the emergencies that arise on a railway every hour of the day. And because this is so, and because the telegraph is a vital feature in railway operations, I have been led to embody this book on telegraphy in the "Science of Railways" series. In its preparation I have been assisted by experts in telegraphy and telephony; and in the case of the wireless telegraph, by Mr. Carl Kinsley, Profesor University of Chicago, and everywhere recognized as an expert in this line, he having been one of a commission appointed by the United States authorities to inquire into and report on the utility of the wireless telegraph for governmental purposes. I say I have been assisted, I should more properly have said that, practically, the work—save the minor feature of editing it—has been performed wholly by these experts. So that if any credit attaches to the work it belongs wholly to them. For although I was a practical telegraph operator for a number of years in my youth, I have not been able to keep myself advised of the progress made in electrical uses, and so am not fitted to write authoritatively on the subject.

That portion of the work devoted to the Telephone is of interest, because this particular feature of communication is coming, more and more, into use in connection with railway operations and is destined, it is probable, to be an important factor. It is therefore desirable that everyone who is going to take up railway work should familiarize himself with its features and its possibilities.

Of the wireless telegraph, which is here intelligently exploited for the first time, I need not speak save to say that no one can comprehend its future or its possibilities. But I can see no reason why a telegraph operator, through its aid, may not signal to an engineer who is rushing headlong to destruction and so instantly stop him where he is. It needs, seemingly, only that the instruments in the telegraph offices and those on the locomotives should be attuned in harmony, so that when the engineer is called, no matter at what speed his engine may be rushing forward, his instrument will respond; and, thus, if the message affects him, he will be warned and so saved. However this may be, it is apparent that the wireless telegraph has come to stay and it is destined to serve a practical purpose in business life. Because of this all who are concerned in the workings of electricity, of the telegraph or the telephone, are interested in this feature and should lose no time in commencing to study it, not speculatively, I may say, but for their particular advancement and the good of their employer.

M. M. K.

BOOK I

THE TELEGRAPH

CHAPTER I.

THE GENESIS OF THE TELEGRAPH.

The word telegraph signifies to write afar; specifiically applied, it refers to an apparatus for communicating intelligence at a distance through the medium of signs addressed to the eye or ear. Its basis is electricity and its manifestations either visible or audible signals.

Visible signals may be (a) momentary—as in some systems of needle telegraph and forms of apparatus on submarine cables—or (b) permanent, as in the case of the Morse register which produces a lasting record.

Audible signals are in their nature momentary and are produced by a device known as a sounder.

The operation of the telegraph, as we know it, dates from about the year 1837. The idea of using electricity for signaling, however, is much older. Telegraphy, is, after all, but an amplified system of signaling, perfected step by step as new discoveries were made as to the adaptability of electric force to mechanical appliances.

Nearly three hundred years ago, when men were still dreaimng of alchemy and the philosopher's stone, the idea was conceived of using two sympathetic needles, which, instead of always pointing towards the pole, should be so powerfully related to each other that in whatever direction one pointed the other would follow. The intention was to use in connection with the needle a dial having the letters of the alphabet inscribed around the edge, the letter it was desired to communicate being indicated by the needle stopping thereat. This conceit was ridiculed as a chimerical dream, as indeed it was, there being no means provided for connecting the two dials. Wheatstone's needle telegraph, well known in England, is based on this idea. The needles are kept in perfect sympathy with each other by means of a wire charged with electricity, stretched from one to the other, any electric disturbance affecting the wire acting on both needles alike. This illustration conveys a more accurate idea of the primary principles of the telegraph than any conception we can form of a current flowing through a long conducting wire.

The first attempts to construct an electric telegraph followed soon after experiments in connection with defining the velocity of frictional electricity had been made by Watson in London, Winkler in Leipsic, and others during the years 1746 and 1747. In the year 1753 an anonymous writer wrote to Scott's Magazine in England, suggesting a telegraph by the use of as many insulated conductors as there are letters in the alphabet, each wire to be used for a separate letter.

The first successful attempt to apply frictional electricity (the only form of electricity at that time known) to the telegraph, was made by Le-Sage, a philosopher of Genoa, in the year 1774.* The medium which he used for communicating between two stations was a rope, composed of

*The first form of electricity known was undoubtedly the frictional. Its discovery is generally attributed to Thales, one of the seven wise men of Greece, a famous philosopher and astronomer who lived in the sixth century B. C. He observed that amber, after being rubbed by silk, had the property of attracting light bodies, such as pieces of paper, particles of bran, etc. It was afterwards found that other substances, such as glass, sulphur and resin gained this same property by friction.

twenty-four strands of insulated wire, one strand for each letter of the French alphabet. The strands were separated over a table of glass, the ends terminating in a couple of pith balls hung over the letter which that strand designated. When any one of the wires was placed in communication with an electrical generating machine, the pith balls at the opposite end repelled each other. In this manner any of the letters could be indicated. LeSage's invention could be operated for only short distances, and was therefore impractical.

Lomond, in 1797, devised a system by which a single wire and a pair of pith balls were used. His system provided for an alphabet of motions, a certain number of deviations of the balls being arranged for each letter.

About this time systems of signaling by means of electric sparks were suggested by Reise, Cavallo and Don Silva of Madrid, but nothing practical came of them.

With the discovery of the Voltaic pile and the discovery by Nicholson and Carlisle of the decomposition of water, and subsequent researches by Davy on the decomposition of salts by the Voltaic current, a new impetus was given to telegraph inventions. This meant the discovery of a new method of generating electricity. The frictional process had been and is able to produce it in but small quantities and in weak measure and therefore rendered it ineligible for practical application. What is now known as "current" or "voltaic" electricity now became available.*

In 1808 Sommering devised an apparatus for the transmission of intelligence, based on the new

*This form is produced by chemical action and is described later on.

principles. Sommering used a strand of twenty-seven insulated wires, each terminating at the receiving station, in a glass trough, filled with water, one wire being used for each letter. At the sending station each wire terminated in a metallic terminal. To signal it was necessary to connect the poles of a voltaic pile or battery with two of the terminals. The current passing through the wires caused bubbles to rise in the water at the terminals at the receiving station, oxygen at one and hydrogen at the other. Sommering signaled two letters at a time. On account of the great expense resulting from the use of so many wires, this system was never used for practical commercial purposes.

With the brilliant discoverey of Prof. Oersted, of Copenhagen, in 1820, of electro-magnetism, the development of telegraphy was given a new impetus in an entirely different direction. He observed that a galvanic current, when placed near a magnetic needle, caused the needle to be deflected from its natural direction pointing north and souht. Immediately attempts were made to adapt this discovery to telegraphic purposes, and various systems of needle telegraphy were devised, too numerous to describe.

Although at this time the electro-magnet had in a certain sense become known, it was but a toy working feebly in a short circuit. About 1831 Prof. Joseph Henry of Albany invented the electro-magnet as it now is, viz., a horse shoe of soft iron wound with many turns of insulated copper wire. He also demonstrated the possibility of exciting magnetic energy at a distance, by the use of a battery of a sufficient number of cells. It was not until this time, after the discovery of a low form of electricity, so low as to allow of easy insulation of thousands of miles of wire, together with the discovery of the relations existing between electricity and magnetism, by means of which magnets many miles apart can be put in communication with each other, and caused to act in harmony, that the invention of the telegraph, as now constructed, became possible.

CHAPTER II.

THE MORSE TELEGRAPH AND ITS DEVELOPMENT; SOURCES OF ELECTRICITY; THE GRAVITY BATTERY; MAGNETISM; ELECTRO MAGNETISM.

No single individual can, it is apparent, justly claim the invention of the electric telegraph. That honor must be divided among many. It was, in fact, a growth, and the work of many minds extending over a long period of years. But to Prof. S. F. B. Morse belongs the credit of adapting the many discoveries, and making the electro-magnetic telegraph practical. The idea of an electro-magnetic telegraph occurred to him while he was returning to the United States from a trip to France in the year 1832. Before the voyage was completed he outlined his ideas of a telegraph substantially as follows:

1. A single circuit of conductors from some suitable generator of electricity.

2. A system of signs consisting of dots and dashes and spaces to represent letters and numerals.

3. A mechanical arrangement operated by clock-work, for causing a record of the signals to be made upon a strip of paper, through the agency of an electro-magnet, armed with a pen or pencil, at the end of a lever.

Two or three years ensued before he was able to embody his ideas in permanent form. In 1835 he constructed the first rude working model of his apparatus and showed it to his friends. A public exhibition of his apparatus was given in

1837, at which time he succeeded in recording signals through a distance of one-third of a mile of wire. Soon after this a recording instrument was devised which registered dots and dashes substantially as in his perfected apparatus.

After many discouragements a line was finally constructed from Washington to Baltimore. This line was completed and successfully operated in 1844. The first mesage was transmitted over it on May 27, 1844.

In the next few years many telegraph lines were built in the United States, and as the country developed, lines constructed from ocean to ocean, until now a vast net-work of wires connects the greatest centers of population with the humblest hamlets in the land.

Sources of Electricity—Electricity is a power in nature. It is, we know, a manifestation of energy, exhibiting itself when in disturbed equilibrium or in activity, by a circuit movement, by attraction between surfaces of unlike polarity and repulsion between those of like. It is generally brought into action by any disturbance of molecular equilibrium whether from chemical or mechanical cause.

Electricity is produced in various ways, and while fundamentally the same in all forms, is called by different names, indicative of the manner in which produced, as frictional, chemical, current or voltaic, magnetic and thermal electricity. The form of electricity particularly applicable to telegraphy is that produced by chemical action.

It is a fundamental law of physics, known as the law of the conservation of energy, that the disappearance of energy anywhere is always accompanied by the appearance of an equal amount of energy somewhere in some other form or forms. If a cannon ball be raised ten feet from the earth and allowed to fall, it will exert exactly the same force in its fall that was expended in raising it. Whatever force is used in separating two substances that are naturally united, the same amount of energy is given out when they are brought together again. The most common case of such separation and reunion is in the abstraction of oxygen (which has a strong affinity for almost all other substances) and its return to its original combination. Considerable force is required to separate these atoms, and when they are re-united a corresponding amount of force is given out. This energy, or force, sometimes reappears in the form of heat, or where the action is very intense, in the form of heat and light, thus producing combustion, and under some conditions in the form of electricity.

It having been found that the development of electric action is always accompanied by the expenditure of some form of force, and that the electric agency can be made to reproduce the forms of energy in which it originated, it becomes apparent that the electric current is simply an impulse of force. This force is not a single force, but exists in two forms, having a remarkable relation to each other. For many years after electricity was first discovered it was generally supposed to be a separate substance pervading all objects. There were supposed to be two kinds which were called fluids. The theory of DuFaye and Symer was that an object when electrically excited was said to be charged with an excess of one fluid or the other, sometimes the vitreous or positive fluid, and sometimes the resinous or negative fluid. When these two fluids came together again and neutralized each other, a disturbance was supposed to be caused which created a current of electricity. Objects not electrically excited were regarded as charged with the same amount of each fluid.

Opposing this idea was the one fluid theory of Franklin. He held that there was but one fluid, and that "vitreous" electricity was a surplus of this one fluid over the ordinary amount, and that

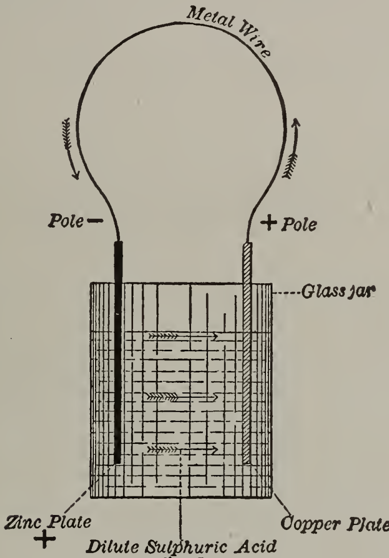


Fig I.

SIMPLE VOLTAIC OR GALVANIC CELL.

a deficiency was "resinous" electricity. Consequently he named the one positive and the other negative, and explained the current, or discharge, as the act of a surplus in an over-charged object passing to an object which was undercharged, thus restoring them to their normal state.

While these theories were in vogue, came the development of the invention of the galvanic battery, hence the adoption of the terms "Current," "Positive" and "Negative" to indicate the action of the battery. These terms though at variance with present opinions are still used.

The Galvanic battery is a device for the generation of the electric current by chemical action. The battery consists essentially of two unlike metals immersed in a liquid which conducts electricity, and which tends to combine with one of the metals, or with one more than the other. The chemical result is greatest when two metals are used, one of which is strongly and the other slightly acted upon. Such metals are classified in groups. Gold, platinum and copper show a decided electrification when placed in a cell with a member of the other group, zinc, iron or magnesium.

A simple form of cell, or battery, consists of a plate of zinc and a plate of copper immersed in water containing a small quantity of sulphuric acid.* Water consists of oxygen and hydrogen held together by a strong chemical affinity. A chemical reaction takes place between the water and the zinc, caused by the oxygen of the water leaving the particles of hydrogen with which it was united and combining with the zinc, the zinc dissolving slowly in the liquid. It will be noticed that bubbles form upon the zinc. These bubbles contain hydrogen gas. If now the zinc and copper are connected by a wire outside the cell, or bat-

*The general name for these plates is Electrodes. The zinc is the positive plate, the copper the negative. The current is said to flow from the positive to the negative. The copper attracting the positive current is known as the positive pole. The copper, while it is the negative plate, is called the positive pole, the zinc or positive plate constituting the negative pole.

tery, the chemical action will become more vigorous, the zinc dissolving with increased rapidity, the bubbles of hydrogen now appearing upon the copper instead of the zinc. This chemical action results in the development of electricity, very vigorous when the cell is first set up, but rapidly falling off, caused by bubbles of hydrogen forming upon the surface of the copper, which prevent the action of the solution thereon. This is called polarization of the cell, and may be diminished by any means which will cause the bubbles to rise to the surface instead of remaining attached to the copper.

This is usually effected by immersing the copper and zinc in two different solutions of unequal density, so that one floats upon the other, like oil on water. To accomplish this a solution of sulphate of copper is placed in the lower half of the cell, and a solution of sulphate of zinc in the upper half. This combination is known as a Gravity or Constant battery from the fact that the solutions are separated by gravity, and its action is even and continual until the material is used up.

The manner in which the electric force or energy is produced in the cell is still an open question. When the zinc and copper are placed in the cell what is termed a difference of potential is set up between them. This term is used to indicate a difference of condition for work, or difference in tendency to do work. The molecules of the liquid are being continually broken up and a continual tendency to equalize the conditions is manifested. This is overcome by the continued reaction in the cell, of such character as to re-establish the potential difference. The force evolved in these changes is in the form of positive and negative electricity. These, separating from each other, pass out of the battery, one going through the fluid to the copper and thence to its wire, and the other in the opposite direction, and they meet and seek to reunite in those parts of the circuit where no change is taking place. Meanwhile the process of evolving more positive electricity upon the copper, and more negative electricity upon the zinc goes on, resulting in the phenomenon known as the electric current, which, for convenience, is said to flow from the battery, traversing not only the wire, but the plates and solutions within the cell, the whole path forming what is termed the electric circuit.

The Gravity Battery—The Gravity or Constant battery may be said to be the standard form in use in the United States.

It consists of a glass jar about seven or eight inches high and six inches in diameter, at the bottom of which is placed sheet copper opened in scroll form, to which is riveted an insulated conducting wire which passes up the side and out of the jar. This constitutes the copper or positive pole of the battery.

If there is no old solution at hand from an old battery, the jar may be filled with pure soft water. Rain water is preferred where obtainable, as hard water tends to impair the strength of the battery.

In the bottom of the jar, on top of and around the copper is placed a combination of sulphuric acid and oxide of copper in the form of sulphate of copper, commonly known as blue vitriol.

Suspended above the copper about two or three inches and completely immersed in the water is hung the zinc plate. This is suspended by means of a brass hanger which serves as a conductor from the zinc and is provided with a clamp screw to which a metallic wire may be attached. This constitutes the negative pole of the battery.

If the wires from the two poles of the battery are now united, thus short circuiting the cell, it will attain its full strength in a day or two. It is not necessary to use any zinc solution in setting up the cell as sufficient will form in the cell to bring it to its full strength. It will be observed that the copper solution in the lower part of the

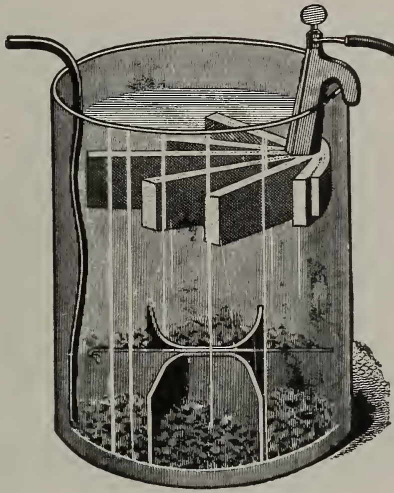


Fig 2

GRAVITY BATTERY—CROWFOOT TYPE.

jar will be of a deep blue color; it should extend to a point, a little above the copper. The zinc solution in the upper portion of the jar will be transparent.

Batteries should be kept in an enclosed box on a shelf about two feet from the floor. The jar should be placed in the position it is to occupy before it is filled, as shaking or carelessness in moving the battery will cause the solution to mingle,—a condition to be avoided.

As the action of the battery progresses, some of the materials will become exhausted. The rapidity with which this occurs depends largely upon the amount of work done by it. The first sign of waste will usually be observed in the solution of sulphate of copper, indicated by the line

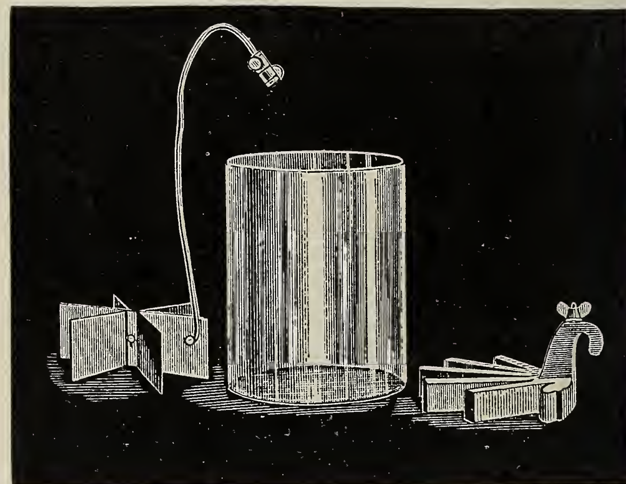


Fig. 3

SEPARATE PARTS OF GRAVITY CELL.

of blue color, falling towards the bottom of the jar. This may be remedied by placing more blue vitriol in the cell. A sufficient supply of blue vitriol should be kept in the cell to keep the blue color up to within an inch of the lower surface of the zinc, but not high enough to touch it. When the blue color rises too high no more blue vitriol should be added until it has receded almost to the bottom of the jar.

It will be observed as the chemical action in the jar goes on that the zinc gradually dissolves, is, in fact, burned up. The copper, on the contrary, gradually increases in weight, owing to the abstraction of copper from the solution which is deposited upon its surface.

Every three or four months the battery should be thoroughly cleaned. The zinc and copper should be carefully removed; the clean liquid should be poured into a separate jar and the dirt and loose copper which has accumulated on the bottom of the jar thrown out. The deposit upon the copper plate need not be disturbed, but the zinc plate, which will be found to be covered with a coating of brown oxide, should be thoroughly scraped down to the metal and washed in clean water and returned to the jar. This should be done while it is still wet.

The copper may then be replaced in the jar, adding a few crystals of blue vitriol, the clean liquid which was taken out should be returned, the zinc replaced and sufficient water added to fill the jar to the proper height. The battery will then be restored to its original strength.

Copper plates gradually become encrusted with metallic deposits, when it becomes necessary to replace them with new copper. Zinc plates, in time, dissolve to such an extent that new zincs must be furnished.

The battery should be kept in a dry clean place, in an even temperature and not exposed to dust. It should never be allowed to freeze.

To gain the force necessary for a main line, a number of cells are joined together. In connecting batteries it must be remembered that the current will not flow unless it can pass from one pole around to the other, thus making a complete circuit. Hence the cells are united by connecting the positive pole of one with the negative pole of its neighbor and so on. Each cell is termed an element. A battery of one-hundred elements means one composed of one-hundred jars or cells.

Magnetism—From time immemorial, it has been known that certain ores possessed the property of attracting iron or steel, and that these metals were themselves capable of being endowed with similar characteristics under certain conditions. A mass of magnetic ore is called a loadstone or *natural* magnet, and magnetism is that variety of electricity or force which exists in the magnet or loadstone.*

A bar of iron or steel to which magnetic qualities have been imparted by unnatural means is called an artificial magnet. The permanence of an artificial magnet depends upon the condition of the iron of which it is constructed. Soft iron is capable of retaining magnetic properties only so long as it remains under the magnetic influence, and is, under such circumstances, a temporary magnet only. Hard iron, and especially hardened steel, retains a portion of these properties after the withdrawal of the magnetizing influence, and hence may be called a permanent magnet.

Artificial magnets are made in various forms. A bar magnet is simply a straight bar of steel. If a bar magnet is thrust into a mass of steel filings, the filings will be attracted to the bar, and adhere in greater quantities near each end and scarcely at all in the middle, showing that the attraction

*The loadstone is said to have been first found near Magnesia, an ancient city of Asia Minor. It is now found in the Hartz Mountains of Germany, and in portions of Siberia.

of the magnet is greatest at the ends of the bar and is neutralized at the center, where it entirely disappears. These points of attraction are called the poles of the magnet.*

Another characteristic of the magnet is that

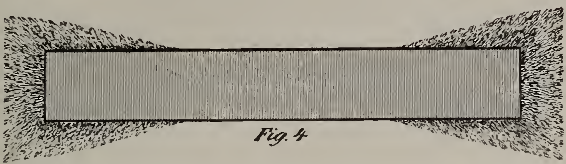


Fig. 4

BAR MAGNET, SHOWING ATTRACTION OF IRON FILINGS.

particles of iron having been attracted, and attached to the magnet, will themselves attract other pieces of iron or steel. This is termed magnetic induction.

Magnets are most commonly formed of a bar

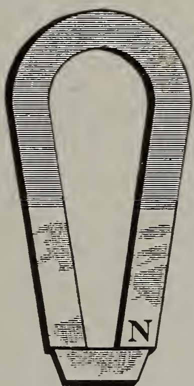


Fig. 5

HORSESHOE MAGNET.

of steel with the ends curved together in the shape

*This characteristic of the magnet was known centuries ago to the Chinese. They applied it to the Mariner's Compass, which is simply a bar magnet and a dial.

of a horseshoe or letter U. A suitably shaped piece of soft iron is usually fitted to the poles of the magnet. Any piece of iron so used is termed an armature.

Electro Magnetism—For many years scientists sought to discover the relation betwen Electricity and Magnetism. Finally, Hans Christian Oersted, Professor of Natural Philosophy at Copenhagen, in 1819 found that if a current of electricity is passed through a wire in the neighborhood of a compass or magnet needle without touching it, the needle will be caused to turn and take a position at right angles to the wire, or tend to that position in

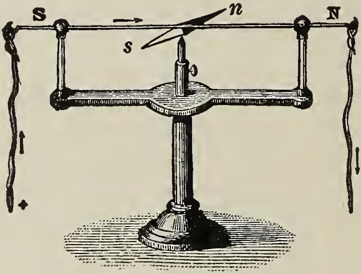


Fig. 6

DEFLECTION OF NEEDLE.

proportion to the strength of the current. The direction in which the needle moves, will indicate the direction of the current.

If a current is passed in like manner across a bar of iron without touching it, the iron becomes a magnet, that is, the proximity of the current will make iron that is a magnet, turn at right angles to the current. When the current is cut off or broken, the needle returns to its original position and the bar ceases to be a magnet. All of the telegraphs now in use are based upon this property of the electric current to make a temporary magnet of every piece of soft iron coming within its influence, and to deflect the magnetic needle at right angles to itself.

The magnetizing influence of the galvanic current upon a piece of iron is more powerful as the

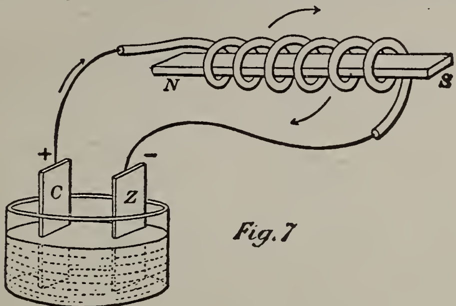


Fig. 7

MAGNETIZATION OF AN IRON BAR.

iron is placed nearer the current, and as a greater length of the wire acts upon the same amount of iron. Therefore if insulated wire is wound spirally around a piece of soft iron the magnetism produced is quite perceptible. This effect is not pro-

Fig. 8

RIGHT HAND WOUND MAGNET.

Fig. 9

LEFT HAND WOUND MAGNET.

duced by winding the bare wire around the bar; the wire is therefore always insulated, and as each turn is separated from the others the current is compelled to follow the whole length of the wire. A magnet produced in this manner is termed an Electro-Magnet. The Electro-Magnet in general use is that called the horseshoe magnet, although not made in precisely that form.

The magnet is constructed of a bar or heel piece of soft iron, into which are screwed two pencil-shaped pieces of iron which form the cores of the magnets. Over these cores are slipped a couple

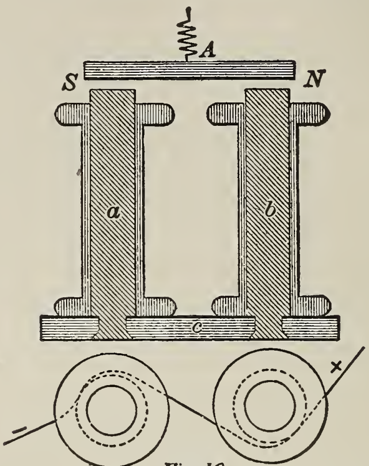


Fig 10

MAGNETS AND ARMATURE.

of spools or bobbins upon which are wound hundreds of feet of fine insulated wire. As much of the wire as possible is wound next the core, as

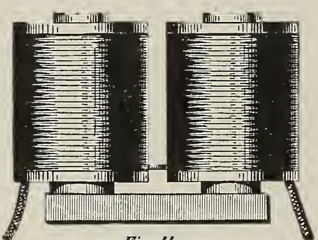


Fig. 11

INSTRUMENT MAGNET.

the inductive influence of the current decreases as the distance increases between the conducting wire and the core. The inner ends of the wires on the two bobbins are connected together, the outer ends remaining free to connect with the battery. The two spools are covered with vulcanized rubber and rudely resemble the barrels of an opera glass.

As the wires of both bobbins form one continuous circuit, when the other ends are connected with the battery the current passes through this wire, the soft cores of iron instantly become magnetic, remaining so as long as the current continues, and becoming demagnetized the instant the current is cut off.

Magnetism may be produced and destroyed in soft iron magnets with infinite rapidity. This fact it will be seen has been taken advantage of in telegraphy. Directly in front of the poles or cores where it will be acted upon when the cores become magnetized, is placed the armature, which is kept just out of reach of touching the poles and so arranged as to be attracted toward them each time the magnetic influence is exerted.

CHAPTER III.

THE ELECTRICAL CURRENT; THE LOCAL CIRCUIT; THE MAIN CIRCUIT; THE TELEGRAPH INSTRUMENT; THE KEY; ADJUSTMENT OF THE KEY; THE RELAY; ADJUSTMENT OF THE RELAY; THE SOUNDER; THE RESONATOR; THE BOX RELAY; CUT OUTS, SWITCH BOARDS AND OTHER DEVICES; ARRANGEMENT OF INSTRUMENTS IN LOCAL OFFICES.

The essential features of the main circuit are as follows:

1. The Generator or Batteries.
2. The Line Conductor.
3. The Earth.
4. The instruments for transmitting and receiving signals.

It has already been stated that a complete circuit must be constructed in order to cause the electric current to move. Early telegraph lines were constructed of a wire running from one terminal to the other and then returning to the battery at the starting point, thus creating a complete metallic circuit. This made the construction of telegraph lines very expensive and efforts were made to do away with the return wire. It was during the year 1838 while conducting experiments in connection with efforts to use the rails of a railway track for the return current, that Prof. Steinheil discovered that the earth would act as a conductor for the return current, thus effecting the saving of the entire cost of the return wire and its insulation.

It is still a question whether the current actually returns through the earth to the starting point or whether the earth is a vast reservoir of electricity, but for all practical purposes the earth acts as a return wire. Since this discovery a single wire suffices for a complete circuit, provided adequate connection is made with moist soil at each terminal. In cities this may be accomplished by establishing a connection with gas or water pipes. At places where there are no such facilities the ground connection may be made by attaching the wire to a plate of sheet copper or galvanized iron which should be buried in moist earth. This is designated making a ground.

What is known as the Closed circuit is the one used in the United States, so called owing to the fact of the generator, or batteries being ordinarily kept in connection with the line, causing a continuous current through the circuit, signals being conveyed by alternately opening and closing the circuit. The batteries in the main line circuit may be located only at one terminal, especially if the line be a short one, but better results are obtained by providing batteries at both terminals. A sufficient battery should be provided to produce a current of adequate strength to cause the electro-magnet of the receiving instrument at the distant terminal to attract its armature, the object being to produce signals by alternately opening and closing the circuit at the sending station, thus alternately magnetizing and de-magnetizing the electro-magnets of the receiving instrument at the distant station.

Galvanized iron wire is generally used for out door lines, and insulated copper wires for interiors and office connections. The lines are carried through the country on poles, numbering about thirty-five or forty to the mile, according to conditions. At each pole the wire is fastened to the insulator to prevent escape of the current.

The insulator in general use is shaped like an inverted glass cup, mounted upon an oak pin which is attached to the pole, the line being attached to the insulator by tie wires passing around the insulator in a groove, and the ends wrapped about the line wire. Where several wires are to be carried on the same poles cross-arms are secured to

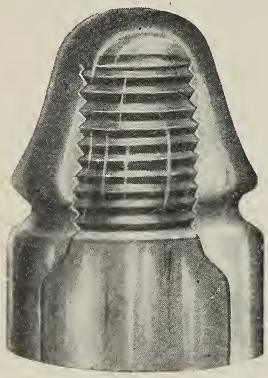


Fig. 12.

GLASS INSULATOR.
(REGULAR PATTERN.)

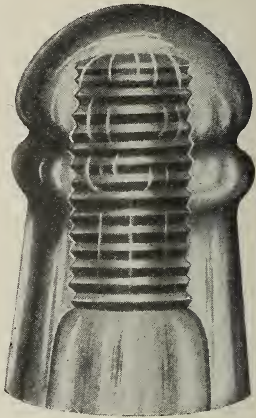


Fig. 13.

GLASS INSULATOR.
(SPECIAL PATTERN.)

each pole, the insulators attached to these being placed about twenty inches apart.

The Local Circuit—The Local Circuit is what is technically termed the "short" circuit; it is confined wholly to the local battery and the wires beginning and ending in the offices where used. Its purpose is to operate the sounder, and the object of the latter is to give volume so that the sound may be heard distinctly by the operator.

The essential parts of the local circuit are as follows:

1. The local battery.
2. The armature lever of the relay and its frame.
3. The local sounder.
4. The wires connecting the battery and these instruments.

The local battery usually consists of two jars, or cells, for each instrument.

Copper insulated wire is generally used for the office connections, as small copper wire is as efficient a conductor as the ordinary iron wire, and is sufficiently strong, as it is not subject to strain as on the main line.

In ordinary country offices the circuit is short, usually but a few feet from the battery to the instruments. In the larger offices, however, the batteries are kept in a room by themselves, necessitating a longer circuit.

The course of the local current is from the battery along the wire, through the vibrating armature lever of the relay and its frame, thence through the electro-magnets of the sounder, and back to the battery.

The Main Circuit—The Main Circuit consists of the main line (wire) proper that conducts the electricity. This wire pases into and through each local office. The electricity thus conducted passes through the relay and key and so out and away to the next office beyond. The operating, electrical force of the main current is the main battery or batteries. The main wire terminates in the earth at each end, as described elsewhere.

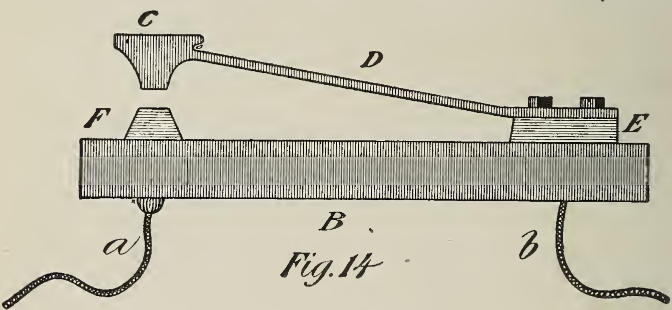
The Telegraph Instruments—The Morse system of telegraphy, which is in general use in the United States, creates audible signals at distant points by means of three instruments, which are essential to every set.

1. The Key, or circuit breaker, by means of which the operator opens and closes the circuit, thereby forming the signals.

2. The Relay, which connects the main and local circuits, by means of which the opening and closing of the former opens and closes the latter.

3. The Sounder, which produces the audible signals.

The Key—The Key is a very simple mechanical



FIRST FORM OF KEY.

device for opening and closing the circuit, thus producing signals. It will be more readily understood from the drawing of a rude form in which it was first made.

The wire "a" is carried through the table "B" and connected with the little anvil "F." When the button "C" at the end of the spring, or lever, "D" is pressed down and touches the anvil "F," the current instantly passes through, and from the metallic block "E" passes to the wire "b."

Keys are now made in various forms, but all have the same fundamental principle as the foregoing. Its essential features are the lever, the finger knob, the spring, the circuit closer and the base.

A pattern of Key much used is shown in the accompanying figure.

This is called a Steel Lever Leg Key. Its principal feature is a steel lever, four or five inches long, provided with trunnions which are supported by adjustable screws at the side. The lever has a small vertical movement upon its axis, lim-

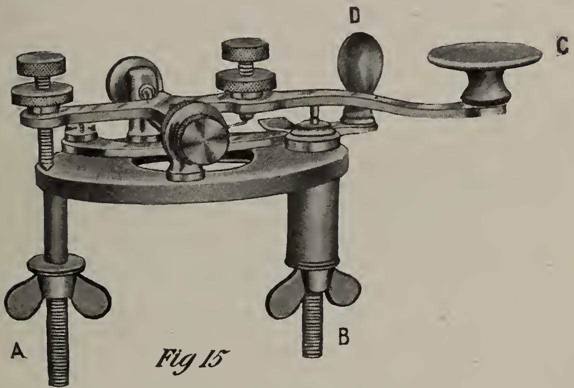


Fig 15

STEEL LEVER LEG KEY.

(To be fastened to table from underneath.)

ited in one direction by an adjustable set screw, and in the other by a platinum contact point, which is inserted in the anvil, and is insulated from the frame.

Underneath the base are two metallic rods or legs, by means of which the Key is fastened to the table, and which serve to connect the wires from the main circuit. One of the wires is fastened to the rod "A" by means of the adjustable set screw. This rod is connected with the frame of the Key. The other wire is connected to the rod "B." This rod is connected with the anvil but is insulated from the frame.

The lever is provided with a knob "C." By this means the lever may be pressed down at will of the operator, thus bringing a platinum contact point on the under side of the lever, in contact with the platinum point in the anvil. When the Key is pressed the circuit is closed, and the current passes through the wires precisely as in the crude form of Key first shown. When the pressure is withdrawn a spring beneath the lever restores it to its normal position.

As the normal position of the Key was open, some means had to be devised for closing the circuit when the Key was not in use. This is accomplished by means of the circuit closer "D," which consists of a metallic arm attached to the base of the Key in such a manner that it can slide into a little recess formed between the lip of the anvil and the frame, thus making an electrical connection between the two, and closing the circuit when the Key is not in use. When the operator desires to use the Key the circuit closer must first be opened.

The finger pieces on the lever and circuit closer are usually made of hard rubber so as to prevent shock to the operator.

Platinum is used for the contact points for the reason that this metal possesses infusible properties which prevent oxidation by the electric spark which is formed whenever the circuit is broken. It is also very hard and therefore will withstand the wear from the constant pounding of the points much better than a softer metal.

The trunnion set screws should be adjusted carefully to prevent friction, or unnecessary lateral movement. These set screws, as well as the one at the end of the lever, are all adjustable and provide for the adjustment of the Key.

Another form of Key is shown here called the Legless Key, which is fastened to the top of a table by screws through the frame, the wire connections being made at the binding posts shown on each side at the rear of the Key.

Adjustment of the Key—The Key should be allowed to play freely, the best results being obtained by allowing a small movement with a moderate upward spring pressure. The distance between the two points should be about the thickness of three or four sheets of ordinary paper. In bad

Fig.16

LEGLESS KEY.

weather when there is more or less escape of the current, or when the battery is weak, it is essential that the adjustment should be loose so that the points will strike together with ample force.

The Relay—When the main line is of some length, or, as is usually the case, when the insulation is poor, the current may be too feeble or too variable to operate a sounder satisfactorily. This difficulty is overcome by using an intermediate instrument caled the Relay, which is connected with both the main and local circuits.

Its connection with the main line is electrical, while with the local circuit it is both electrical and mechanical; its function being to open and close the local circuit to which the sounder is connected, by means of which the sounder is made to produce the required volume of sound.

The Relay consists of an electro-magnet having a vibrating armature delicately balanced so as to move freely when acted upon by minimum magnetic attraction, and which, when moved, puts the local circuit in motion.

The electro-magnet "A" is composed of two soft iron cores, each two inches long and 11-32

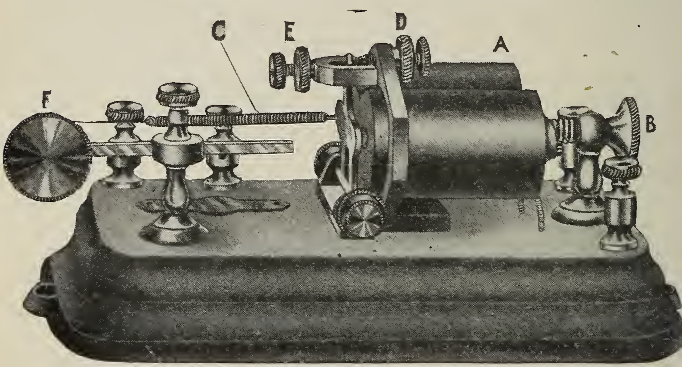


Fig. 17

MAIN LINE RELAY.

of an inch in diameter, screwed into a yoke two inches long and ¼ inch in diameter.

The front ends of the magnet are supported in a vertical metallic frame which is firmly secured to the base by screws from beneath.

The frame has two circular openings large enough to allow the helices, or coils, of the electro-magnet to pass through them without being fastened. The rear, or yoke end of the magnet is upheld by a passing through, and supported by, a brass pillar "B" fastened to the base. This contrivance imparts a forward and backward movement to the electro-magnets through a small distance horizontally. In front of the poles of the magnet is the soft iron armature attached to a lever, the lower end mounted upon a steel arbor, turning between two adjustable set screws mounted upon standards projecting from the lower part of the frame.

The armature and the lever have a to and fro movement upon the axis. In one direction from the attraction of the electro-magnets, and in the other from the retractile force of the spring "C." The movement is slight, confined in one direction by the adjustable screw stop "D," and in the other by another screw stop "E." By means of a hook at one end of the spring "C" is attached to the lever, and at the other end to a thread which winds upon a spindle "F" to which a milled head is attached.

The spindle is mounted upon one end of a brass rod which moves through a pillar and is rendered adjustable by means of a set screw.

The electrical connections of the Relay are as follows: On the base are two binding screws or posts, for the attachment of wires, two being known as main binding posts and the remaining two local binding posts.

The insulated wires leading from the electro-magnet pass through the base, beneath which they are connected to the two right hand, or main line binding posts. The current enters at one binding post, passes through the electro-magnet and goes out through the other binding post.

As before stated, the principal function of the Relay is to open and close the local circuit to which the local sounder is connected. To effect this the armature lever is insulated from the frame by a bushing of hard rubber inserted between the lever and the axis upon which it turns. A wire runs beneath the base, from one of the local binding posts, and is connected with the lever of the armature, being attached to it just above the axis.

When the armature is attracted by the magnet a platinum pin near the top of the lever strikes upon a corresponding platinum point inserted in the end of the adjustable screw "D." The stop "D" is electrically connected with the frame, and this is in turn connected with the remaining local binder post by a wire passing underneath the base.

Whenever a current traverses the main circuit it enters the magnets of the Relay, attracting the armature and armature lever, bringing the platinum points in contact, and closes the local circuit. When the main current ceases the magnets are instantly de-magnetized, and the armature is drawn back by the retractile spring separating the points and opening the local circuit. Thus the Relay acts upon the local circuit exactly as the Key does upon the main circuit, opening and closing it in the same manner.

Adjustment of the Relay—The adjustment of the Relay are of two kinds:

1. The adjustment of the to and fro movement of the armature.

2. The adjustment of the opposing action of the magnet, and of the spring upon the armature.

The first adjustment is accomplished by means of the screw stop "D," which is movable. The space between the platinum points should be about 1-32 of an inch, and, if the current is weak, as much closer as possible. Ordinarily when this is once adjusted no change is necessary.

The second adjustment requires considerable skill and experience. When the attraction from the magnet is very strong the armature does not act quickly when released, and the tension of the spring may be increased by turning the milled head. If this does not accomplish the desired result, by turning the screw "B" the action of the electro-magnets upon the armature may be reduced by moving the magnets further away from the armature.

The Sounder—The essential features of the Sounder are an electro-magnet "A," together with

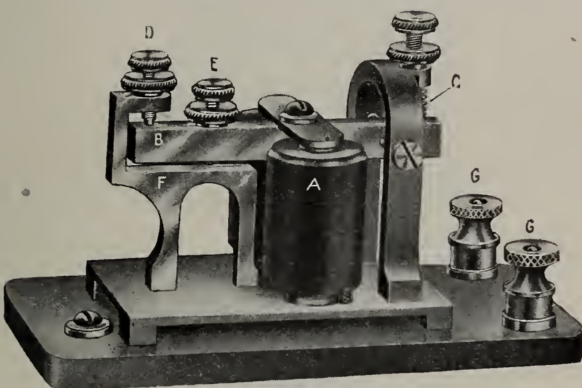


Fig. 18
SOUNDER.

an armature fastened to a very heavy movable lever "B," mounted on trunnions between set screws, in a manner similar to the Key. A spring "C" attached to the lever is designed to draw the armature away from the magnets. Also two other set screws "D" and "E" forming adjustable stops which limit the motion of the lever in each direction.

When the current passes through the magnets the armature is attracted and strikes against the sounding post "F." When the sounder is fastened securely to a table this vibration is communicated to the table, which acts to some extent as a sounding board.

When the Morse telegraph was first invented a register was used by which the signals were indicated upon a moving strip of paper, by means of a lever, to which a pen or pencil was attached. Operators soon noticed the dissimilarity of the various signals used and learned to interpret the message by the sound.

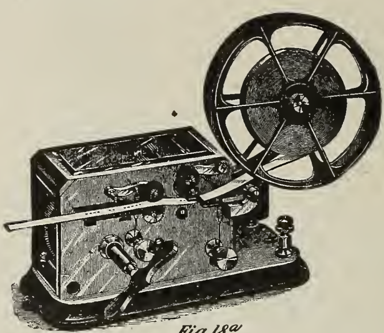


Fig. 18a

REGISTER.

Gradually the register was done away with, until now they are rarely used.

It will be noticed in practice that there is a difference between the "down" and the "up" strokes. The "down" stroke indicating the length of the signal, whether a dot or a dash, and the "up" stroke the interval between the signals. One soon learns to distinguish between them and thus a substantial advance has been made by the student.

The Sounder is provided with two binding posts "G," by which it is connected with the local circuit. The wire passes from one post to the Relay, and from the other post to the local battery.

The adjustment of the Sounder is less difficult than that of the Relay. The trunnion set screws should be adjusted so that the lever will work freely without binding. The set screw "E" should be adjusted so that there will be a space the thickness of a sheet of paper between the armature

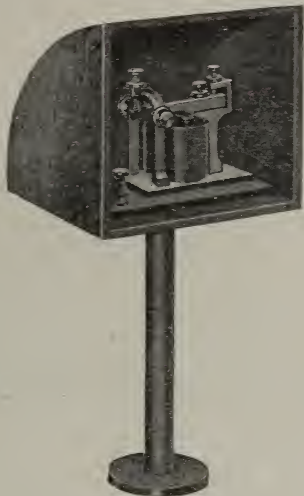


Fig. 19

RESONATOR.

and the magnets. The stroke is adjusted by means of the screw "D," the spring "C" being tightened until the up and down strokes appear about even. As the ear becomes educated to the sounds this is readily determined.

When there is a great deal of noise in a room the sounder may be placed in a resonator, illustrated in Fig. 19. This is found to be a great aid to the operator, as it can be provided with a movable base and moved about on a table at will. will.

The Box Relay—Another instrument frequently used in telegraph offices is the combination set, or box relay and key.

This instrument is provided with powerful electro-magnets enclosed in a wooden box, the resonance of which greatly increases the sound made by the strokes of the armature lever, which strikes against a screw point attached to the box.

This instrument, being complete in itself, is very convenient for the use of line repairers, or for

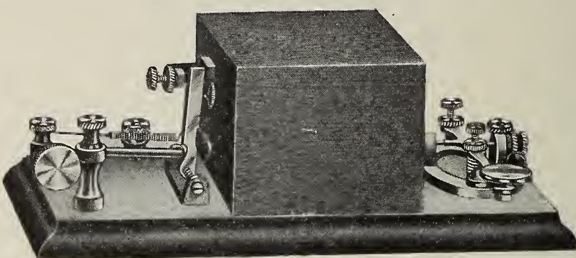


Fig. 20

BOX RELAY.

establishing temporary offices in case of accidents, as it can be worked directly by the main line current, no local battery being needed.

The box relay is provided with four binding posts arranged as in the ordinary relay. If desired it can be connected with a local circuit and made to operate an ordinary sounder. Its adjustment is similar to the relay.

Cut Outs, Switch Boards and Other Devices—In addition to the instruments already described several other mechanical contrivances are usually found in telegraph offices, viz.: Switches or Cut

Outs, Switch Boards, Ground Wires and Lightning Arrestors.

The Cut Out is a device by means of which the instruments may be entirely disconnected from the main line, without breaking the circuit for an

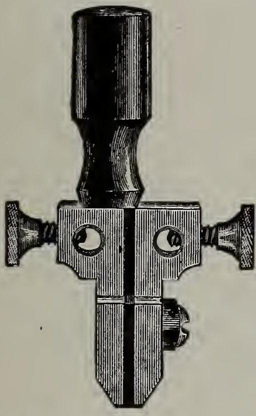


Fig. 21

WEDGE.

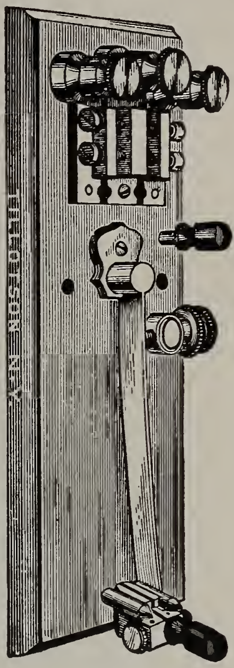


Fig. 22

SPRING JACK AND WEDGE.

instant. In small offices, what is known as the Wedge or Spring-Jack cut out is used.

The line wires are connected with the elastic brass strip by a wire from one of the binding posts, running in under the base-board. The other binding post has a similar connection with the pin at the bottom of the board.

The instrument wires are fastened to the switch wedge or plug. When the wedge is inserted between the two pins at the bottom of the board, the brass strip is separated from the stationary pin, causing the current to go through the instrument wires. When the wedge is pulled out the spring

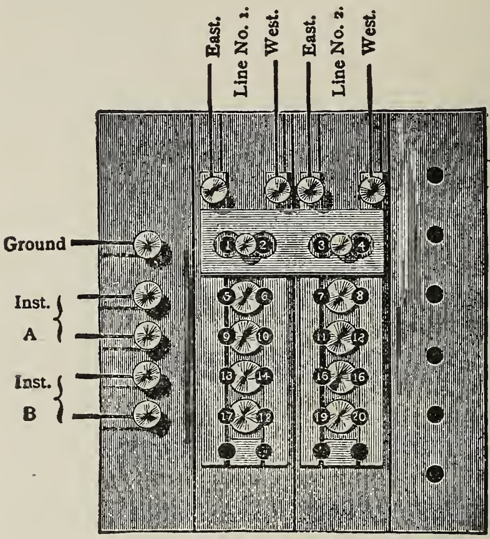


Fig. 23

TWO-LINE UNIVERSAL SWITCH.

shuts against the pin and keeps the main circuit closed.

The Cut Out is inconvenient for use in an office which is provided with more than one main line wire from the fact that wires cannot be interchanged without disconnecting them, which takes time; therefore nearly all offices are provided with switch boards.

The switch board shown in the illustration is designed for use in offices having but two main line wires, and is called the Peg Switch. It is so called from the metallic plug used to make connections. Where many wires enter an office a larger switch board is used, as the convenience of the service requires that all the wires entering an office should go to the same switch board.

By means of the Switch Board various combinations may be made. During stormy weather new circuits may be formed by patching parts of different wires together and making one continuous circuit, where possibly no one wire is working clear through at the time.

The accompanying diagram shows the connections and construction of the Switch.

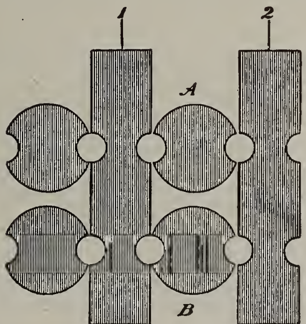


Fig. 24

CONNECTIONS AND CONSTRUCTION OF SWITCH.

"1" represents a metallic bar, or strip, upon the switch, to which is connected a wire running into the office. To bar "2" is attached the same wire going out of the office. "A" and "B" are metallic discs, or buttons, to which are attached the instrument wires. All the discs in the same horizontal line are connected together at the back of the switch board.

To place the instrument in the circuit pegs should be put in the holes at "A1" and "B2," the course of the current will then be from the line "1," through the peg connection at "A1," through the instruments to the peg connection at "B2," and out through the wire "2."

At the terminals ground wires are kept connected with the main lines all the time in order to complete the circuit. But at intermediate points the ground wire should only be used to test the wire, and should not be kept connected except by instructions from the proper source.

The Lightning Arrestor, or as it might be called, the Lightning Deviator, is usually combined with the Switch Board. It is a device for protecting the instruments from a heavy charge of electricity during thunder storms, or from powerful currents from electric light wires which sometimes become crossed with telegraph wires. On most Switch Boards it is placed at the top of the board in the form of a large disc, each disc covering two strips. They are connected with the ground wire, and are placed very close to the strips, but do not touch them.

The ordinary current of electricity employed will not be diverted, but a heavy charge of atmospheric electricity will jump the little space between the strips and the disc, and take the short cut to the earth, thus preventing injury to the instruments, which otherwise might be ruined. It will not always prevent injury, however, and the best plan is to cut out all the instruments at night when leaving the office. This is done by inserting pegs in the bottom row of holes on the Switch Board.

The instruments described are those to be found in common use in telegraph offices and are those which operators must be familiar with. There are other instruments used in large offices, such as Galvonometers and Rheostats for testing and measuring currents. These instruments are used only by the expert known as the wire chief, and operators never, as a rule, have occasion to use them.

Other devices, such as the Wheatstone instruments, for transmitting messages from strips of perforated paper, are used.

Duplex Telegraphy—Among the improvements of the telegraph are the duplex instruments by the use of which two or more messages may be sent over one wire at the same time.

Thus the capacity of a wire is multiplied.

The ordinary relay cannot be used in connection with the Duplex telegraph, as an instrument must be used that will respond only to signals from the distant station and remain unaffected by signals from the home station.

For this purpose a relay is used having its "helices" wound in opposite directions, so that equal currents passing through it equalize each other.

In connection with this a resistance regulator called the "Rheostat" is used. This when properly adjusted will act upon one wire of the relay in such manner that the current through the other wire of the relay will cause it to respond to the distant signal.

An especially constructed transmitter is also used, so made that when the key is depressed it is in contact with the battery, and when elevated with the ground.

By this means the wire is never "open," but is always in readiness to be operated from either end.

The transmitter also acts as a sounder to the sending operator, who being accustomed to the sound of his own sending needs this as a guide when transmitting.

The above method of operating the duplex is known as the "differential method."

To those who wish to familiarize themselves with the more abstruse and specialized subjects connected with the application of electricity to telegraphy, knowledge not necessary to a telegraph operator, the higher technical books on the subject should be sought and mastered.

Arrangement of Instruments in Local Offices—In Figure 25 but one set of instruments is used, this being the simplest combination possible. This consists of the Key, Relay, Sounder, Switch Board, Local Battery and the wires connecting the different instruments. The Key, Relay and Sounder should be placed upon a table about two feet wide and three or four feet long. The Key should be placed at the right, back from the front of the table so that the elbow may rest upon the table when the fingers touch the button of the Key. The Relay should be placed at the left side of the table and the Sounder between the two as shown in the diagram.

The Switch Board should be upright upon the wall in any convenient place and the two jars of the local battery in a box under the table.

When the main line wires are brought into the building they are connected to insulated office wires which lead to the two binding posts of the switch board 1 and 2. The wires from the instru-

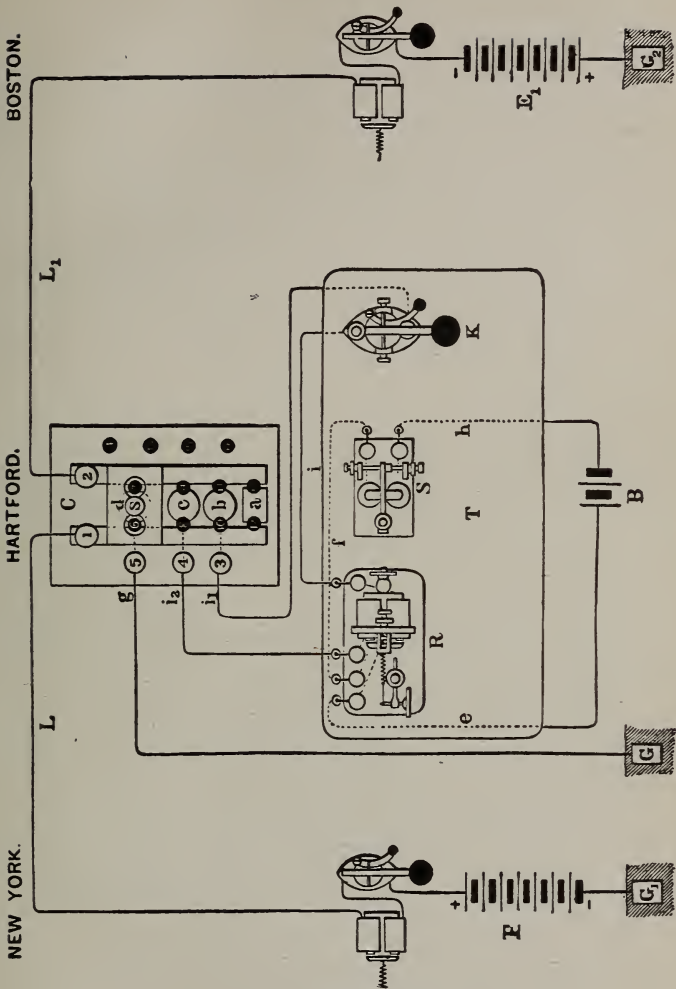


Fig 25

ARRANGEMENT OF INSTRUMENTS IN LOCAL OFFICE.

ments are attached to the switch board at posts 3 and 4.

The connections are made as follows: The wire attached to post 3 is carried down the wall and under the table and fastened to one of the legs of the key. The wire from post 4 is fastened to one of the main line binding posts of the relay. Another wire leads from the other main line binding post of the relay to the other leg of the key.

Now if pegs are inserted in the switch board at holes 8 and 11, the current will flow from the main line wire 1 through the instruments and out at wire 2, thus forming the main circuit.

The wires of the local circuit run as follows: One wire from one pole of the battery to one of the local binding posts of the relay; a wire from the other pole of the battery to one of the binding posts of the sounder; another wire from the other post of the sounder to the remaining local binding post of the relay, thus completing the local circuit.

It has already been explained how the relay works the sounder through the local circuit.

Another wire fastened to the switch board at 5 is called the ground wire from its leading to the ground or forming a ground connection as already explained.

To cut out the instruments: Insert pegs in holes 12 and 13 and remove pegs from the other holes in the board. The current will now run into the switch board at 1, down the plate to 12, across to 13 and out of the switch board at 2.

To cut in the instruments: First insert pegs at 8 and 11, or 9 and 10 (either way will answer), then remove the pegs from 12 and 13. In this manner the instruments may be cut in without interrupting the circuit.

The peg holes 14 to 17 are for extra pegs or for pegs not in use.

To ground the wire, insert a peg at 6 or 7. This is sometimes necessary to locate breaks in the main wire. If no circuit can be obtained by grounding either way, the wire is either open on both sides or, what is more likely, the break is in the wires of the office. This can be determined by carefully going over all the connections; thus binding screws sometimes work loose and allow the circuit to open, or other mishaps occur.

CHAPTER IV.

INSTRUCTIONS TO STUDENTS; THE MORSE ALPHABET; FIRST EXERCISE (i. e., FIRST LESSON FOR NEW BEGINNERS); EXERCISES NO. TWO, AND SO ON UP TO AND INCLUDING EXERCISE NO. TWELVE; RECEIVING MESSAGES; PENMANSHIP; RECEIVING ON THE TYPEWRITER; GENERAL SUGGESTIONS.

Instructions to Students—In taking up the study of telegraphy the student must remember that to become an expert operator requires time and an unlimited amount of patience and practice. Telegraphy can be mastered by any one with ordinary intelligence. Like any other trade, if the student has a good education to begin with, he is that much better fitted for the work.

The beginner will not require a regular main line outfit to learn with. Most electrical concerns manufacture what are called learners' outfits, consisting of a key and sounder on one base, together with a single jar for the battery.

The key and sounder are connected by fine wires under the base. Connection with the battery should be made by running wires from each pole of the battery to each binding post of the combination outfit.

If two are learning at the same time, which is advisable, if practicable, two instruments can be used, placing them in one circuit. This can be done by running a wire from one pole of the battery to a binding post of one instrument, and another wire from the other pole of the battery to a binding post of the other instrument, connecting the remaining posts of each instrument by another wire—thus completing the circuit.

A single jar or cell of battery will be sufficient for one instrument, but another cell should be added to the battery for each instrument added to the circuit.

Telegraph signals are formed by the manipulation of the key, the operation of which is called sending. When this is done in connection with the battery and other instruments, audible signals

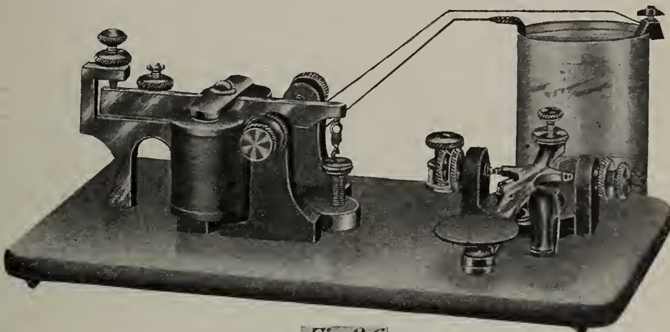


Fig. 26.

LEARNER'S OUTFIT.

are made by the receiving instrument. These signals having been arranged in the form of a code or alphabet, we are thus enabled to transmit intelligence to distant points.

The most approved manner of holding the key is to place the first finger on the knob or button so that the end of the finger will rest on the opposite edge of the knob, allowing the thumb and second finger to support it on each side of the button.

The key should be held firmly but not rigidly; let the arm rest upon the table near the elbow. The motion in sending is up and down, there being no side motion whatever. The movement is produced principally by the wrist, the fingers and hand being perfectly flexible. The student

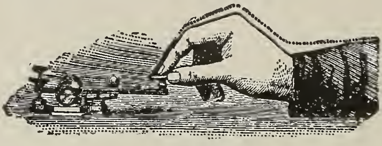


Fig. 27

POSITION AND MOVEMENT.

should not attempt to send by using the muscles of the fingers only, or by tapping the key, for these muscles soon tire. The most expert senders are those using the wrist movement; the hand, wrist and arm moving uniformly in the same direction, up and down.

The Morse Alphabet—The Morse alphabet or telegraphic code is made up of combinations of dots, dashes and spaces. Many have the idea that the code is formed of dots and dashes only, but it will be found that the spaces are of equal importance.

The following table will enable the student to more clearly understand the relative value of the dot, dash and space, based upon the dot as a single unit of time.

The space between the elements of a letter is equal to one dot.

The dash is equal to two dots.

The letter space is equal to two dots.

The word space is equal to three dots.

The long dash is equal to four dots.

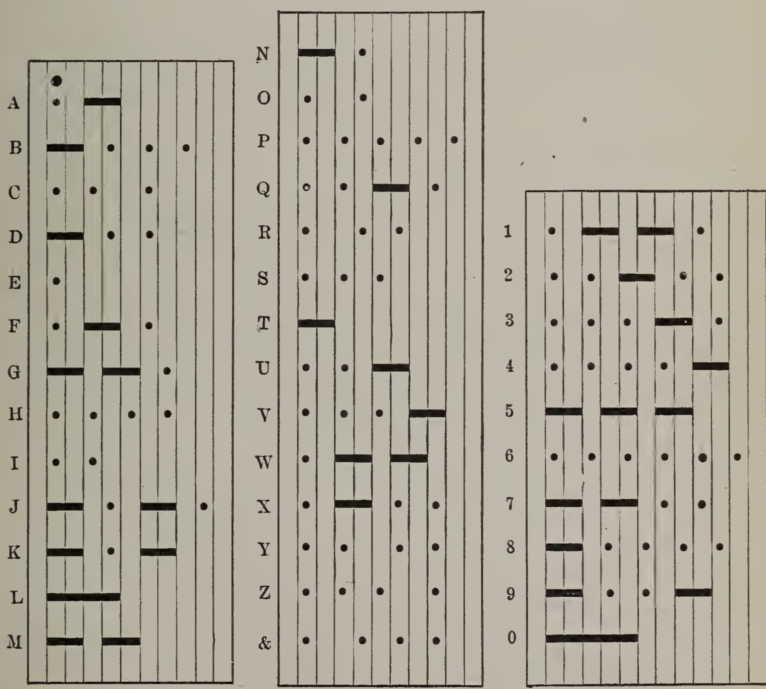
The sentence space is equal to six dots.

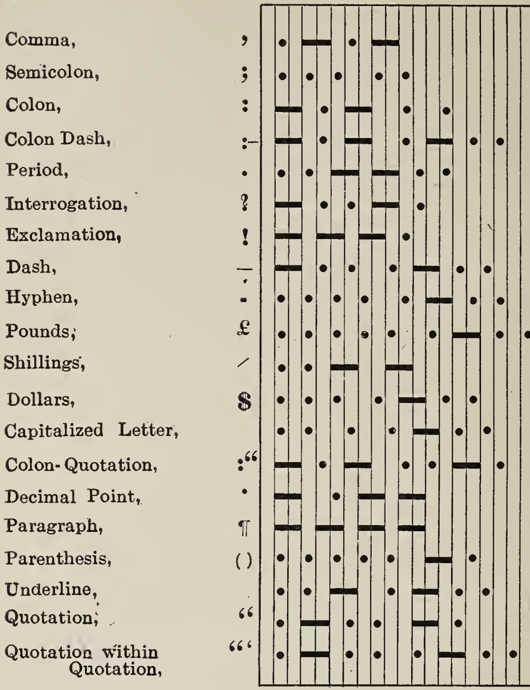
The dot or unit of time in the alphabet is produced by a quick downward movement of the key, followed by a quick upward movement.

The dash is made by holding the key closed (down) twice as long as in making the dot.

The space is produced by the upward movement of the key, the space between the parts of a letter being equal to the time used in making a dot. A longer space, one equal to two dots should be used between the letters, and a still longer one, equal to three dots between words. Great care should be taken in spacing, otherwise the sending will be disjointed.

THE MORSE ALPHABET.





First Exercise—The beginner should first learn to make dashes, starting at the rate of about one per second and gradually increasing the speed to three per second. The upward movement between the dashes should be made quickly, so that the interval between the dashes will be very short, the tendency being to make the space too long.

Second Exercise—Next he should learn to make dots. Try and form the habit at the very beginning of making them like short firm dashes, avoiding the tendency to clip them too short and light. Make them slowly and at regular intervals, practicing until the speed can be increased to about 300 per minute.

The ticking of a clock will be found a good guide to uniform sending.

While the beginner is practicing dashes and dots he should memorize the alphabet, learning all the letters, numerals and principal punctuation marks, viz., the period, comma and interrogation point. The other punctuation marks are little used by the student and can be learned later.

The characters of the alphabet should be so thoroughly impressed upon the mind that the student's entire attention can be devoted to the mechanical movement of producing the given signals when the time comes to practice them. They should be memorized without regard to their position in the alphabet and should be practiced upon the key in like manner.

It will be found easier to remember them if they are memorized in the order given in the lessons for practice, memorizing them in this manner—

B dash, three dots.
R dot, space, two dots.
9 dash, two dots, dash.

After having become proficient in making dashes and dots the other exercises may be taken up in their order.

Third Exercise—Dash Letters.

T.	M.	5.	L. or Cypher.
—	— —	— — —	———

The L or cipher should be twice the length of the T. Care should be taken not to make the final dash in the M or 5 too short; they should be of uniform length.

Fourth Exercise—Dot Letters.

E.	I.	S.	H.	P.	6.
.	. .	. . .	. . . .	. . . . .	. . . . . .

Make the dots of equal length and practice each letter separately until the correct number of dots can be made, avoiding the tendency to prolong the final dot into a dash. Take particular pains to make exactly five dots for the letter P, and six dots for the figure 6. Many otherwise good operators have trouble with these two characters, making six or seven dots for the P, and an indefinite number of dots for the 6.

Fifth Exercise—Dash followed by dots.

N.	D.	B.	8.
— .	— . .	— . . .	— . . . .

Do not allow too much space between the dash and dots, making TE of N.

Sixth Exercise—Dots followed by dash.

A.	U.	V.	4.
. —	. . —	. . . —	. . . . —

Avoid too much space between the dot and dash, or making the dash too short.

Seventh Exercise—Spaced Letters.

O.	R.	C.	Y.	&.	Z.
. .	. . .	. . .	. . . .	. . . .	. . . .

The greatest care is necessary in making these spaced letters. The space used should be double that used between the parts of a letter and just sufficiently long so they will not be confused with I, S, and H.

These letters, when combined with others into words, are the cause of more errors in transmission than any other characters, and great pains must be taken to produce them correctly.

Eighth Exercise—Dash followed by dots and dashes.

G.	7.	K.	J.	9.	?.
— — .	— — . .	— . —	— . — .	— . . —	— . . — .

To most learners K and J are the most difficult characters in the code. Avoid separating the J by a space into double N, or the K into NT. Make them compact and uniform. The 7 and 9 are also found difficult by some.

Ninth Exercise—Dot followed by dashes and dots.

W.	F.	X.	1.	
. — —	. — .	. — . .	. — — .	. — . —

The danger here is in making the W sound like AT, and the X like ED. Learn to form them compactly.

Tenth Exercise—Dots and dashes mixed.

Q.	2.	3.	•
. . — .	. . — . .	. . . — .	. . — — . .

Eleventh Exercise—Additional punctuations.

Colon :	Semi-Colon ;	Exclamation !
— . — . . .	. . . . .	— — — .

Paragraph ¶	Parenthesis ( )	Dollar Sign $
— — — —	. . . . . — .	. . . . — . .

It will be noticed that the dollar sign is really the letters SX.

Twelfth Exercise—Fractions are made by substituting a dot for a hyphen between the figures.

1-2	2-3	3-4
. — — . . . . — . .	. . — . . . . . . — .	. . . — . . . . . . —

7-8
— — . . . — . . . .

The student should practice the foregoing exercises carefully until he is thoroughly proficient in them, and able to make any letter at will. After that he should practice making words. It will be found beneficial to make the same words over and over again. If a mistake is made always go back and correct it.

Send slowly and carefully. Cultivate a firm, correct style of sending. Remember that the speedy, careless sender will dispatch less business than the slow, even sender. Send accurately, and speed will come in time by practice. There are few operators who can send forty words per minute and keep it up. The man who can send twenty or twenty-five words per minute and keep up an even speed will accomplish much.

Receiving Messages—When the student has mastered the art of sending accurately and thoroughly memorized the alphabet, he should take up the more difficult task of learning to read by sound. This will be found to be very difficult at first, and as one cannot read by sound from their own sending, it will be necessary to get another person to do the sending. Thus great benefit may be derived by two beginners practicing together. If the student is learning alone, he should arrange with some experienced operator to send for him, a little each day.

It will be necessary to learn the sound of each letter separately. Then learn to read short words, and finally sentences, after the manner of learning to send.

In reading by sound the downward and upward strokes of the lever must both be taken into consideration. The down stroke is the beginning of the dot or dash, the sound of the up stroke denotes its termination. Without the back stroke the duration of the down stroke could not be determined, and the letters E. T. and L. would all sound alike.

When the student can read words by sound let him commence to copy them as sent, with pen or pencil. If a word is missed, or not correctly received, open the key (break), repeating the last word received correctly. Never be afraid to "break," as this is termed. Remember that when a position as operator is obtained it will be necessary to receive messages correctly. Better a dozen breaks than one error.

At first the student will be obliged to copy each word, almost each letter, as quickly as it is sent; but gradually he will be able to linger a word or two behind; and as he becomes more expert, several words behind the sender. The advantage of this is that the receiver gets the connection between the different words, and the sense of the message, and is less liable to errors. When he has learned to send, and can receive slowly, it then becomes purely a question of application, of time and incessant practice. If a telegraph office is near it would be well to arrange for the privilege of studying there. In that case, the student would not be allowed to handle the main line instruments perhaps, but could copy whatever was going over the wires. He might at first be able to write but one word in ten, but would gradually receive more and more.

The student should always be ambitious to become a first-class operator, never second-class, or, what is worse, a "plug," as poor operators are called.

Penmanship—It is especially important that the telegraph operator should write a legible hand. He should cultivate a round, plain, business hand. The ordinary business man receiving a message does not care for an ornamental piece of work, but a plain, business handwriting that can be readily made out.

Attention to the following rules in regard to writing is recommended:

1. Capital letters should not be joined together, or joined to smaller letters.
2. Avoid looping the capital T at the top, making Twenty look like Seventy.

3. Make the capital H in such a manner that it will not be mistaken, and called A.

4. Use care in making the capitals I and J so that they will not be confused. Capital I should be above the line, and capital J should extend through it.

5. The letter Q should not be made like a 2. This is especially dangerous in a cipher message.

6. Avoid all eccentric forms of writing. Cultivate a plain, business hand.

Receiving on the Typewriter—It is probable

Fig. 28

TYPEWRITER.

that in time the typewriter will be used generally in receiving messages.

Learning to use it is not not difficult, and when the art is acquired it is every way preferable to the pen for receiving messages.

Moreover, in its use one or more copies may be taken by using carbons, and this with greater ease and plainness than with a pen or pencil.

At many points operators will not be given employment unless they know how to operate the typewriter. This discrimination will extend and widen with the passing of time.

General Suggestions—Many who take up the study of Telegraphy have a very inadequate idea of the proper qualification necessary to become a good operator. Their idea seems to be that the ability to send and receive messages correctly is all that is necessary. While this is the first requisite, much more is required if the operator would make himself valuable to the company employing him. He should have a good education, or, if not, should study till he possesses it. He should be upright and honorable, so that he will command the respect of his employers and the community.

In his intercourse with the public, and with fellow employes he should be courteous and pleasant. It should be remembered that telegraphy may be made the stepping-stone to many other positions.

His general health should be good, and his eyesight and hearing must be faultless.

CHAPTER V.

RULES AND REGULATIONS GOVERNING COMMERCIAL BUSINESS; MESSAGES; STANDARD RULES OF COMMERCIAL TELEGRAPH OFFICES; RAILWAY TELEGRAPHY; MOVEMENT OF TRAINS BY TELEGRAPH; ABBREVIATIONS IN RAILWAY TELEGRAPHY.

For the information of students seeking to inform themselves in regard to telegraph matters it may be said that the commercial telegraph business of the world is done by companies organized for that purpose and controlling many thousands of miles of wire. They have offices in practically every town and from these are sent and received millions of messages each year. Much of the important business of the world is done by telegraph. In addition to this myriads of personal and social messages are annually transmitted. The telegraph is also used by the great news gathering agencies of the world, and to them we are indebted for immediate knowledge of current events.

More messages, it is claimed, are sent per capita in England than any other country; the United States is said to be second.

In small towns and villages the commercial business is usually handled at the railroad stations, arrangements being made for the railroad operators to handle the messages. The same rules apply to the handling of messages in these offices as in those devoted exclusively to commercial business.

In cities the commercial telegraph office is located in the business portion of the city, convenient to patrons. The office is in charge of a manager who exercises jurisdiction over its affairs.

He is, however, not allowed to sell or otherwise dispose of any property belonging to the Company or to make any expenditures without authority.

The manager is responsible for the cash receipts of his office. He either deposits them under orders in some designated bank or remits them directly to the Treasurer, at stated intervals. Receipted vouchers for authorized expenses incurred are forwarded by him to the proper official with his monthly report.

Salaries are usually paid monthly, at the close of each month, either by deductions from the receipts of the office, or by payment directly from the office of the Treasurer, as may be directed.

Messages—Messages received for transmission must be written upon the printed forms provided by the Company for that purpose, or if that is impracticable, must be pasted upon the form beneath the printed contract.

Messages are, in technical phrase, divided into five parts, viz., "check," "date," "address," "body of message" and "signature." The check shows the number of words subject to tariff, states whether paid, collect or free, and if free, why. Also any special instructions, such as "Report delivery" or "Delivery charges guaranteed."

The "date" follows the check, and gives the name of the originating point of the message and the date.

The address shows the name of the person or firm to whom the message is to be delivered, with street and number, and name of city. The body of the message is embraced between the address and the signature. Following the body of the message is the signature of the person or firm sending the message.

The words to be counted and charged for are the words in the body of the message; all words in an extra date; all extra words in address; when there is more than one signature, all except the last; all words after the signature which are not title words. In collect messages the word "collect" in the check will be counted but not charged for. For example, the check of a ten-word message if paid, will be 10 paid, but the check of a ten-word collect message will be 11 collect. This enables the operator to detect errors in transmission.

The rates charged for transmitting ordinary commercial or social messages vary according to the distance from the sending point, and are determined by referring to the tariff or rate sheet which is provided at each office. Rates are based on a minimum charge for ten words or less, and an additional charge for each additional word over ten. Thus when that rate for ten words is $.25, the rate for each additional word is $.02. In this case the charges for a fifteen word message would be $.35. The rates charged for ten words or more increase somewhat in proportion to the distance. For example, $.25 and $.02, $.40 and $.03, $.60 and $.04, $.75 and $.05.

Messages to many points can be sent at night at reduced rates with the understanding that they will not be delivered until morning. These are called "Red" or night messages, blanks printed in red ink being provided to distinguish them from day messages.

Government and press messages are usually transmitted at special rates.

When a message is accepted for transmission, the receiving clerk or manager should see that a sufficiently clear address is given so that there will be no difficulty in delivering the message. Messages must not be accepted with two addresses, for instance, "if absent forward to." Delivery will be made only to one address. The address of the sender should be secured to effect prompt delivery of replies.

All messages should be prepaid except answers to paid messages, answers to "D. H." messages, and messages sent free on account of frank or pass held by sender.

The charges for the message are based on the number of words in the body of the message, being that portion between the address and the signature. If the message has more than one signature all but the last one is counted and charged for. Titles following the signature, not exceeding two words, are not charged for, thus, Gen. Supt., Chief Police, Manager, Chairman, President, Cashier, etc. When extra words follow the signature as, for instance, the address of the sender, the extra words must be counted and given in the check.

Names of cities or town when used in the body of the message are counted as one word. Example, New York, New Haven. Names with a prefix such as O'Brien, McBride, Van Duzen are counted as one word. Such common words as to-day, to-morrow, tonight, any thing, every-body are counted as one word. Each initial in a message is counted as one word, and figures are counted as one word each. Figures should be written out in words to avoid danger of errors in transmission.

All messages are to be treated as strictly confidential, and no information given to anyone concerning their contents except under orders. Too much care cannot be exercised in this respect.

Each message should be numbered, and each day's business carefully filed and retained until such time as the rules direct that they shall be disposed of.

At the end of each month a report is made showing the amount of business sent and received, with each office, and the amount of charges, whether paid or collect.

An error sheet or notice of errors is made in the Auditor's office and forwarded to the office in fault when errors are found in auditing the reports.

In accepting messages for transmission they should be read over carefully in the presence of the sender and care taken to transmit them exactly as written. Obscure words or those infrequently used should be transmitted slowly and carefully. Speed in sending must be sacrified to insure correctness.

Example of message received for transmission:

New York, Aug. 4, 1903.

J. D. Jones, Grand Pacific Hotel, Chicago, Ill.:
Will meet you at hotel at ten o'clock Monday morning.
S. B. Smith.

As transmitted:

No. 1—B. 10 paid (from) New York 4 (to)
J. D. Jones, Grand Pacific Hotel, Chicago, Ill.:
Will meet you at hotel at ten o'clock Monday morning.
(Sig.) S. B. Smith.

The "from," "to" and "Sig." are not copied by the receiver.

When the operator is through sending a message or messages, the receiving operator acknowledges the receipt by responding "OK", adding his initials and office call. If the "OK" is not received the message is not considered as sent.

The number, time of sending, office sent to, and initials of sending and receiving operators is to be endorsed upon the message at time of sending. This is usually done with the left hand while sending with the right. The receiving operator will also show this upon the message.

Example of office message:

If Mr. Jones cannot be found at the Grand

Pacific Hotel, the Chicago office will send the following message to New York:

To New York—

Your No. 1 today Jones, signed Smith, cannot find at Grand Pacific. Chicago, 4th.

To this New York might reply:

To Chicago: Try Palmer House my No. 1 Jones signed Smith today. New York 4.

In transmitting messages to repeating offices the sending operator should prefix the message with town or city to enable the operator to copy in proper blank.

The following prefixes are used to indicate the kind of message to be sent:

Govt.—Government message.
Red.—Night message.
C. N. D.—Stock message.
Special—Press message.
Ofs.—Office message.

All messages are numbered each day; the sending office numbering in rotation the messages sent to each office, a different set of numbers being kept with each office. If more than one circuit is worked between two offices a separate set of numbers is kept for each, each day's business being numbered separately, commencing with No. 1.

When messages are to be delivered at some distance from the receiving office, requiring special delivery service, the words "Deliver and report charges," if charges are to be paid by the sender; or "Delivery charges guaranteed," if charges are to be paid by the receiver, should be inserted in the check of the message, and the same counted and charged for.

Messages for transmission by cable should be written on cable blanks. In counting and charging for cable messages, the only part of message sent free is the name of the place from and date. Count and charge for address, message and signature. Hyphenated words are counted as two words and the maximum length of a chargeable word is fixed at ten letters. The name and address of the receiver must consist of at least two words, and the body of the message must contain at least one word. All cable messages are repeated back to insure correctness. Charges are based upon a tariff per word.

Standard Rules Governing Commercial Telegraph Offices—For further and more minute particulars governing commercial business—paid for and free—including the rules and regulations governing the receiving, handling and sending of messages, the care and management of offices, collections, accounts and returns, students and others, who desire to inform themselves in regard to such matters, are referred to the chapter elsewhere herein giving the rules and regulations of Commercial Telegraph Companies, and this at needed length and with great particularity.

Railway Telegraphy—As the traffic on railroads increased the difficulty of making a schedule sufficiently flexible to allow trains to move freely under every emergency became at once apparent. Hence the application of telegraphy to the operation of railway trains and the elaborate system of rules and regulations governing the same.

The telegraph department of railways is under the charge of a Superintendent of Telegraph, who has charge of all the electrical business of the railway company. Operators are usually appointed by the Chief Train Dispatcher of the different divisions, subject to the approval of the Division Superintendent and Superintendent of Telegraphy. Office hours for operators are usually from 7 A. M. until relieved by the Chief Dispatcher, or at points where there are night offices from 7 A. M. to 7 P. M. days and from 7 P. M. to 7 A. M. nights. Each operator is required to report for duty promptly and remain until relieved by his colleague or the train dispatcher.

Where there is no night office, day operators are required to post their place of residence in bill boxes or in the window of the office so that train men may know where they can be found in case of emergency. Operators when on duty can not go out of hearing of their call instrument or leave the office without permission from the Chief Dispatcher. When it does not interfere with their duties as operators they are expected to assist the station agent.

Contention for circuit (the right to use the wire) is not permitted, and operators who follow such practice after being cautioned are dismissed.

Operators are required to be familiar with switch boards and cut-outs so that they can connect or disconnect wires as directed by the testing operator.

Operators are expected to familiarize themselves with the rules of whatever Commercial Telegraph Company operates on the wires and must be governed by them.

Messages for officials should be inclosed in envelopes for delivery and must not be read or handled except by those to whom they are addressed.

All instruments, switch boards, cut-outs, etc., should be kept in good order.

Instruments should not be changed without instruction from the Superintendent of Telegraph.

Telegraph students are not permitted to send or receive messages except under the direct supervision of the regular operator.

Students should be instructed in the rules of the company, especially those regarding the privacy of business.

Railway messages are much less formal than commercial messages. Abbreviations are used for addresses and signatures. The words are not counted and checked and frequently the date is left out.

All messages except those pertaining to the business of the railroad are considered as commercial messages, and should be handled as such, subject to the rules and regulations of the Commercial Telegraph Company.

At points where there is a city office established by the Commercial Telegraph Company it is customary for the railway operator to handle only such commercial messages as are tendered him by passengers, the receipts for which he turns over to the local manager. Where there is no city office the day operator acts as manager and is held responsible for the commercial business transacted at his office.

At many stations on railroads, operators are required to report the time of all trains passing their office in each direction.

Detailed car reports are also transmitted by wire at some designated time each day.

In order to avoid danger of accidents from variations of clocks and watches, it is necessary that some standard time should be maintained upon all sections of a road. In order to do this nearly all railway companies arrange to receive time signals from some observatory. This is done by making telegraphic connections with the observatory clock so that the circuit is broken and closed at each vibration of the pendulum.

If time is to be received at 10 A. M. the Wire Chief before the appointed minute connects all wires with the observatory wire and calls "time," at which signal all business ceases. At or about 9.58 he completes the circuit and the seconds are beat consecutively until ten seconds before ten o'clock, at which time the circuit remains open, closing at precisely the hour. In this manner the clocks in the different offices are regulated daily.

Movement of Trains by Telegraph—Operators and telegraph officers of railway companies are expected to familiarize themselves with the rules and regulations relating to and governing the movement of trains. They are also expected to keep the train order signals and other similar apparatus in order at their stations.

In this connection, I may say that the movement of trains by telegraph orders dovetails with the standard regulations of railroads governing their train service. Therefore, students and others seeking information in this direction should study the rules and regulations governing the movement of trains at the same time and as a whole. For this reason I have not attempted to embody the rules and regulations governing the movement of trains by telegraph orders here. To those who would familiarize themselves with the intricate and important details governing the movement of trains by telegraph, I would respectfully refer to "Train Service," one of the volumes of the "Science of Railways Series." In the book in question particulars (that is, the rules and regulations) governing operators, trainmen and employes generally, are stated at great length and with due reference to the intricacies and needs of the service—and consecutively and in order of their just relations to each other. This for both double and single tracks.

The information in question, while in no way needed by the student who is simply learning to operate the telegraph, is necessary to those who seek to enter the service of railroads. It explains the workings of the train service, and while the rules and regulations of railroads in this respect are not more uniform than they are in others, nevertheless, familiarity with the practices of one company renders it easy to acquire knowledge of all others.

Abbreviations in Railway Telegraphy—In order to economize time many abbreviations are used, especially in Railway Telegraphy. These vary on different lines, but those given below are in more or less common use.

X signifies "I have displayed my train order signal and hereby acknowledge receipt of order and pledge myself to hold train or trains, and when O. K. response is received, to deliver."

Ct.—Circuit.
O. K.—Complete.
No.—Number.
Eng.—Engine.
C. & E.—Conductor & Engineer.
Condr.—Conductor.
Eng'r.—Engineer.
Sec.—Section.
Frt.—Freight.
Psgr.—Passenger.
Dispr.—Train Dispatcher.
Opr.—Operator.
1—Wait a minute.
3—Train Report.
4—Where shall I go ahead.
5—Have you any business for me?
8—Keep circuit closed.
12—Answer how you understand.
13—I or we understand.
18—What is the trouble?
19—Operators' signal for train orders.
23—Life, death, and market messages.

Ck.—Check.
D. H.—Free.
Ex.—Express.
G. A.—Go ahead.
G. M.—Good morning.
G. N.—Good night.
G. W.—Ground Wire.
G. B. A.—Give better address.
Rlf.—Relief.
Sfb.—Stop for breakfast.
Sfd.—Stop for dinner.
Sfn.—Stop for night.
Tel.—Telegraph.
Tkt.—Ticket.
U.—You.
Wa.—Way.
Wo.—Who is at the key?
Y.—Yes.
Inst.—Instrument.
Imp.—Important.
Lv.—Leave.
Mgr.—Manager.
Mo.—Month.
Mt.—Meet.
Msg.—Message.
Msk.—Mistake.

25—Busy on other wires.
31—Train Despatchers' signal to clear line for train orders.
34—Message for all offices.
73—Accept my compliments.
86—Division Superintendent or Superintendent of Telegraph
92—Deliver quick.
96—President, General Manager or General Superintendent.
134—Who is at the key?
A. M.—Morning.
Abt.—About.
Agt.—Agent.
Ahr.—Another.
Amt.—Amount.
Ans.—Answer.
Adj—Adjust.
B. M.—Baggage Master.
Bag.—Baggage.
Btr.—Better.
C. O. D.—Collect on Delivery.
Msgr.—Messenger.
No.—Number.
N. M.—No more.
O. K.—Correct or complete.
O. T.—On time.
Ofs.—Office.
Pd.—Paid.
P. M.—Afternoon.
P. O.—Post Office.
Pls.—Please.
Q.—Question.
Qk.—Quick.
Ret.—Return.
Sig.—Signature.
Stk.—Stock.
Smtg.—Something.
Supt.—Superintendent.
Tru.—Through.
Thot.—Thought.
Ur.—Your.
Wt.—What.
?—Repeat.

CHAPTER VI.

COMMERCIAL TELEGRAPH COMPANIES AND THE RULES AND REGULATIONS GOVERNING THEIR BUSINESS, INCLUDING CARE AND MANAGEMENT OF OFFICE; RECEIVING, SENDING AND DELIVERING MESSAGES; PARTICULARS OF COLLECTIONS, REMITTANCES, ACCOUNTS AND RETURNS.

The rules and regulations of commercial telegraph companies are not more uniform than those of railroad companies. Nevertheless—as in the case of railroad companies—they are generally alike, and familiarity with the provisions of one company make it an easy task for the student to perfect himself in the business and so, when he gets an office, to acquire specific knowledge of the rules and regulations of the company employing him.

Hence, the subjoined rules and regulations of a commercial company, while not claiming to be specifically accurate—for such things are subject to change from day to day to meet the emergencies of business—are, nevertheless, abundantly sufficient for students and inquirers who seek to perfect themselves in general and technical knowledge concerning the workings of commercial telegraph companies. These subjoined rules and regulations are so minute, so clear and explicit, that the novice in such matters will have no difficulty in understanding them.

With this explanation, I proceed to give the rules and regulations in question. And, first, those in regard to the

RECEIVING DEPARTMENT—RULE 1.—*Messages to Be on Message Forms.*—Each message for transmission will be written upon the form provided by the company for that purpose, or will be attached to such form by the sender, or by the person presenting the message as the sender's agent, so as to leave the printed heading in full view above the message.

RULE 2.—*Messages to Be Timed, etc., by Receiving Clerks.*—Each message will be timed by the receiving clerk, who will see that the month and day are correctly noted thereon; he will also carefully read each message before accepting it, and, when necessary, will make it plain by marginal notation before it is sent to the operator.

Remarks: The receiving clerk should give any aid or explanation necessary to enable the sender to prepare his message so that errors or delays may be avoided.

No change should be made in any message by an employe of the company, but misspelled or abbreviated words may be courteously referred to the sender for correction. If the sender decline to make correction, the message will be accepted as written.

The importance of the address cannot be overestimated. When the address given seems insufficient, a better one should be requested.

If a message be offered without signature, the sender's attention should be called to the omission, and if the sender then decline to sign the message, the receiving clerk will write in the place of the signature the words **"Not signed."**

RULE 3.—*Words to Be Counted and Charged For.*—In a prepaid message the under-mentioned words will be counted and charged for, viz:

All words in an extra date. (See Rule 8.)

All extra words in an address.*

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*In the address of a message to one person, or to a firm, or to "Mr. and Mrs. ——," there are no extra words; but in the address of a message to either of two or more persons in the same place or town, as to "John Smith, or James Brown, 80 Wall Street, N. Y.," there are three extra words, viz: "or James Brown," which will be included in the count and charged for.

All words, figures and letters (as per Rule 4) in the body of a message.

All signatures, when there are more than one, except the last.

All words in excess of two, in a title after the last or the only signature.*

All words after the signature which are not title words; and, in the check, the words *"Deliver and report charges," "Delivery charges guaranteed," "Report delivery,"* and *"Repeat back."* (See Rules 6 and 7.)

In a collect message this rule will apply, except that the word *"collect"* in the check will be counted, but not charged for.

When a message bears two or more addresses, *and delivery is to be made to each address,* it will be charged for as two or more messages, as the case may be.†

RULE 4.—*Words to Be Counted and Charged For.—Continued.*

In counting a message as directed in Rule 3, dictionary words, initial letters, surnames of persons, names of cities, towns, villages, states or territories, or names of the Canadian provinces, will be counted and charged for each as one word. The abbreviations for the names of cities, towns, villages, states, territories and provinces will be counted and charged for the same as if written

*In a signature such as "Mr. and Mrs. ——," or "John Smith and family," or "Henry Jackson, Vice-President," there are no extra words, but in a signature such as "James Brown, First Vice-President and Secretary," there are two extra words, viz: "and Secretary," which will be included in the count and charged for.

†A message addressed, for example, to "W. Brown, 197 Broadway, and B. Wells, 60 Exchange Place, N. Y.," will be charged for as two messages. A message addressed to "J. B. Jackson and S. B. Smith, Senate Chamber, Washington, D. C.," will be charged for as two messages The additional addresses will not be considered as extra words.

in full. Abbreviations of weights and measures in common use will be counted each as a word.

In names of countries or counties all the words will be counted and charged for.

To prevent liability to error, numbers and amounts should be written in words, and, when not so written, the receiving clerk will request that it be done. If the customer refuse to write the amounts in words, the message will be accepted as written, and the figures counted as indicated in the following paragraph:

Figures, decimal points and bars of division, and letters (except the pronounceable groups covered by the sixth paragraph of this rule) will be counted—each separately—as one word.

In ordinal numbers the affixes st., d., nd., rd. and th. will each be counted as one word.

All pronounceable groups of letters, when such groups are not combinations of dictionary words, will be counted each group as one word. When such groups are made up of improper combinations of dictionary words, each dictionary word so used will be counted as one word.

Remarks: The following examples will illustrate the application of this Rule:

Van Dorn	1	word.
McGregor	1	"
O'Connor	1	"
DeWitt	1	"
Brown, Jr	2	"
New York (or N. Y.)	1	"
New York State	2	"
Nova Scotia (or N. S.)	1	"
St. Louis	1	"
East St. Louis	1	"
North Carolina	1	"
Queen Anne County	3	"
New Mexico	1	"
District of Columbia (or D. C.)	1	"
North America	2	"
44.42	5	"
42B618	6	"

74¾	5 word.
No. 185 22d St	8 "
10 000 000	8 "
Ten Millions	2 "
3d or (3rd)	2 "
10th	3 "
Lbs	1 "
Cwt	1 "
Hhds	1 "
Amaurecis	1 "
Adbantia	1 "
Chancin	1 "
Interavis	1 "
Byxtrmgo	8 "
Xyf194sm	8 "
All-right or Alright	2 "
Exceptions.	
A. M	1 "
P. M	1 "
F. O. B. (or fob)	1 "
C. O. D. (or cod)	1 "
C. I. F. or C. F. I. (or cif or cfi)	1 "
O. K	1 "
C. A. F. (or caf)	1 "
Per cent	1 "

RULE 5.—*Checks of Messages.*—The receiving clerk's check upon a paid or collect message will be made in accordance with the following examples:

Remarks: The check of a ten-word message to a "this" line office will be, for example,

"10 paid 25," or,

"11 collect."

The check of a ten-word message to an "other" line office will be, for example,

"10 paid 25 and 30 via Chicago,"—or,

"11 collect 25 via Chicago."

The check of a ten-word message for special delivery from a "this" line office when the delivery charges are known will be, for example,

"10 paid 25 and 1.00 delivery,"—or,

"11 collect 25." (See note below.)

If the delivery charge be unknown the check will be, for example,

"14 paid 33 deliver and report charges,"—or,

"11 collect."

If the delivery charge from an "other" line office be, for example, 50 cents, and the "this" line and "other" line rates each 25 cents, the check will be,

"10 paid 25 and 75 via Chicago."—or,

"11 collect 25 via Chicago."

(The 75 includes the "other" line tolls and 50 cents for delivery."

(See Rule 25 for D. H. message checks.)

Note.—Offices connecting with "other" lines will note that in these checks the amount which indicates the "this" line tolls appears in the check before the amount for "other" lines. In checking messages received from "one," "two" or "three" star stations this arrangement of the tolls should be preserved by inserting the "this" line tolls immediately after the word paid or collect.

RULE 6.—*Request to Report Delivery.*—If the sender of a message requests a notice of its delivery, the receiving clerk will insert in the check the words *"report delivery."* (See Rule 47.)

Repeated Messages—If the sender request a repetition of his message, the receiving clerk will insert in the check the words *"repeat back,"* and will charge a half rate for the repetition, in addition to the rate for the message. (See Rule 37.)

In such instances the words *"report delivery"* or *"repeat back,"* as the case may be, will be included in the count and charged for.

RULE 7.—*Special Delivery.*—A message to be specially delivered beyond the free delivery limits of the terminal office, and for which the delivery charge is not given in the Tariff Book, will be accepted upon the payment or guarantee of an amount sufficient to cover the message tolls and the probable cost of delivery. The words *"deliver and report charges,"* when the charges are to be paid by the sender, or the words *"delivery charges guaranteed,"* when they are to be paid by the addressee, will be inserted in the check of such a message, and will be counted and charged for. (See Rules 13 and 52.)

Rule 8.—*Extra Dates.*—Whenever a message which has come over the line of any other telegraph company is offered at a place not indicated by the Tariff Book of this company as the proper place for such message to reach this company's lines; or whenever a message is received at any office by mail to be forwarded by telegraph; or in case a person, having received a message, requests the same to be forwarded to another place; or if a person leave town before the arrival of an expected message, and it be forwarded to him—in each of these instances the name of the place where the message originated and the date will be counted and charged for as a part of the message. For example, if the following message should pass over the line of another telegraph company from Buffalo to Boston, or through the mail, or be received by any other person than the addressee by telegraph or mail, or should arrive by "this" line after the addressee had left town, and a request be made that it be forwarded to Fall River, it will be sent as follows:

Buffalo, N. Y., Oct. 24.
via Boston, Oct. 24.

John Brown, Fall River, Mass.

Meet me next Monday, at ten o'clock in the forenoon.

H. Smith.

15 paid.

Thus adding in and charging for, as a part of the message, the five words, "*Buffalo, N. Y., Oct.* 24."

Fowarded Messages.—When a message, which is to be forwarded, is a "received collect" message, the forwarding office will check it so that the tariff from that office to destination shall appear in the check as "this" line tolls, and the tariff from the originating office to the forwarding office as "other" line tolls.

Remarks: Suppose the tariff from Buffalo to Boston to be 35 and 2, and from Boston to Fall River 25 and 2, and a ten-word message (as per above example) has been sent "collect" by Buffalo to Boston, which the latter office is to forward to Fall River; Boston should check the message (counting five extra words): "16 collect 35 and 35." The "35" (tariff from Boston to Fall River) represents the "this" line tolls for fifteen words, and the "35" (tariff from Buffalo to Boston) represents the "other" line tolls for ten words.

RULE 9.—*Messages Offered During Interruption of Lines.*—If a message be offered when communication is known to be interrupted, it will be accepted only if the sender choose to leave it for transmission when communication is restored. Upon such a message write the words "Subject to delay," and request the sender to affix thereto his signature or initials.

RULE 10.—*No Promises as to Transmission or Delivery.*—Employes are particularly cautioned against making any promise to customers respecting the transmission or delivery of a message.

RULE 11.—*Sender's Address to Be Taken.*—The address of the sender of a message, unless it be well known, will be requested and recorded.

RULE 12.—*Messages to Be Prepaid.*—All messages will be prepaid, except free messages and those covered by Rules 13 and 47.

RULE 13.—*Collect Messages.*—An answer to a prepaid message, or a message for which payment for transmission, or for special delivery, is guaranteed by a responsible party, may be accepted *"collect."*

Guarantee Deposits.—When a deposit has been made to guarantee payment for transmission, or for special delivery, the deposit will be returned after three days, if no notice of failure to collect the charges has been received. But if a notice of failure to collect be received, the amount due to the company will be deducted from the deposit, and the remainder will be returned. (See Rules 52 and 58.)

RULE 14.—*Insured Messages.*—For an insured message the receiving clerk will observe the conditions in relation to such a message contained in the printed heading of Form 2.

RULE 15.—*Night Messages.*—A night message will be written upon a night message form, and will be accepted only between the hour of opening and midnight. An office closing before midnight will not accept a night message that cannot be started before the closing hour. In case of an interruption of the lines, which it is believed will prevent the transmission of a night message before the following morning, such messages will not be accepted.

RULE 16.—*Profane or Obscene Messages.*—A message containing profane or obscene language will not be accepted for transmission.

RULE 17.—*Franks.*—Franks are issued to persons who are entitled to send messages free or at half rates, and are of four classes, viz: Business franks, half-rate franks, complimentary (stamp) franks, directors' franks.

RULE 18.—*Acceptance of Franked Messages.*—A message offered for transmission under a frank will be carefully scrutinized before acceptance, so that any improper or fraudulent use of the frank may be prevented; but the message will not be refused unless the evidence is clear that its free transmission is not authorized by the frank.

RULE 19.—*Franked Messages to "Other" Line Offices.*—A message to an "other" line office, offered for transmission under a frank, will be accepted upon payment—by the sender—of the "other" line tolls, and provided that the place of transfer is within the territorial limits indicated on the frank.

Rule 20.—*Messages Beyond Limits of Franks.*—A message to a "this" line office beyond the territorial limits of a frank will be paid for from the place of origin to destination.

Rule 21.—*Franks Not Good for Cable Messages.*—No frank issued by this company entitles its holder to transmit cable messages free over any portion of this company's lines.

Rule 22.—*Railroad Messages.*—A message of an officer or agent of a railroad company with which this company has a contract, when on the business of such railroad company, may be sent free, without a frank, between stations on such road; but when such a message is offered at or for a place beyond or off such road, it will not be sent free unless covered by a frank.

Rule 23.—*Service Messages.*—Service messages between the employes of the company will be limited to matters of an urgent nature. The mails will be used in all cases when the service will not suffer by delay.

Service messages will not be sent free for the information of customers, nor to correct their errors.

Rule 24.—*Personal Messages of Employes.*—Personal messages of employes of an urgent social or domestic character may be sent free upon the written approval of the manager or superintendent.

Rule 25.—*Free and Half-Rate Message Checks.*—The receiving clerk's check of a free message will show the reason for its acceptance without payment of tolls. A half-rate frank message will be checked as a full-rate message.

Remarks: The following are examples of free message checks:

"10 D. H. Frank No.———."
"10 D. H. Employe."
"10 D. H. Answer to D. H."
"10 D. H. Frank No.———, and paid 25 via Chicago."
"10 D. H. Frank No.———, and D. H. Frank No.———"
(when free over both "this" line and "other" lines).

OPERATING DEPARTMENT — RULE 26. — *Office Calls.*—An operator, when calling an office, will sign his own office call at short intervals, and will also sign it in answering calls.

RULE 27.—*Sending Operator to Decide Route, Etc.*—The sending operator will decide as to the proper route for the transmission of a message and as to the count of words. He will also number each message to the office to which he sends it, and will write after the number the call of that office. No operator will refuse to receive any message offered by an operator at another office.

The sending operator will regulate the transmission of a message to suit the ability of the receiving operator.

RULE 28.—*Order of Transmission.*—In sending a message, the operator will observe the following order of transmission:

1.—The number of the message.
2.—The operator's personal signal.
3.—The check of the message.
4.—The place from and the date of the message.
5.—The address of the message.
6.—The body and signature of the message.

RULE 29.—*Transmission of Checks.*—All the figures and words in the check of a message will be transmitted, except:

1.—The amount of tolls, in case of a prepaid message to a "this" line office.

2.—The reason why free, in case of a free message.

RULE 30.—*Time, Etc., on Sent Messages.*—The sending operator will write upon each message sent the time of sending and his own and the receiving operator's personal signal.

Acknowledgment of Receipt.—No message will be regarded as transmitted until acknowledged by the usual signal; but if a number of messages be sent in succession, the acknowledgment of the last may be regarded as an acknowledgment of all.

RULE 31.—*When Messages Cannot Be Promptly Transmitted.*—When for any reason an operator cannot transmit a message promptly, he will note the cause of delay upon the back of the message, and will report the facts to the manager or chief operator.

RULE 32.—*Order in Which Messages Are to Be Received.*—In receiving a message the operator will write his personal signal in the space headed "Received by;" he will write the name of his office immediately after and on the same line with the words "Received at," and the time of reception also on the same line or immediately over the check. The acknowledgment of receipt will be made by transmitting the signal "O. K." and the receiving operator's personal signal and office call.

RULE 33.—*Verification of Checks, Etc.*—The receiving operator will count the words, verify the check, and otherwise satisfy himself that a message is correct, before allowing it to leave his hands.

RULE 34.—*Messages to More Than One Address.*—When a message is addressed, for example, to "A or B," for delivery to either, it will be transmitted as a single message. When a message is addressed, for example, to "A and B," or to several persons, for delivery to each of them, the manner of its transmission will be determined by the manager or chief operator of the sending office, so as to use the facilities at his command to the best advantage. (See Rule 3, Remarks, and Rule 48.)

RULE 35. *Night Messages to Be Sent as Far as Possible on Day of Date.*—An office which is not kept open all night will, before closing, transmit its "night" messages to their destination or to the nearest repeating office. A repeating or a press report office will forward "night" messages to their destination, or as near thereto as practicable, during the night. If any night messages are left over until next morning, they will be transmitted before new business.

RULE 36. *Duplicate Transmission.*—If, to correct an error in a message, or for any other reason, a second transmission becomes necessary, the sending operator will begin the second transmission with the word "Duplicate," which word the receiving operator will write conspicuously on the form above the message.

RULE 37. *Transmission of Repeated Messages.*—Special care will be observed in sending and receiving a message requiring repetition, which should, of course, be from point of origin to destination. At the office of origin, and at each repeating office, an operator, upon receiving back a repeated message, will carefully compare it with his copy, underlining or checking each word, and if the repetition be found to be correct, he will write on the back of the message the words: "Repeated back O. K.," with his personal signal and the personal signal of the operator who repeated back the message. (See Rule 6.)

RULE 38. *Transmission of Insured Messages.*—An insured mesage will be preceded in transmission by the word "Insured," and will be repeated back from office to office. The receiving operator will carefully copy such message, and if it is to be forwarded on another circuit, he will take it to, and transmit it over, such circuit and have it repeated back to him. The same course will be pursued in each repeating office through which such message may pass.

RULE 39. *Operators' Signals.*—No operator will change his personal signal without the consent of the manager, nor will any two operators in the same office use the same signal.

RULE 40. *Contention for Circuit.*—Contention for circuit is positively prohibited.

RULE 41. *Number Reports.*—At each office, before closing, the operators will examine the number sheets, exchange number reports of the day's business with other offices, and immediately correct any errors discovered.

Inspection of Messages for Evidence of Transmission.—At each office it will be the duty of some employe to scrutinize, before filing for record, all "sent" messages, to see that they bear the proper indication of transmission.

RULE 42. *Wire Tests.*—The manager of a testing office, or a chief operator, where one is employed, will make early morning tests of the wires, and see that the necesary orders to linemen are given and acted upon without delay. He will make every effort to have the circuits ready for business at the opening hour.

Directions to Linemen.—In giving directions to linemen, care will be taken to definitely locate the trouble, and to state its nature as accurately as possible.

The word "wire" will be recognized as giving the right of circuit at all times for testing purposes.

Office Diary.—A manager of a principal office will keep a daily record of all interruptions and incidents which occur in the working of the lines.

RULE 43. *Ground Wire.*—The ground wire at intermediate offices will be used only in the event of an interruption of the circuit, and then only to notify the chief or testing operator concerning the interruption, and to receive his instructions.

RULE 44. *Care of Batteries.*—Each manager will see that his main and local batteries are kept in good condition, and that each cell is thoroughly insulated so as to prevent any escape of the current. The floors and fixtures of the battery room will be kept scrupulously clean and dry.

RULE 45. *Instruments to Be Cut Out at Night.*—Before closing an office temporarily, or for the night, its instruments will be cut out, care being taken that the circuit through the switch or cut-off is complete.

DELIVERY DEPARTMENT—RULE 46.* *Messages to Be Copied, Etc.*—Each message for delivery will be copied and enclosed in the proper envelope, which will be carefully sealed and fully and plainly addressed.

Amount of Tolls to Be Written on Envelopes.—When tolls are to be collected, the amount in words

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*The following in regard to the collection of tolls is reprinted from the Journal of the Telegraph, April 20th, 1888: "Hereafter for messages received 'collect' from offices on 'other' lines or from telephone (three star) stations, managers will collect tolls for 'this' and also for 'other' lines, whether the checks of such messages show tolls for both lines or not."

will be written in ink upon the envelope, and also upon the messenger's delivery sheet.

RULE 47. *Sending Office's Instructions as to Delivery.*—Instructions from the sending office in regard to delivery of a message will be carefully observed. A request to "*report delivery*" (see Rule 6) will be answered by a collect message addressed to the sender of the original message, stating the time of delivery, or, if not delivered, the reason why.

RULE 48. *Messages Addressed to More Than One Person.*—When a message addressed, for example, to "*A or B*" is received, it will be delivered to either one of the addressees. (See Rule 3, Remarks, and Rule 34.)

RULE 49. *Messages Requiring Answers.*—When a message requires an answer, the word "answer" will be plainly written on the envelope, and the messenger will be instructed to make diligent efforts to obtain such answer. Should he fail to obtain it, he will report the reason to the delivery clerk. Mesengers will, in all cases, be supplied with the proper blanks on which answers can be written.

RULE 50. *Free Delivery Limits.*—Messages will be delivered free within a radius of one-half mile from the office in any city or town of less than 5,000 inhabitants, and within a radius of one mile from the office in any city or town of 5,000 or more inhabitants. Beyond these limits only the actual cost of the delivery service will be collected; the manager will, however, see that such cost is as reasonable as possible.

RULE 51. *Special Delivery.*—If the services of a special messenger be required, and the special delivery charges have not been provided for, the sending office will be promptly notified by telegraph of the cost of delivery, and that office will endeavor to collect the charges from the sender, who, if he pay or guarantee the delivery charges, will also pay for the message ordering special delivery or guarantee the collection of the tolls thereon. If the sending office be unable to collect, or if a reply from the sending office to the notice be not promptly received, a copy of the message will be mailed to the addressee, and if another copy be afterwards delivered, the word "Duplicate" will be plainly written across its face.

RULE 52. *In Case of Failure to Collect Delivery Charges.*—When special delivery charges which have been guaranteed (see Rules 7 and 51) cannot be collected by the office making the delivery, the sending office will be immediately notified by a service message of the failure to collect and of the amount of the charges.

RULE 53. *Messages Not to Be Delivered to Unauthorized Persons.*—A message must not be left with a janitor or porter of a building for delivery by him, nor be slipped under a door, nor left in a letter box, unless the addressee has filed with the manager a written request for such delivery; nor will a messenger allow any unauthorized person to know to whom a message is addressed.

RULE 54. *Messengers to Obtain Receipts.*—A messenger will obtain a receipt on the proper form for each message delivered, which receipt will include the name of the person to whom delivery is made and the time of delivery. A messenger will in no case receipt for an addressee.

RULE 55. *Notice to Addressees of Undelivered Messages.*—When a message cannot be delivered because of the addressee's place of business or residence is closed, or because no authorized person can be found to receive the message, the messenger will leave a notice (Form 66) at the place of address, to the effect that a message for the addressee is at the office of the company, awaiting delivery. The undelivered message will then be returned to the office, with the reason of the non-delivery indorsed upon the envelope, and will be delivered as early thereafter as possible.

RULE 56. *Non-delivery in Consequence of Wrong Addresses, Etc.*—When a message cannot be delivered because of wrong or inadequate address, or because the addressee is not known, a record of the facts will be made upon the envelope of the undelivered message, and the sending office will be promptly notified by telegraph of the non-delivery; the service message giving such notice will contain the address of the message as received and the reason for the failure to deliver. On receipt of the telegraph notice, above referred to, sending office will compare addresses, and will correct by telegraph any error that may be found. If no error appear, notice will be given to the sender of the message, who, if he desire to change the address, must either send a new message, or pay for the service message necessary to change the address of the original.

Pending the correspondence as to "better address," the receiving office will put a copy of the message, addressed as first received, in the Post Office.

RULE 57. *Messages Delivered "Subject to Correction."*—If a manager believe that an error has been made in the transmission of a message to his office, and the correction cannot be quickly made, he will deliver the message with the words *"Delivered subject to correction"* indorsed thereon. He will then take immediate steps to secure a correct copy, which will be indorsed *"Corrected copy,"* and will be promptly delivered. If no error be found, a notice to that effect will be delivered.

RULE 58. *Delivery of Collect Messages Without Payment.*—If the addressee of a collect message refuse to pay for the same, the message will nevertheless be tendered to him and —*unless the message be an answer to a free or to a paid message*— notice of the failure to collect will be at once given to the sending office by service message and by mail, in order that tolls may be obtained from the sender of the message. (See Rule 13.)

RULE 59. *Delivery of Night Messages and Delivery of Night Messages when Called For.*—A night message will not, unless called for, be delivered until the morning of the next business day after its date; but when called for, it may be delivered on the day of its date, upon payment of full day rates in the case of a collect message, and the difference between the night and day rates in the case of a paid message. The additional amount collected will be accounted for as "Sundry Receipts."

RULE 60. *Delivery of Insured Messages.*— Where an insured message is received at an office from which it is to be delivered, it will be the duty of the manager, or of the person in charge, to satisfy himself that prompt and correct delivery is made.

RULE 61. *Messengers Books to Be Examined.*— The manager or delivery clerk will examine the delivery sheets or books of messengers on their return from each service, and at the close of the day, to see that faithful delivery has been made, and that all proper notifications have been given.

Accounts, Reports and Remittances.—Rule 62. *Classification of Offices.*—For the purpose of accounts and reports, offices will be classified as follows:

"First-Class," those whose messages number over one thousand per month.

"Second-Class," those whose messages number over two hundred, but not over one thousand per month.

"Third-Class," those whose messages number less than two hundred per month.

Rule 63. *Classification Not to Be Changed.*—An office of one class will not change the method of keeping its accounts to the method of another class, without the consent of the superintendent.

Rule 64. *Record of Messages.*—A daily record of its messages will be kept by each office. For this purpose offices of the First Class will use Forms 40, 68, 69 and 77; offices of the Second Class will use Forms 40 and 77, and offices of the Third Class will use only Form 40.

Rule 65. *Receiving and Delivery Clerks' Records at Offices of First Class.*—Offices of the First Class will enter on Form 69 *all* messages accepted for transmission, at the time and in the order of their acceptance; and on Form 68 *all* messages received for delivery, at the time and in the order of their reception.

Rule 66. *All Messages to Be Entered on Form 40.*—Offices of each class will, each day, enter on Form 40 the paid and collect messages of the preceding day—including the "half-rate frank" messages, which must be entered as paid at full rates. The messages will be entered so that the names of the offices with which the business was done will appear in exactly the same order in which they are in the Tariff Book; *i. e.,* so that the names of the States (or the abbreviations therefor), and also the names of the offices *in each State,* will appear in alphabetical order. The amount entered in the last column ("This Office Checks for Other Lines") will be made up of the amount paid to "other" lines, the amount paid out for special delivery service, and that part of the tolls on forwarded messages which the last paragraph of Rule 8 designates as "other" line tolls.

Entry of "Other" Line Messages.—A message to or from an "other" line office will be entered with messages of the office *via* which it reaches or leaves "this" line.

RULE 67. *Record of Free Messages.*—A separate record of free messages, not including service mesages and local railroad messages (*i. e.,* messages between two stations, both located on the same road), will be made by offices of each class, on Form 40. This record will state the number of messages sent *to,* and the number received *from,* each office, together with the total amount of "this" line tariff on the messages at *full day* rate; the tariff on sent messages being entered as credits, the tariff on received messages being entered as checks. No account of "other" line tariff will be taken in this record of free messages.

In the case of a message free for "this" line and paid for "other" lines, an entry in both the free and the paid message records will be made. A copy of the message will be made for the paid message files, and the original will be placed with free messages, as required by Rule 72.

RULE 68. *Sunday's Messages.*—Sunday's messages will be entered as a part of the previous Saturday's business, except when the first day of the month falls on Sunday, in which case Sunday's messages will be entered as a part of the business of the following Monday.

RULE 69. *Checks Not to Be Changed.*—A paid or collect message will be entered as originally checked and transmitted.

RULE 70. *Check Ledger Entries.*—After the entry of a day's messages on Form 40, offices of the First and Second Classes will transfer the record to Form 77, keeping a separate ledger for free business. Offices of the Third Class need make no entry other than that on Form 40.

RULE 71. *Record of Cable Messages.*—Daily records of Atlantic Cable, Halifax and Bermudas cable, Bahamas cable, Cuba cable, and Central and South American cable messages (*five separate records*), will be kept on Form 67. These records will form part of the monthly report.

The total amount received for cable messages, *after deducting amounts refunded as per cable rules in Tariff Book,* will be entered on Form 4, under "Sundry Receipts."

RULE 72. *Uncollect, Guaranteed, "Half-rate" and Free Messages.*—Before filing away the day's business the under-mentioned messages will be taken out and held to be sent in with the monthly reports:

Copies of messages "received collect" for which payment has not been obtained, together with the telegraphic notices relating thereto required by Rule 58.

The original messages "sent collect" which have been reported by delivery offices as uncollectible.

The original messages "sent paid" *by,* and copies of those "received collect" *for,* the holders of half-rate franks, on which less than full tolls have been paid.

The originals of all *sent* messages (except service and local railroad messages, *i. e.,* messages between two stations, both located on the same road) which have been transmitted free.

When more than three in number, the uncollected messages referred to above will be listed on Form 34, the half-rate frank messages on Form 33, and the guaranteed messages on Form 35.

RULE 73. *Filing Messages.*—All messages not required for other purposes (see Rule 72) will be filed in the order in which they appear on Form 40, and properly labeled by days and months. Each month's messages will be retained for a period of six months, at the end of which time, unless otherwise ordered, they will be sent to the superintendent with the monthly reports.

RULE 74. *Monthly Reports.*—Immediately after the close of the month, offices not otherwise instructed by the superintendent will make out and return reports on Forms 4, 7, 38 and 67.

If no free business has been done, the report on Form 38 will be omitted, and the words "No free business" will be indorsed on Form 7, under the manager's signature. If no cable business has been done, the report on Form 67 will also be omitted.

The above-named reports with their enclosures will be sent to the superintendent by offices of the Third Class within three days after the close of the month; by offices of the Second Class within five days, and by offices of the First Class within seven days.

RULE 75. *"Paid 'Other' Lines."*—The amounts entered in the column headed "Paid Other Lines," on Form 4, will be made up of the amount paid to "other" lines, the amount paid for "special delivery," and the "other" line tolls on forwarded messages. The total of the amounts in this column will be entered under "Schedule of Ordinary Disbursements," opposite the item "Paid Other Lines."

RULE 76. *"Received for Guaranteed Messages."* —Under "Sundry Receipts," on Form 4, opposite the item "Received for Guaranteed Messages," will be entered the amount received for the payment of messages which other offices have reported "uncollectible." The originals of such messages will be sent in with the report; and upon those for which no tolls have been collected will be indorsed the reason why no collection has been made.

RULE 77. *"Refunded and Uncollectible.*—The amount opposite the item "Refunded and Uncollectible,"on Form 4, will be made up of the amount refunded for errors, etc., the total amount of the refunds on "half-rate frank" messages and the amount of tolls on uncollectible messages received from other offices.

All the messages included under the head of "Refunded and Uncollectible" will be sent in with the report, as vouchers for the unpaid tolls. Each uncollected message will be accompanied by the service message referred to in Rule 58.

RULE 78. *Check Reports.*—A check report (Form 7) is required from *every* office.

The names of this company's offices to which messages have been sent, or from which messages have been received during the month, will be entered on this report in the order indicated by the note in the heading of the Form, and opposite each name will be entered the amounts as indicated by the headings on the Form. The totals of the columns under the heading "This Office Receives" must agree with the totals on Form 4 under the heading "Telegraph Receipts;" and the total of the column headed "For Other Lines," under "This Office Checks," must agree with the total of the "Paid Other Lines" column and with the item "Paid Other Lines" under the heading "Schedule of Ordinary Disbursements."

RULE 79. *Free Message Reports.*—On Form 38 will be made a check report of free messages and a statement of messages which have been sent free for any railroad, transportation, express or other company or for any individual, showing the number of messages sent for each company or individual, and the amount of tariff at full day rates therefor as if paid for. The original messages will show the place of origin, be checked with the number of words, *the amount of tariff at full day rates* (which rates should be plainly marked in the upper right hand corner) and the *reason why free,* and will be sent with the report to the superintendent.

RULE 80. *Vouchers. How Made Out, Numbered, Etc.*—A voucher will be rendered for every expenditure.

Each voucher will be written and signed in ink, made out in such manner as to clearly and fully explain itself, and numbered to correspond with the entry on Form 4.

The amount of the expenditure will be written in the receipt in words.

No voucher bearing erasures or alterations of figures or amounts will be accepted.

Each voucher will be signed by the person to whom payment is made.

If a voucher be signed by any other than the person to whom payment is due, it will be accompanied by a written order from such person giving authority for the payment and signature.

Signature by "his mark" will be witnessed by some person other than the one making payment.

RULE 81. *Service Vouchers.*—A service voucher will state the full name of the person paid, the kind of service and where rendered, the dates between which the service was performed, and the rate per day, week or month. When the payment is for a part of a month, the number of days as well as the dates will be given, and the time will be computed according to the number of week days in the month.

RULE 82. *Error Sheets.*—Each manager will give prompt attention to error sheets, and will answer inquiries respecting them with full and clear explanations.

RULE 83. *Balances Due Company.*—Every office balance due the company will be remitted to the treasurer at the close of each month, unless otherwise specially ordered by him.

Remittances, Etc.—A remittance to the treasurer will be made either through the mail in the form of draft on New York, or, where bank drafts cannot be obtained at less expense, by express company's money order.

If neither bank draft nor express money order can be obtained, post office money orders should be forwarded.

If neither draft on New York, express money order nor post office money order can be obtained, then currency should be forwarded by express.

If neither of the above means is available, then as a last resort, the remittance should be forwarded by registered letter.

The small treasurer's envelope, Form 123, must be used where remittances are made by mail.

The large envelope, Form 124, should be used only for making remittances by express.

Mutilated silver coin is uncurrent, and its value as bullion is much less than its nominal value. Offices should not accept either mutilated or foreign silver coins, and must not remit such to the treasurer.

When a remittance is made by express, the amount will be plainly indorsed on the envelope and the express company's receipt taken.

An explanatory letter, on Form 65, stating on what account the money applies, will be enclosed with each remittance.

RULE 84. *Bank Deposits.*—When an employe deposits funds of the company in bank, the deposit will be made either to his credit in his official name, or to the credit of the company in its corporate name. In the latter case the funds will be subject to checks by the treasurer only.

Deposits will be made in banks designated by the treasurer.

MISCELLANEOUS.—RULE 85. *Manager's Jurisdiction.*—Each manager will exercise jurisdiction over the property, employes and business of his office; and, unless otherwise ordered, such jurisdiction will extend to branch offices, if any, in the same city or town.

RULE 86. *Care of Property.*—Each manager will be held to a strict accountability for the property of the company in his possession or under his control; and he will hold employes under his direction responsible for the careful use and preservation of such property.

Property Not to Be Sold.—No article belonging to the company will be sold or transferred without authority from the superintendent.

RULE 87. *Expenditures for Office Fittings, Etc.*

—No expenditures for office fittings, alterations or furniture will be made without authority from the superintendent.

RULE 88. *Surplus Materials.*—Old copper, zinc, waste paper and other old or surplus materials of value will be carefully preserved and, at regular intervals, reported to the superintendent.

RULE 89. *Instruments, Etc., Sent to Supply Department.*—When instruments or other articles are sent to the supply department by order of the superintendent, they will be accompanied by a copy of such order, and by a letter from the manager stating what disposition is to be made of them.

RULE 90. *Requisitions.*—Requisitions for supplies will be made once in three months for each office having over fifteen cells of battery, and once in six months for other offices. Such requisitions will be forwarded to the superintendent at least one month before the beginning of the period for which the supplies are needed.

RULE 91. *No Admittance to Operating Rooms, Etc.*—A manager will refuse to admit to the operating room and private offices of the company any person not an employe under his own direction, except when permission to enter has been given by a superintendent or other officer of the company.

RULE 92. *Privacy of Messages and Records.*—Messages, books, press reports and other papers of the company will be guarded with the greatest care and held in the strictest privacy. Employes are expressly forbidden to disclose any information in regard to the contents of a message, or the name of the sender or addressee thereof.

RULE 93. *Forms to Be Used Only for Designated Purposes.*—The printed forms of the company will be used only for the purposes for which they are designed. Under no circumstances will forms for received messages or message envelopes be given to the public, except in the usual delivery of messages.

RULE 94. *Change of Managers.*—If a manager vacate his office before the close of the month, he will make up his accounts to date, and will pay over to his successor all funds in his possession. The retiring manager will send to his superintendent a report of such settlement with the receipt of his successor for money paid and property delivered.

RULE 95. *Applications for Copies of Messages.*—When the sender or the addressee of a message applies for a copy of such message, he may, if known or properly identified, be allowed to see the message and make a copy thereof; but under no circumstances will a received message form or a message envelope be furnished him.

Employes will not certify to the correctness of any message or copy thereof nor furnish a copy, except as per Rule 96, nor will they show any message to any person other than the sender or addressee thereof, except by authority from an Executive Officer of the company.

RULE 96. *Correction of Errors.*—If after the delivery of a message, the addressee claim that an error has been made by the company, and the error be not apparent to the manager, the manager may, by service message to the sending office (*which message must be paid for*), ask for a duplicate, and if an error be thereby disclosed, a copy indorsed "*Corrected Copy*" will be delivered, and the tolls paid for the service message refunded. If no error be disclosed, a notice to that effect will be delivered.

RULE 97. *Refunds.*—Whenever satisfactory evidence is furnished to a manager that a message has failed to accomplish its object by reason of imperfect service on the part of the company, he may refund to the sender the tolls paid for the message. The receipt given for the refunded tolls, together with the message and explanatory memorandum, will be sent in with the report on Form 4.

RULE 98. *Complaints.*—Upon receipt of a complaint, which cannot be satisfied under Rule 97, the manager will promptly forward it to his superintendent with a clear statement of the case. If the complaint be founded upon a message, the original message or copy as delivered will be forwarded with the statement.

Employes will not furnish information relating to complaints under investigation, except under instructions from a superintendent or other officer of the company.

Patient and courteous attention will be given to any person complaining of the service.

RULE 99. *Summons and Other Legal Process.*—Immediately upon the service of any summons or other legal process in any legal proceeding affecting the company, the employe upon whom such service is made will report the fact by telegraph to the superintendent, stating briefly the nature of the process, and the day and hour when it was served. He will then transmit to the superintendent, by first mail, a copy of the paper or process so served, with a statement of such facts relating to the matter as are within his knowledge. The original paper will be retained, subject to instructions.

RULE 100. *Court Orders for the Production of Messages.*—Whenever a manager or other employe is subpœnaed on the part of the *sender* or *addressee* of a message to produce it before a court or other legal tribunal, he will comply with the subpœna, and afterward return the message to the files; but whenever a manager or other employe is subpœnaed on the part of any person other than the sender or addressee to produce a message, or testify in relation thereto before a court or other legal tribunal, he will take the message into court, and then submit to the judge that he ought not to produce it or testify in relation thereto, and that he cannot do so, unless a rule or order of the court be entered requiring it, for the reason that telegraphic messages are of a confidential nature and that the communication is claimed to be privileged. If such order be made and entered, it will be obeyed, and the clerk of the court will then be requested to furnish a copy of the order, which, together with the subpœna, will be filed with the message to which it relates.

Note.—A subpœna, to be regular and valid, must describe the desired messages by such specific reference to the names, dates or subject matter concerned as will enable such messages to be readily found and identified in the files; but a subpœna which only calls in general terms for such messages as may be found after a search through the files (for example: "All messages passing between John Smith and Richard Brown between the 1st day of July and the 5th day of August, etc.") is irregular and unlawful, as being in the nature of a search-warrant, and not founded upon messages known to have existed.

It is the policy of the company to contest subpœnas of this latter character, especially where the production of the messages concerned is likely to create public scandal or political excitement. On receipt of subpœnas of this class, managers will bring the same to the attention of their superintendent, stating particularly the language of that part of the subpœna which calls for the messages.

INDEX TO FOREGOING RULES AND REGULATIONS OF A COMMERCIAL TELEGRAPH COMPANY.

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Form 34.—Uncollected Message Statement	Rule	72.
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" 38.—Free Message Report	"	74, 79.
" 40.—Register Sheet (messages)	"	64, 66, 67, 68, 69.
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" 45.—Night Message (counter) . .	"	1.
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" 67.—Cable Message Report	"	71, 74.
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" 69.—Receiving Clerks' Register.	"	64, 65
" 77.—Check Ledger	"	64, 70.
" 87.—Messengers' Delivery Sheet	"	61.

RULES AND RATES FOR PRESS DISPATCHES—RATES FOR NEWSPAPERS

RULE 1. *Language.*—The following rates per word will be charged newspapers on special dispatches, *in plain language,* for publication. No dispatch or message to be rated as containing less than ten words.

RULE 2. *East of Cheyenne, Etc.*—Between all points on this company's lines east of and including Cheyenne, Wyo., Denver, Col., and El Paso, Texas, between 6 a. m. and 6 p. m., one-third; and between 6 p. m. and 6 a. m., one-sixth of the additional word rate on *day* commercial messages between the points of origin and destination of such specials.

RULE 3. *West of Cheyenne, Etc.*—Between all points on this company's lines west of and including Cheyenne, Wyo., Denver, Col., and El Paso, Texas, between 6 a. m. and 6 p. m., one-third; and between 6 p. m. and 6 a. m., one-sixth of the additional word rate on *day* commercial messages between the points of origin and destination of such specials.

RULE 4. *East and West of Cheyenne, Etc.*—From points *east* of Cheyenne, Denver and El Paso to points *west* of those cities, and from points *west* of Cheyenne, Denver and El Paso to points *east* of those cities on this company's lines, between 6 a. m. and 6 p. m., one-half; and between 6 p. m. and 6 a. m., one-quarter of the additional word rate on *day* commercial messages between the points of origin and destination of such specials.

RULE 5. *Minimum Word Rate.*—No special filed for transmission between 6 a. m. and 6 p. m. should be charged for at less than one-half cent per word, and no special filed for transmission between 6 p. m. and 6 a. m. should be charged for at less than one-quarter cent per word.

The rates given in the preceding rules are repeated in the following tables:

RULE 6. *Rate Table for East of Cheyenne, Etc.*—Between all of this company's offices east of and including Cheyenne, Wyo., Denver, Col., and El Paso, Texas:

If your regular commercial DAY rate is	The special press rate per word will be	
	From 6 A. M. to 6 P.M.	From 6 P. M. to 6 A. M.
	CENTS.	CENTS.
20 & 1 25 & 1	One-half.	One-quarter.
25 & 2 30 & 2 35 & 2	Two-thirds.	One-third.
40 & 3 45 & 3 50 & 3	One.	One-half.
60 & 4	One and one-third.	Two-thirds.
75 & 5	One and two thirds.	Five-sixths.
1.00 & 7	Two and one-third.	One and one-sixths.

RULE 7. *Rate Table for West of Cheyenne, Etc.*—Between all of this company's offices west of and including Cheyenne, Wyo., Denver, Col., and El Paso, Texas., same as Rule 6.

RULE 8. *Rate Table for East and West of Cheyenne, Etc.*—Between all of this company's offices east of Cheyenne, Denver and El Paso to this company's offices west of those cities, and from this company's offices west of Cheyenne, Denver and El Paso to this company's offices east of those cities:

If your regular commercial DAY rate is	The special press rate per word will be	
	From 6 A. M. to 6 P. M.	From 6 P. M. to 6 A. M.
	Cents.	Cents.
20 & 1, 25 & 1	One-half.	One-quarter.
25 & 2, 30 & 2, 35 & 2	One	One-half.
40 & 3, 45 & 3, 50 & 3	One and one-half.	Three-quarters.
60 & 4	Two.	One.
75 & 5	Two and one-half.	One and one-quarter.
1.00 & 7	Three and one-half.	One and three-quarters

RULE 9. *Maximum State Rate.*—The maximum rate on specials in any State will be one cent per word on day matter and one-half cent per word on night matter.

RULE 10. *Day Capital Rate.*—The day rate of one-half cent per word on specials to newspapers from the capital of any State east of the Mississippi River to any point within the same State is continued in force.

RULE 11. *Filing Time.*—The local time of the place at which dispatches are filed shall govern the rates to be charged.

Press dispatches to be forwarded at night press rates may be filed at any time during the day, but will not be transmitted until after 6 p. m., except in cases where it may be more convenient or desirable for the company to forward them earlier, and when such a dispatch is forwarded before 6 p. m., the words "*night special*" should be transmitted in the check.

RULE 12. *Rate for One Paper.*—These rates apply to specials for publication, *at point address,* in one newspaper only, but there is no objection to newspapers giving their specials to correspondents to forward to papers in other cities, when they are to be forwarded by this company's lines.

RULE 13. *One Copy Only.*—More than one copy of dispatches to newspapers or Press Associations should not be delivered without special instructions covering each case.

RULE 14. *Combination Specials.*—Combination specials are to be handled only when ordered by superintendents.

RULE 15. *Counting Figures.*—Amounts in figures in newspaper specials or Press Association reports should be counted according to the least number of words in which they may or can be expressed. Examples:

999	Three words—	(Nine ninety-nine.)
1,000	One word—	(Thousand.)
23½	Three words—	(Twenty three half.)
15½	Two words—	(Fifteen half.)
9,961,000	Six words—	(Nine Million nine sixty-one thousand.)
9,960,000	Five words—	(Nine million nine sixty thousand.)

RULE 16. *Cipher Dispatches.*— Press Dispatches written in cipher, or containing cipher or code words, in any language, although intended for publication, are not entitled to be sent at special rates, but should be charged for at the same rate as other business messages to the paper receiving such cipher dispatch.

RULE 17. *Queries and Checks.*—Messages (not in code or cipher) ordering or relating strictly to newspaper specials, transmitted or to be transtransmitted by this company's lines, should be checked and charged for at special press rates, the same as matter for publication. The check of such messages, as well as the check of press dispatches, should always be transmitted and contain the words "day press rate" or "night press rate," as the case may be, so as to prevent confusion in checks between the sending and receiving offices; no such message to be rated less than ten words.

Rule 18. *Authority of Correspondents.*—Persons filing matter for transmission to the press, who are not known to be the authorized correspondents of the papers or Press Associations their matter is addressed to, should be required to present proper authority, or prepay or guarantee the payment of tolls on their dispatches, before they are accepted.

Rule 19. *Other Line Business.*—Where prepaid press dispatches are sent to an "other" line office, or where dispatches are received "collect" from an "other" line office, the "other" line tolls for such dispatches should be added to those of this company.

Dispatches addressed to newspapers or Press Associations in foreign countries, other than the "Dominion of Canada," should not be accepted at press rates, without special orders in each case.

Rule 20. *Transmission of Filing Time.*—The filing time of dispatches to newspapers or Press Associations should not be transmitted unless placed in the body of a dispatch by the sender, in which case it should be counted and charged for as part of the message.

Rule 21. *Reporting Business.*— *All special* *press receipts and checks* should be included in Form 7 report as part of "checked" business, and also reported in Form 81 (Press Report). Unchecked business should be reported in Form 81 only. See Rule 23.

Managers should make no entry in "Amount Paid" column of Form 81 if money is not received by them.

Rule 22. *Reporting Count.*—When impracticable to count the number of words contained in press dispatches before transmission, the number of words should be reported by service message as early as possible, the sending office being responsible for correctness of count; but this does not in any wise relieve the receiving office from careful counting and comparison.

This applies to both checked and unchecked matter.

Rule 23. *Unchecked Business.*—Unchecked business is regular circuit matter sent from a common distributing point to many receiving stations, for and on account of a Press Association, arranged by order of superintendents, and reported in Form 81.

Any other unchecked business to be reported will be the subject of direct instruction from superintendents.

Rule 24. *Application of Rules.*—The foregoing instructions are not intended to apply to or interfere with any Press Association or special service that may be covered by contract, or particular agreement, the checking rates for which are, or should be, made on special orders from superintendents.

Rule 25. *General Service.*—The general manner of rendering any press service must not be changed, or any information given as to the expense of performing any press service, or as to the rate that the company should charge for any service (except as hereinbefore mentioned on specials), or any unusual privileges granted the press, or the company committed in any way to any line of action or policy regarding press matters, without first receiving proper approval. All applicants for any regular press service should be referred to the agent or manager of the Press Association whose service they may desire. It should be borne in mind by all officers and employes of the company, that the company has no ownership or voice in any of the Press Associations; that it is in nowise responsible for their management or for news served by them, or for their action in giving or withholding franchises or rights to the news, or the privileges of publishing or using it.

Rule 26. *Not to Act as Press Agent.*—No employe of this company will be permitted to act as agent or correspondent of any newspaper or Press Association except on extraordinary occasions, and then only by the direction or approval of his superintendent.

Rule 27. *Forwarding Dispatches.*—When, for any cause, a dispatch of any Press Association cannot be forwarded to the point addressed, managers should endeavor to forward such dispatch to the care of the nearest general office or agency of the Press Association addressed, with such notation as may be necessary for intelligent action on the part of the agent receiving it.

BOOK II

THE TELEPHONE

CHAPTER I.

THE TELEPHONE. THE SWITCH BOARD.

The telephone is an instrument which, through the agency of electricity, transmits sound, more particularly speech, from one point to another distant point.

In order to understand in a general or elementary way how this is accomplished, it is necessary first of all to have a general idea of what sound is.

Sound is the sensation produced through the ear which sensation is caused by vibrations of the air or other medium. The simplest illustration is a tuning fork which when struck vibrates and these vibrations produce sound. The vibrations are conveyed to the ear by a medium which may be the air or a gas, or a liquid, or an elastic solid. There must, however, be a medium for the transmission of sound; it cannot live in a vacuum. The vibrations produce in the medium (air for instance) waves which propagate in all directions at a speed dependent upon the nature of the medium and its temperature. The velocity of sound in the air at freezing point is nearly 1,100 feet per second increasing slightly with rising temperature; in gases other than air the velocity varies inversely as the square root of the density; in liquids it is greater than in the air—in the case of water it is four times as great as in the air; in solids the velocity varies, being relatively small in in-elastic substances, such as wax and lead and great in wood and steel. Sound waves are not uniform; they differ in sevral ways: (a) in their length (i. e., the number of vibrations per second), (b) in the amplitude of the motion of the particles forming them and (c) in their form (i. e., whether they are "simple" consisting of a series of pendulum-like vibrations, or "compound" consisting of several such series superimposed on each other). The length of the sound waves produces pitch—if long (i. e., the number of vibrations low) the pitch is low; if the length of the waves is small (and the number of vibrations consequently great) the pitch is high and shrill. Vibrations must be as high as twenty-four in a second or the ear does not unite them as a continuous sound; if they exceed thirty thousand to forty thousand per second they cease to produce sensation upon the ear.

The intensity or loudness of sound depends upon the amplitude of the vibrations—it diminishes with the square of the distance from the body emitting the sound; it also diminishes as the density of the medium decreases and is increased by the proximity of a sonorous body which can vibrate in unison with it. Sound differs in quality or timbre as for instance the difference in the same tone sounded upon different musical instruments. This is because notes produced on musical instruments are generally compound notes consisting of the fundamental note, the pitch of which the ear perceives, and with it a number of higher notes of small intensity whose vibrations as compared with the fundamental note are usually as the numbers 2, 3, 4, 5, 6. These upper notes blend with the fundamental note, and upon their number and relative intensity the result and combined effect upon the ear or quality of the note depends. Sound waves may be reflected from an opposing surface, as in the case of an echo, or they may be refracted or change their direction in passing from one medium to another of different density; they may also be interfered with so as to cause pulsations of sounds called beats.

As to electricity, the agent by which sound is transmitted by means of the telephonic apparatus, it has as yet never been defined; though once believed to be a fluid or some form of material substance that theory has been abandoned and all that can be said of it is that it is one of nature's many forms of energy; although we speak of the "current" and the "flow" of electricity such terms are misleading and are the result of the original misapprehension which regarded electricity as a fluid. One of the greatest electricians of our day, Elisha Gray, thus graphically and simply described the electric current. "When you were a boy did you never set up a row of bricks on their ends, just far enough apart so that if you pushed one over they all fell, one after another? Now, imagine rows of molecules or atoms, and in your imagination they may be arranged like the bricks, so that they are affected one by the other successively with a rapidity that is akin to that of light-waves, and you can conceive how a motion may be communicated from end to end of a wire hundreds of miles in length in a small fraction of a second, and no material substance has been carried through the wire—only energy. We do not mean to say that the row of bricks illustrates the exact mode of molecular or atomic motion that takes place in a conductor. What we mean is, that in some way motion is passed along from atom to atom."

Electricity, as we know it, is classified as "Static" and Dynamic." Static Electricity is that which is stationary as when stored in a

Leyden jar. Dynamic electricity is that which is in motion—a closed telegraphic current is charged dynamically while the prime conductor of a frictional electric machine is charged statically.

It will be seen from the elementary description of sound already given that when one utters a spoken word the air is thrown into vibrations and waves flow out and that each sound has a different form and every word creates a different effect on the air. The problem is to transmit the sound waves.

This is accomplished through the effect on an induced alternating or pulsating electric current acting upon a diaphragm at the receiving point, a direct current of approximately six volts, from a primary or a storage battery at the sending end passing through the transmitter. The voice of the person desiring to transmit a message is directed against a diaphragm in the transmitter which diaphragm owing to the rapid vibrations of the human voice and through its quick response to these vibrations, changes the direct current from the battery of a pulsating current. This pulsating current is stepped up to a higher frequency by means of an induction coil, introduced between the diaphragm and the line, and acts directly upon a receiving diaphragm bridged across the circuit at the distant end. In this way it is found possible by means of the telephone to reproduce sounds and even intonations of the voice at a distance of 1,500 miles or more under favorable conditions.

Elisha Gray, one of the inventors of the telephone, thus describes its construction in its simplest form:* "Take a piece of iron rod one-half or

*Nature's Miracles. Vol. III.

three-quarters of an inch long and one-quarter inch thick, and after putting a spool head on each end to hold the wire in place, wind it full of fine insulated copper wire; fasten the end of this spool to the end of a straight-bar permanent magnet. Then put the whole into a suitable frame, and mount a thin circular diaphragm (membrane or plate) of iron or steel, held by its edges, so that the free end of the spool will come near to but not touch the center of the diaphragm. This diaphragm must be held rigidly at the edges.

"Now if the two ends of the insulated copper wires are brought out to suitable binding screws the instrument is done.

"The permanent steel magnet serves a double purpose. When the telephone was first used commercially, the instrument now used as a receiver was also used as a transmitter. As a transmitter it is a dynamo-electric machine. Every time the iron diaphragm is moved in the magnetic field of the pole of the permanent magnet, which in this case is the free end of the spool (the iron of the spool being magnetic by contact with the permanent magnet), there is a current set up in the wire wound on the spool; a short impulse, lasting only as long as the movement lasts. The intensity of the impulse will depend upon the amplitude and quickness of the movement of the diaphragm. If there is a long movement, there will be a strong current, and vice versa. If a sound is uttered, and even if the multitude of sounds that are required to form a word, be spoken to the diaphragm, the latter partakes in kind of the air-motions that strike it. It swings or vibrates in the air, and if it is a perfect diaphragm, it moves exactly as the air does, both as to amplitude and complexity of movement. There are hundreds and sometimes thousands of superimposed motions in the tones of some voices that give them the element we call quality. All these complex motions are communicated by the air to the diaphragm, and the diaphragm sets up electric currents in the wire wound on the spool, corresponding exactly in number and form, so that the current is molded exactly as the air-waves are. Now if we connect another telephone in the circuit, and talk to one of them, the diaphragm of the other will be vibrated by the electric current sent, and caused to move in sympathy with it and make exactly the same motions relatively, both as to number and amplitude.

"It will be plain that if the receiving diaphragm is making the same motions as the transmitting diaphragm, it will put the air in the same kind of motion that the air is in at the transmitting end, and will produce the same sensation when sensed by the brain through the ear. If the air-motion is that of any spoken word it will be the same at both ends of the line, except that it will not be so intense at the receiving end; it is the same relatively. And this is how the telephone talks."

The original telephone, that of Bell, devised in 1876, was simple, consisting of a magnet provided with an extension iron pole piece, about which pole piece was wrapped a few turns of insulated wire. The placing of a thin diaphragm in front of the pole piece and separated from it by a small air gap completed his invention. If the diaphragm were spoken against, it would be thrown into vibration in nearly exact accordance with the air waves striking it; this diaphragm being made of iron, by its change of distance from the pole piece, permits of a greater or lesser flow of magnetic force through the coil of wire on the pole piece and changing the field of magnetic force through a closed coil set up in it electrical currents which are directly proportional to the rate of change of magnetic force. Consequently the varying current will increase or decrease the magnetic field and vary the pull upon the diaphragm and these vibrations being reproduced upon another diaphragm connected electrically at a distance and corresponding with the sound waves spoken, the speech is reproduced and the effect on the ear drum of the listener will be the same as if he stood by the speaker. The original Bell instrument was inadequate because of faintness of transmission.

Shortly after Bell's invention Berliner and Edison evolved an improved transmitter, which depends upon the variable resistance of two bodies placed loosely in contact when subjected to changes of pressure. The most successful forms of transmitters make use of the variable resistance between two carbon electrodes separated by means of carbon granules. It has been found that if one of these electrodes be connected to a diaphragm which is spoken agaist, the resistance of the carbon will vary in accordance with the pressure upon the electrodes and therefore with the condensations and rarefractions in the air waves striking the diaphragm. A current of electricity from the battery flowing through this contact will, it is clear, be varied in exact accordance with the sound waves striking the diaphragm. The receiver diaphragm will perform the same evolution as the transmitter diaphragm and thus speech will be reproduced. These diaphragms take up even the minute over tones of the voice as is evidenced by the fact that particular voices can be clearly distinguished.

The reasons for the use of a permanent magnet in the telephone receiver is that otherwise the received sounds would be an octave above the sounds at the transmitting end; also because the amount of movement of the diaphragm for a small charge of current is within practical limits proportional to the strength of the permanent magnetic field.

The secret of a good transmitter is said to be in the arrangement and treatment of the carbon electrodes and carbon granules and it required many years of experiment before an efficient and durable grade of carbon was produced.

While telephone currents are not of large magnitude, yet because of their high frequency, the distorting and attenuating effects of self induction and capacity are marked. Therefore in long aerial lines and cable lines the distributed capacity must be at the minimum. Care must be exercised not to place impedance in improper places in a telephone circuit or choking effects may be produced on the current or if the line is so long that the transmission assumes a wave form serious reflections of current from improperly placed impedance coils may result.

To have accomplished the fact of a person at one end of a wire being able to speak to another person at a distance over this wire was much; but had the art of telephony rested there, it would have been at best a toy or available only in the most limited way. To be of practical use to the commercial world it must be generally available for intercommunication between all those located within a certain radius or district. To accomplish this it was necessary that for each district there should be a Central Office, a sort of brain from which the lines, like nerves, should radiate and where the different lines could be brought together quickly and effectively. The switch board is the means by which these connections are made.

The type of switch board in general use is what is known as the "Common Battery System," which is very fully described in the following.*

"In a modern common battery office the lines are brought in underground in large paper insulated cables. These cables are made up of twisted pair wires insulated with spiral wrappings of paper and the whole enclosed in a continuous lead sheath. As many as 600 pairs of wires are sometimes placed in a single cable. The reason for using a paper insulated and lead covered cable, is, first, because of its low cost and second, that with a paper insulation we obtain a very low mutual static capacity of each pair of wires. This low capacity is necessary in order not to seriously attenuate or distort the high frequency telephone currents traversing over the circuit.

"The wires from the underground cables are ended in what is known as a main distributing frame. On the terminating end of each pair of wires is placed a carbon plate lightning arrester and a fuse known as a sneak coil. The function of the carbon plate arrester is to discharge to ground any foreign current having a potential of more than 400 volts. If a current over .4 of an ampere flows in the line this coil will heat up and melt a small block of fusible metal which causes the releasing of the line spring and the opening of the line to the switchboard.

"The telephone lines after passing through the arresters are carried through loose wires, known as jumpers, to the opposite side of the main distributing frame and then to the intermediate frame and from there straight to the switch board.

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*Extract from a paper read by Mr. S. P. Grace before the Electric Club, Pittsburg, Pa.

"The object of the main frame is to allow the changing of the wires upon which a subscriber's line enters, without being obliged to change the number of his telephone instrument. The object of the intermediate frame is to permit of any telephone line being answered at any position of the switchboard, which is desirable in order to equalize the load on the different operators. Ordinarily each operator is obliged to answer from 100 to 200 lines. Your telephone line will enter the switch board and appear at some position in a switch which is known as an answering jack. Directly above this answering jack is placed a small incandescent lamp, known as a line lamp. Your telephone line, besides appearing in an answering jack at some operator's position, will also appear in what are known as the multiple jacks in every third position of the entire switch board.

"The question has often been asked how one operator at a switch board can make connections with a telephone line which is answered by some operator probably 100 feet away. The explanation is simple. Each telephone line, besides appearing in front of a certain operator, is, as stated above, multiplied in front of every third operator, and is therefore within easy reach of all the operators. In a large switch board there are sometimes as many as 30 jack switches for a single line into any one of which an operator may plug and make connection with the line and therefore the subscriber connected with it. Each telephone operator is provided with a number of flexible cords on the ends of which are placed plugs which can be inserted into the answering and multiple jacks. The operation of the modern common battery relay switch board is as follows:

"When a subscriber removes his receiver from the hook, immediately a small incandescent lamp lights in front of his operator. The operator will insert one of her plugs into the answering jack directly under the lamp, which by this operation will be automatically put out. She will then, by means of a listening key, connect her telephone circuit with the cord and plug used in answering, and will inquire the number wanted. She will then take the other plug connected with the same pair of cords and will reach up in the multiple and touch the jack switch of the subscriber's line wanted. If the subscriber's line wanted should be in use, the operator will be apprised of the fact by a sharp click in her ear, which signifies to her that this line is plugged in some other part of the switch board and is therefore "busy." This is one of the very necessary features of the multiple system since it prevents two or more operators from connecting with the same line at the same time.

"If the line is not busy, the operator will plug into the jack switch and will send a signalling current over the line which will ring the called subscriber's bell. Until the called subscriber answers, a small lamp, known as a supervisory lamp, which is associated with the calling plug, will remain lighted. When the subscriber answers, this lamp is automatically put out. When both subscribers are through talking and hang their receivers on the hook, the supervisory lamps on both the front and back cords will be displayed, which is a signal to the operator that that pair of cords, and consequently the connected lines, are no longer in use. She will then remove the plugs from the jacks which operation automatically puts out the supervisory lamps.

"Should the subscriber wanted be in some distant office, it is only possible to make the connecing the local instruments have been explained in detail, because most systems, both for long and short distance work, use coherers, and the local circuits must always be handled in the same way. The utmost care and patience must be used. Experience with ordinary telegraph instruments is of but little value in making the extremely delicate adjustments necessary when using wireless telegraph instruments.

An American method of connecting the local circuit, which has not previously been published, is shown by Figure 7. It is free from many of the difficulties and objections of the European method shown in Figure 5. The American method was used in September, 1900, in telegraphing between Fire Island lighthouse and Fire Island light ship, a distance of ten miles. The work was carried out at the expense of the Signal Corps by a civilian electrical expert. This was the first time wireless telegraphing over a considerable distance had been accomplished in America. Marconi had not yet used his instruments to report international yacht races, and only rumors, without detail, had reached us of his methods used in England. By referring to Figure 7 it is seen that the relay is normally closed. The inductive resistance R is very large, so that the current is very small and divides between the coherer j and the relay. Since the coherer resistance is normally very large, practically all of the current goes through the relay. Upon the decrease of the resistance of the coherer, caused by the signals, the current is largely shunted through the coherer and away from the relay. The relay then releases n and the tapper and printer are operated by the battery r. The advantage of this method is that the action of the relay causing local disturbances in the circuits battery transmission, the "repeating coil" and the "retardation." The repeating coil system is the one most generally used. It is shown diagramatically in Fig. 1. In this system one large storage battery is used as a source of current for all the lines. When two telephone lines are connected, it is done by means of a flexible cord in which cord is placed a repeating coil or transformer, each winding of which has the same number of turns. The centers of these coils are connected to the poles of the main battery, as shown in Fig. 1.

"It is apparent that any change of current in either branch caused by a variation of the transmitter resistance will, by reason of the mutual magnetic reaction of the repeating coil, induce similar currents in the other branch of the circuit. We will then have a variable curent of alternating character superimposed on the direct current in each branch of the circuit. This superimposed alternating current represents the energy of the speech transmission. Since the resistance of the main battery is very low, there will be no appreciable change of potential over its terminals due to a variable curent in any line, and we may therefore connect as many repeating coils, and consequently the same number of lines, without fear of there being cross-talk from one line to another.

"The following describes briefly the various operations which take place in the connection and conversation betwen two subscribers located in the same office. At the left of Fig. 2 will be observed a wiring diagram of a subscriber's telephone. This telephone may be a wall set, a desk set, or any one of the numerous types which are now in use for special cases. The apparatus in the telephone is practically the same in all cases and consists of a

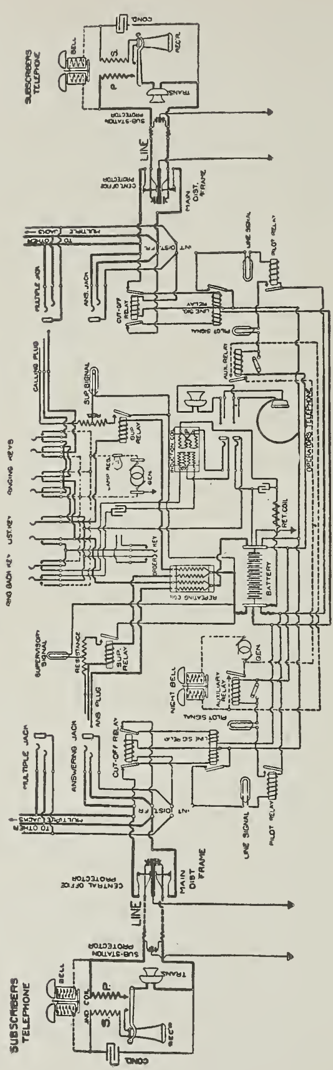


Fig. 2

DIAGRAM OF COMMON BATTERY SWITCHBOARD CIRCUITS.

transmitter, a receiver, an induction coil, a condenser, a polarized bell and a hook switch.

"The functions of the transmitter and receiver have already been explained. The induction coil, which is nothing more than a small transformer, is used so that the receiver may be taken out of the line circuit, which carries the current for the transmitter battery. From Fig. 2 it will be noticed that the receiver is in a secondary circuit closed through a condenser. It has been found that direct current through the receiver is liable to demagnetize the permanent magnet and also injure the diaphragm.

"The condenser is placed in the instrument in order that the two sides of the line circuit may be kept open to the direct current which tries to flow from the central office main battery, thus preventing the operation of the line signal relay at central. The operator can ring the polarized bell at the subscriber's telephone through the two microfarad condenser since for ringing purposes single-phase alternating current is used which passes readily through the condenser. From the subscriber's telephone the line passes through open wires or through a pair in a cable to the protectors on the main distributing frame at the central office.

"The underground and outside wire plant of a large telephone exchange is very extensive and great skill is required in the proper designing and constructing of the underground conduits, pole lines and aerial cables so that a high insulation may be maintained on all the lines and so that the wire plant will be valuable for use at any point where service is demanded. It is clear that no matter how good instruments or switch boards may be, without good line construction, poor service will result. The best practice of to-day recommends that as much of the wire plant as is economical will be placed underground and that where the distribution is not heavy enough to warrant underground conduit, the wires will run in aerial cables on short heavy pole lines.

"After the line reaches the main frame it passes to the intermediate frame and then over to the relay rack, where both sides of the line are connected through the contacts of the cut off relay to line relay and the main office battery. At the intermediate frame a branch is taken from the line and connected to all the multiple jacks in the switch board corresponding to the line number. One branch of the line is also connected to an answering jack in some particular operator's position.

"It will be observed that in the switch board three wires and three jack and plug contacts are used for each line. Two of these wires are for the talking circuit, the third being a signaling or controlling circuit for the operation of the various relays, signal lamps, etc., which are necessary for a proper supervision of the connection. Let us observe what will happen when the subscriber removes his receiver from the hook. The rising of the hook will close the contacts of the switch and close the line at the subscriber's station through the transmitter, the primary of the induction coil, and the hook switch contacts. The line being now closed will permit of current flowing through it from the main battery, and since the line signal relay is inserted serially in this circuit at the central office its armature will be attracted which, closing a secondary circuit, will cause the lighting of the line lamp in the face of the switch board adjacent to the answering jack of the subscriber who has called. The lighting of the line lamp is practically simultaneous with the removing of the receiver from the hook.

"As previously stated the operator is provided with a number of pairs of double-ended plugs and cords which are so wired as to permit of the connection of two subscribers' lines. Upon seeing the line lamp light the operator will pick up a plug connected to one of her answering cords and insert it into the answering jack associated with the lighted line lamp. The inserting of the plug in the answering jack causes a flow of current in the controlling, or third wire, circuit. It will be noticed that this current in the third wire flows through the cut-off relays, thus causing its armature to attract and open the circuit through the line lamp. This causes the extinguishment of the line lamp automatically. As the subscriber has his receiver off the hook the line is closed at the telephone, and as soon as the plug is fully inserted the line current. which the instant before was broken by the cut-off relay, is re-established through one-half of the repeating coil and the cord circuit. The current flowing in the main line will cause the operation of the 10-ohm supervisory relay which is placed in series with one side of the cord circuit. This relay being operated will connect the 40-ohm shunt around the supervisory lamp which therefore will not receive sufficient current to be illuminated. The operator will now depress her listening key which will connect her telephone set in parallel with the cord circuit which is connected to the subscriber's line. She will now speak into her transmitter and obtain from the subscriber the number wanted. The operator's set is practically the same as an ordinary telephone, but arranged with switching devices so that it may be connected to the various cord circuits.

"Upon receiving the number wanted the operator will take the calling plug of the same pair of cords and reaching to the multiple jack of that number will touch the sleeve of the jack with the tip of the plug. In Fig. 2 the called subscriber's line is represented at the right of the diagram. If the subscriber's line wanted is plugged at some other part of the board the potential of the sleeves of all the multiple jacks of that line will be raised above the earth and under this condition if the sleeves of any of these multiple jacks are touched by the tip of a plug there will be a rush of current through the cord circuit which will cause a click in the operator's ear and thus inform her that the line is "busy." If the line wanted is not busy, which would be indicated by silence when the tip of the plug is touched to the sleeve of the jack, the operator will fully insert the plug and depress one of her ringing keys connected to the cord. This will send a single-phase alternating current over the line of the called subscriber through the condenser and bell located in his telephone. The ringing of the bell will summon the called subscriber to his telephone.

"The insertion of the calling plug has operated the cut-off relay and will prevent the called subscriber from flashing his line lamp when he answers the call. However, until the called subscriber answers the supervisory relay connected with the calling plug will not be operated and therefore no shunt will be around the supervisory lamp. The supervisory lamp will thus be illuminated and will clearly indicate to the operator that the called subscriber has not answered. She will therefore keep on ringing until he answers or finally sends back a "don't answer" report to the calling subscriber. Should he answer, current will flow through both sides of the line from the right-hand half of the repeating coil and will operate the supervisory relay which will shunt the supervisory lamp and cause it to be extinguished. The connection now being completely established, the two subscribers will converse with each other on the principles outlined in describing Fig. 1. When the conversation is finished and both subscribers hang up their receivers, both lines will be opened at the hook contacts and the supervisory relays will release. This will remove the shunt from around the supervisory lamps and cause them to be illuminated. The lighting of the supervisory lamps connected with the cord circuits indicates to the operator that the conversation is finished. She will then remove the plugs from both the answering jack and the multiple jack and all circuits will return to normal and all lamps will be extinguished.

The circuits described show the connections which take place for local connections between two subscribers connected with the same office. In a modern telephone system in a large city this is only one of the many hundreds of circuit combinations which must be used. Suitable trunks and signals between relay office are provided for local connections and for toll connections, also trunks between long distance boards and local boards, order wire circuits and ringing circuits to private branch exchanges, etc. So many are the circuit combinations that a complete description of them is practically impossible."

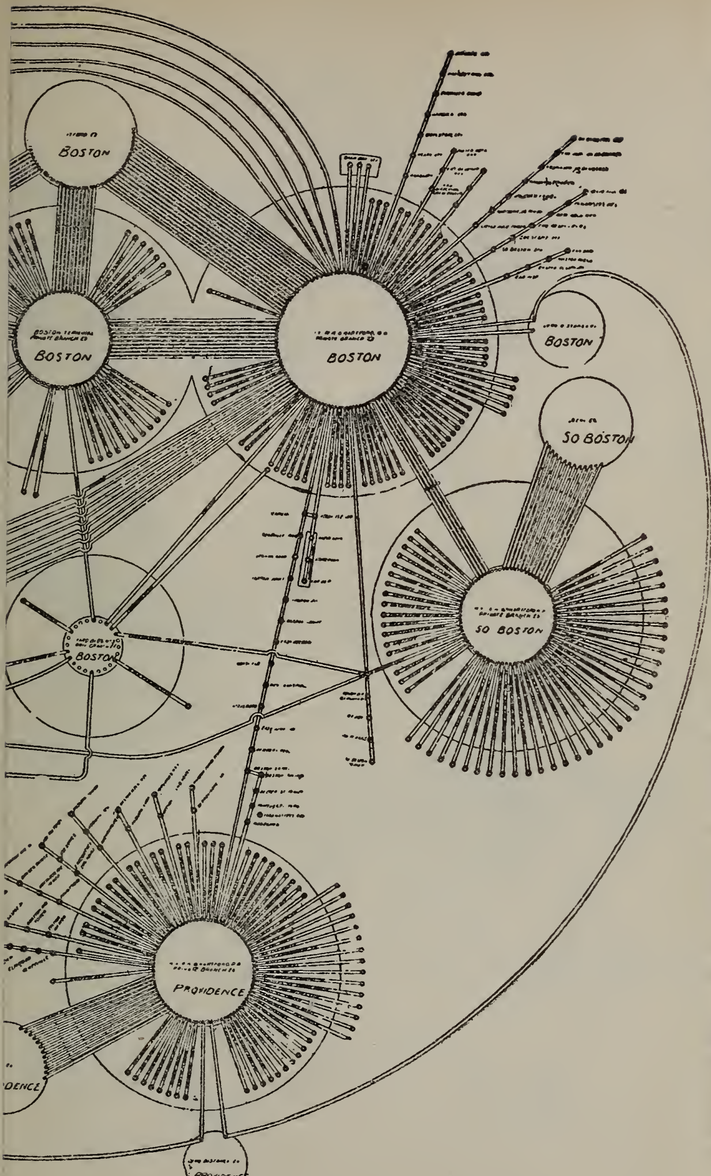
CHAPTER II.

APPLICATION OF THE TELEPHONE TO RAILROAD BUSINESS.

With the adoption of the telephone by business institutions generally it was natural, nay necessary, that it should enter into daily use by railroads. But for some years its use by railroads was limited to those departments and offices which had business dealings with the public. With the improvements made in the instrument, the reduction in cost of operation and the benefits apparent from its limited use with the public, the railroads discerned in it an appliance that would be of the greatest benefit to them in their internal administration, and in time the telephone service was extended to outlying offices, freight yards, towers, switch cabins, etc., indeed, to every point to which it was of advantage to have quick and easy communication and which would relieve the overburdened telegraph.

At this time the telephone is put to many uses. It may be said to be the principal adjunct of the ticket business and at freight yards, connecting as it does the various houses and yard points, it has become essential to the rapid manipulation of freight. By its use consignees are often notified of the arrival of freight and thus the equipment and warehouses of the railroad company are quickly relieved of their burden and their capacity correspondingly increased, while the public is widely benefited by this accelerated service.

Some of its applications and benefits are as fol-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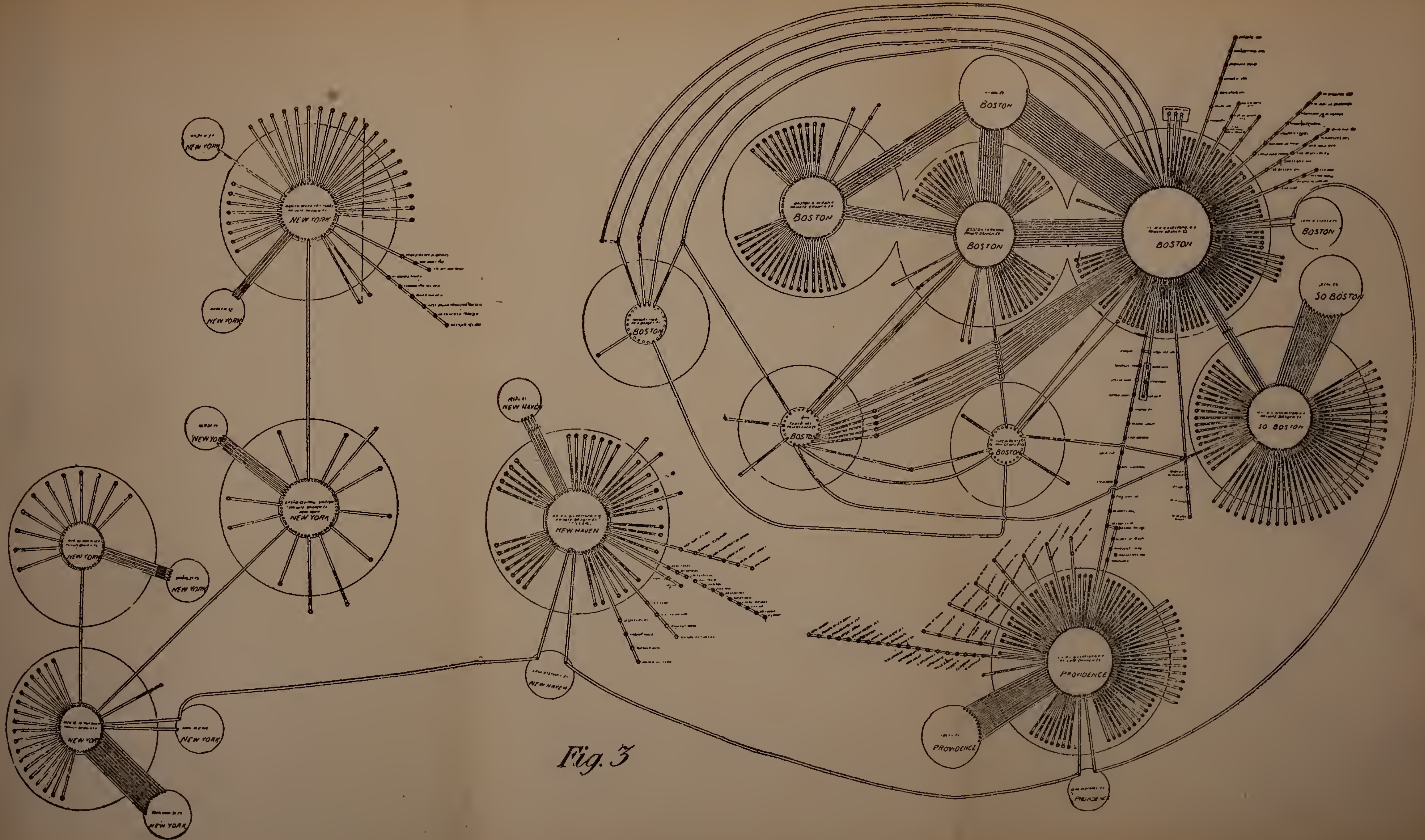
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Fig. 3

lows: By its use the transfer of freight from one road to another is accelerated; the maximum switching service is performed because of prompt advice being available as to delayed trains; cars unaccompanied by way bills are convoyed; way bill corrections are made; and officials have ready access to their subordinates, and vice versa whereever situated.

The accompanying chart, Fig. 3, will show the telephone system of a great railroad. A perusal of the diagram will show one exchange wherein something like fifty stations in one building and quite as many more outside are cared for. Another exchange takes care of the station departments, ticket agent, baggage rooms, gates, etc. So perfected is the system on this particular road that any of the general officers at headquarters is enabled to transact business with any other official or employe of the company in his office or at any of the stations on the entire length of the road.

The telephone has not, as yet, become an important factor in the operation of trains. This has been probably because the telegraph is a tried and proved servant, doing the work economically and well, but when the railroads shall have equipped themselves so that they can care for their commercial and internal office business and have appliances equal to the task, the telephone will probably appear as a rival of the telegraph in this field. The criticism now ventured against the use of the telephone is an assumed danger in communicating train orders by word of mouth. This may have been a sound objection in the early days of telephony, when the sound of the speech transmitted was faint and uncertain, but to-day, when the instrument has been so perfected that a watch tick can be heard miles away, the objection is more specious than real. Nor must it be forgotten that in itself the substitution of the telephone for the telegraph is no more radical a change than took place when reading the telegraph by sound supplanted the use of the register.

It is undoubtedly only a question of time when railroads will adopt the telephone to its fullest extent, constructing lines especially for that service, should it be necessary, so that managers and others may talk personally with any employe, whether he is far away or near; when this time comes it will be natural that the telephone should be employed in the movement of trains, especially in cases where celerity of action is necessary, as in the case of extreme density of traffic or unforseen contingencies requiring promptitude of action.

Experiments have been made in telephoning from moving trains, but it has not passed to the practical stage. Originally it was designed to use the rails for conductors, but difficulty was experienced in telephoning any considerable distance in this way. More success has been achieved in telephoning by induction over a circuit alongside the right of way.

A great step looking toward the more full adoption by railways of telephoning in the conduct of their internal affairs has been taken in the adoption of methods by which telegraphic wires can be utilized jointly for telephonic purposes.

Systems have been devised for the purpose of allowing telephone service to be added to grounded telegraph lines without requiring additional line wire or interfering in any way with the telegraph service already carried on over such lines. Such a one is described by a company which inaugurated it as follows:*

The length of telegraph line and the number of way stations with which this system can be successfully employed depend largely on the character of the telegraph line. On a short line the service is better, and more way stations can be employed, than on a long line.

The size and material of the line wire and the amount of wire in cable are the most important factors limiting the range of the system.

In arranging lines for this service it must be remembered that iron wire for telephonic transmission is much inferior to copper wire of the same size, and also that wire in cable is much less efficient than open wire. Furthermore, wires in rubber insulated cable are less efficient than wires of the same size in paper insulated cable.

To afford a general indication of the scope of the system, it can, however, be stated that it should be possible to operate it successfully over ordinary telegraph lines up to 100 miles in length, with as many as five intermediat stations.

The apparatus employed in the railway composite system consists of station sets, portable sets, terminal differentiators, intermediate differentiators, and relay condensers. The arrangement of these pieces of apparatus, and their place and purpose in the system, will now be described.

The general arrangement of the system is shown in Fig. 4.

At each terminal of that portion of the line over which telephone messages are to be transmitted is placed a terminal differentiator (No. 28 Con-

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*American Telephone and Telegraph Company.

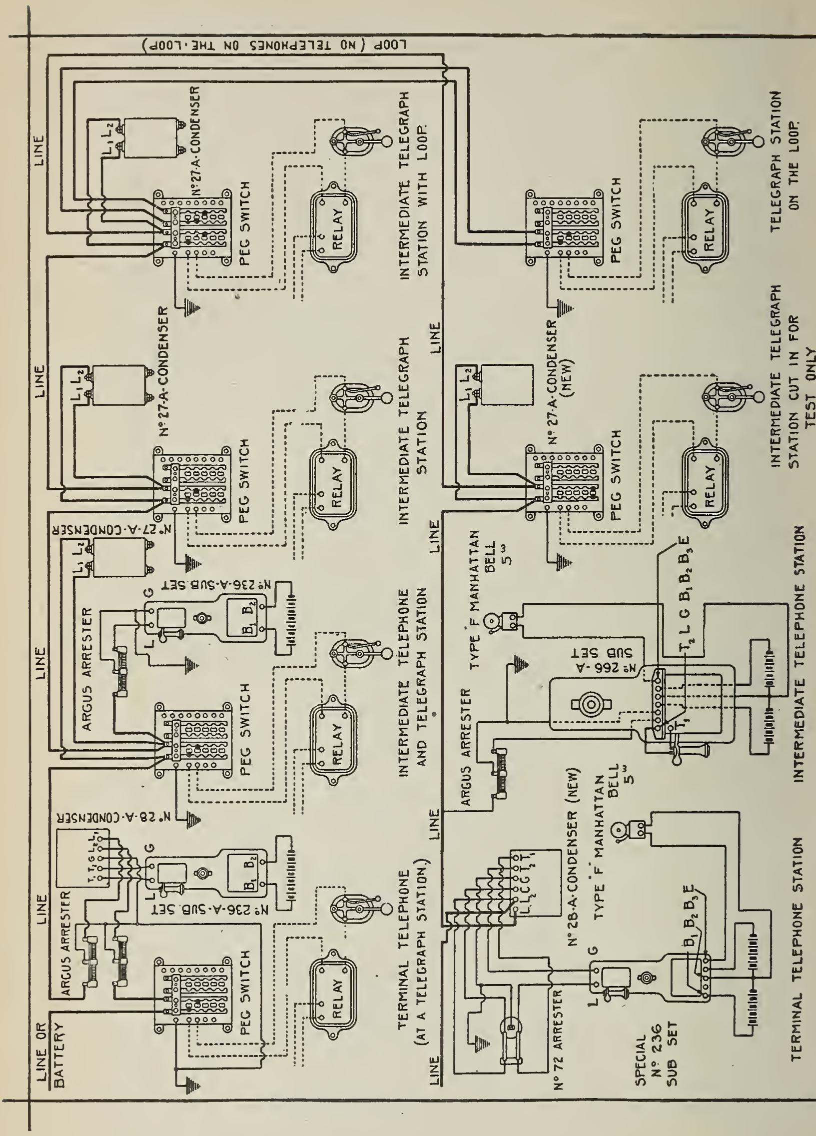

Fig. 4

DIAGRAM OF SYSTEM OF TELEPHONY IN CONJUNCTION WITH TELEGRAPH.

denser, Fig. 5), consisting of an impedance coil in series with the line wire, and a condenser from the line wire to earth.

Fig 5

NO. 28. CONDENSER.

As the telegraph battery and instruments are placed outside this piece of apparatus the Morse signals will not interfere with the telephone service, and inductive or other disturbances will not be transmitted to the telephone from portions of the line beyond the coils.

Each telegraph way station is provided with an intermediate differentiator (No. 27 Condenser, Fig. 6), consisting of a condenser and impedance coil. The impedance coil is placed in series with the telegraph relay, and relay coil and key are shunted by the condenser. This apparatus affords a by-pass through the condenser for the telephone talking and signalling currents. Were it not for this, the talking currents would be seriously reduced by the impedance of the relays and interrupted by the operation of the keys, and the telephone signalling currents would cause the relays to "chatter" or give false signals. With the improved ringing apparatus in the later types of composite sets, however, it is unnecessary to connect this impedance coil in series with the telegraph relay.

In addition to the above precautions, the relays are directly bridged by relay condensers. The latter offer such opposition to the passage of the direct telegraph currents that their presence does not in the least interfere with telegraphic signalling. At the same time they serve as a shunt for telephone signalling current, that, not passing through the bridged condenser, would affect the relay. With the improved ringing apparatus in the later types of composite sets, however, it is unnecessary to bridge the telegraph relays with this type of condenser. Each telephone set contains a condenser wired into the circuit to prevent grounding of the telegraph line.

The telephone set, in addition to the transmitter, receiver and induction coil, contains, for calling, a special interrupter, transformer and push button, and, for receiving calls, a direct current

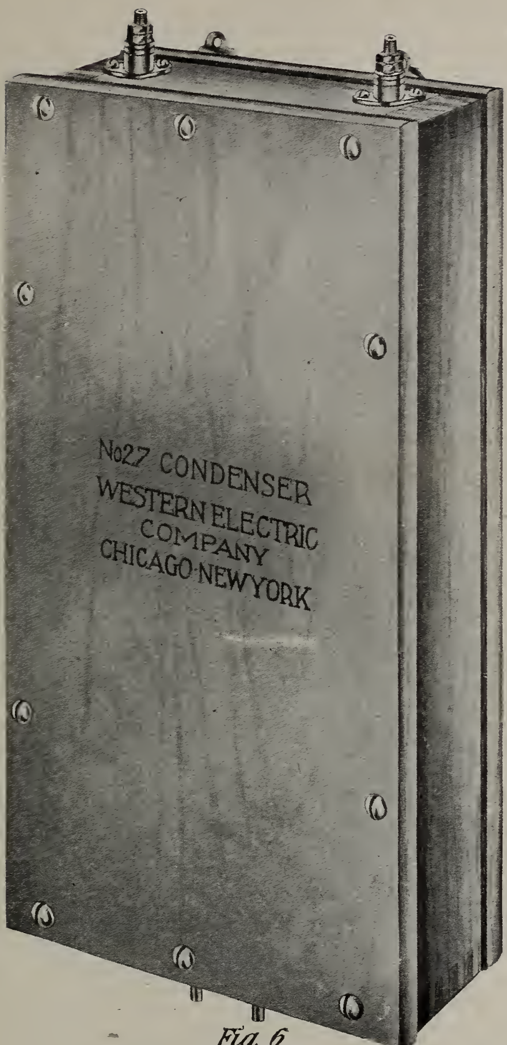

Fig. 6

NO. 27. CONDENSER.

bell, controlled by a slow-acting relay, which, in turn, is controlled by a biased polarized relay.

For signaling and talking, suitable batteries are provided at each station.

The principal methods of connecting the railway composite apparatus are shown in Fig. 4.

What is known as "Substation Set No. 236," (Figs. 7 and 8) is arranged to be mounted on the wall. A special transmitter marked C. R. C. (Composite Railway Circuit) is employed with this set. The receiver is of the standard type, but is permanently shunted by a special impedance coil, which is designed to divert from the receiver currents which, otherwise, would cause disturbing noises to be heard. This impedance coil has a movable iron core which can be moved in or out and locked in any position, thus widely varying the impedance and regulating the proportion of the current that is shunted around the receiver. If there is any excessive amount of disturbing noise heard in the receiver, the iron core of the impedance coil should be moved out, thus reducing the impedance of the coil and permitting more current to be shunted around the receiver.

On the other hand, to maintain the volume of transmission at a high standard, the amount of current diverted from the receiver should be small, as is consistent with the necessary fredom from disturbing noise. This is accomplished by withdrawing the core no further than is necessary to give the degree of freedom from noise.

The circuit of the above set is shown in drawing Fig. 9.

To call a distant station the operator presses the ringing button, which causes the circuit of the battery to be closed through the vibrator, the operation of which produces an interrupted current in

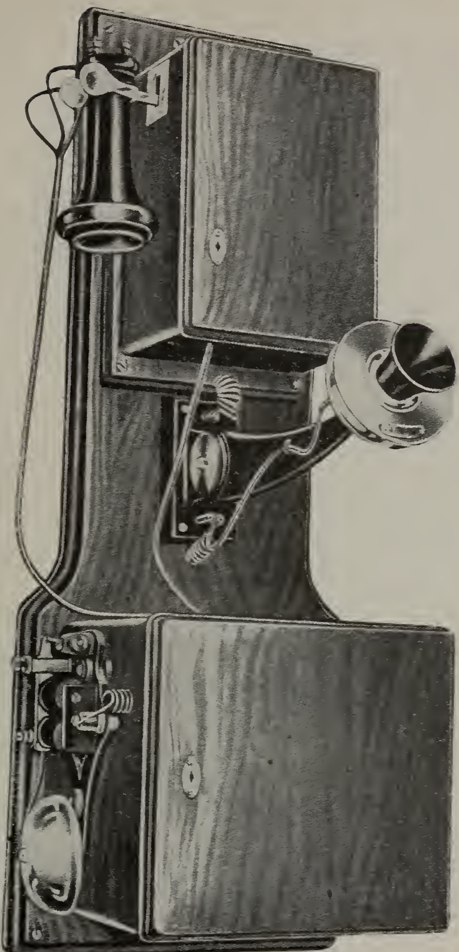

Fig. 7

SUBSTATION SET NO. 236.

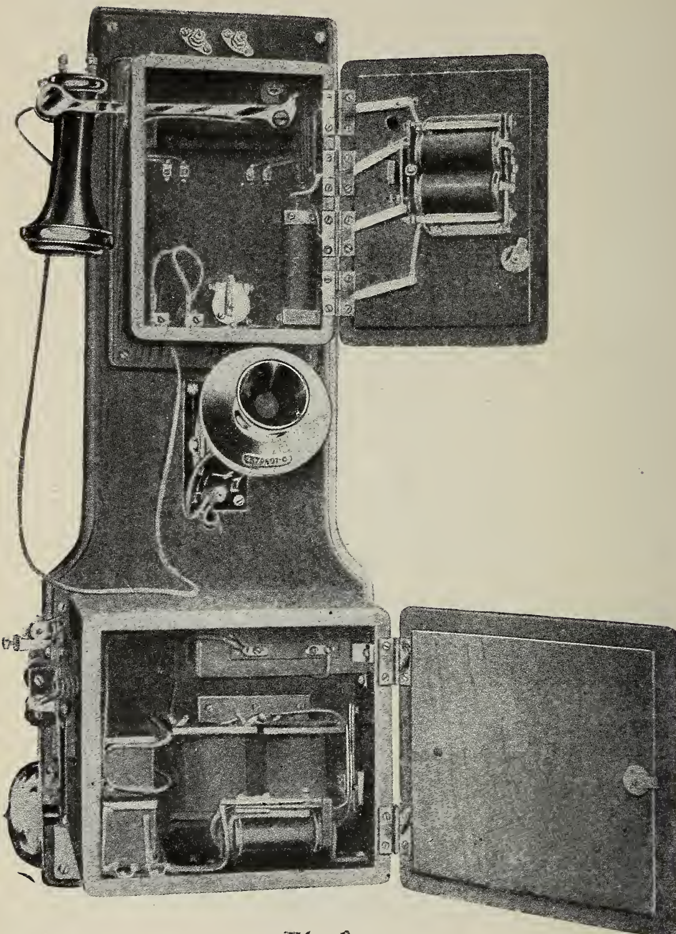

Fig. 8

SUBSTATION SET NO. 236.

Circuit
of
No. 236 Subscriber's Set.

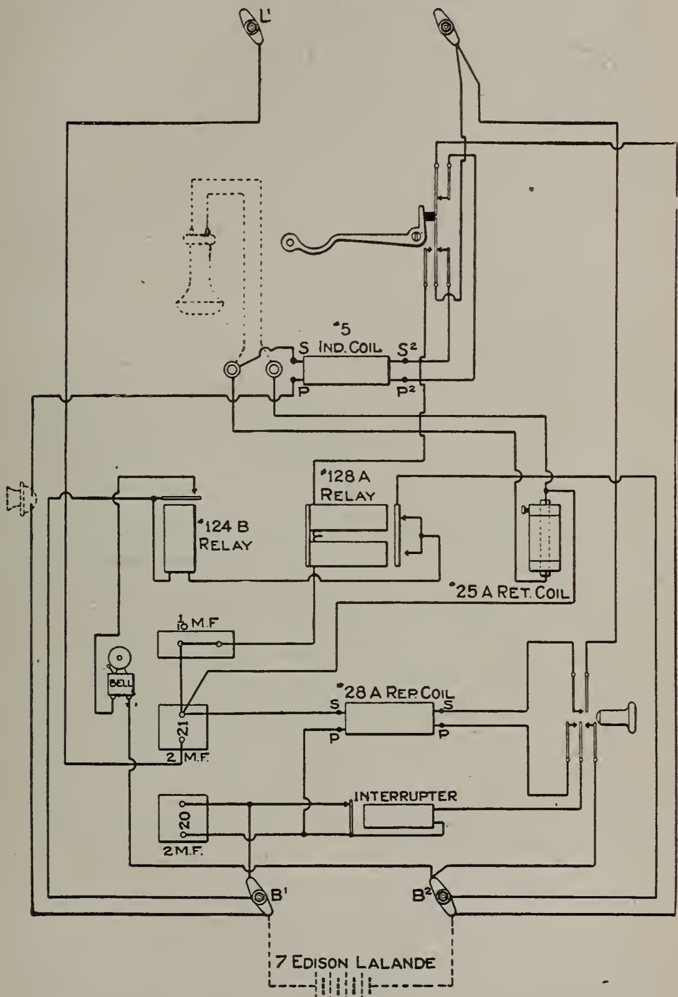

Fig. 9

the primary winding of the ringing transformer, and consequently an induced alternating current in the secondary, this current being transmitted through a condenser at any intermediate telegraph station and beyond.

At a telephone station this signaling current flows through condensers and a polarized relay to earth. This current causes the armature of the polarized relay to vibrate, thus opening the circuit which previously existed from the battery through the slow-acting relay. The armature of the relay, falling back, closes the circuit of the direct current bell, which gives the signal.

The talking circuit is of the simplest character, and requires no explanation.

The adjustment of the polarized relay is an important factor in the successful operation of the railway composite sets, as it is necessary that the telegraph currents should not cause any false signals in the telephone apparatus.

It is found desirable to give the armature of this relay a slight bias in the direction in which the heaviest impulses tend to throw it. The amount of this bias and the extent of the motion of the armature may be controlled by back contact screws.

By means of the adjustment provided to regulate the distance of the armature from the poles, a position of the armature may be readily obtained such that calls are received well, and, on the other hand, the telegraph impulses will not ring the bell.

The slow-acting relay should be so adjusted that a momentary opening of its circuit, as by a jar of the controlling polarized relay, will not cause it to release its armature.

Its retractile spring should have only sufficient tension to pull back the armature when the circuit is broken.

It has been found that the relay condensers, being a type of polarization cell, will, when first

CIRCUIT
OF
Nº 266 SUBSCRIBER'S SET

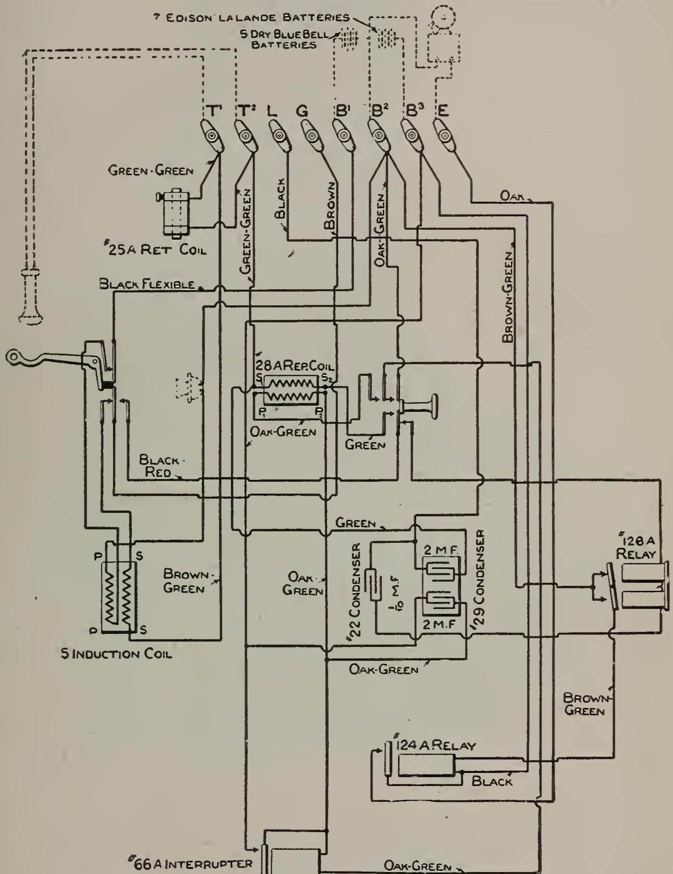

Fig. 10

placed in service, divert more or less current and interfere to some extent with the adjustment of the telegraph relays. In a short time, however, the shunting action to direct currents will disappear.

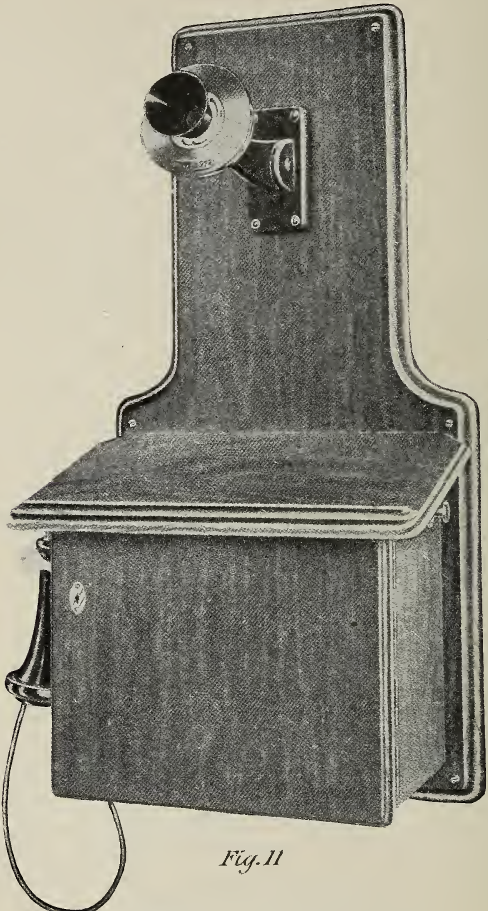

Fig. 11

SUBSTATION SET NO. 266.

In this system the sub-station batteries are required to furnish current for signaling and for talking. As the signal receiving apparatus operates on the closed circuit principle, batteries of the closed circuit type are required. A relatively large current is required to produce the outgoing signal, therefore a battery giving a large current output is necessary.

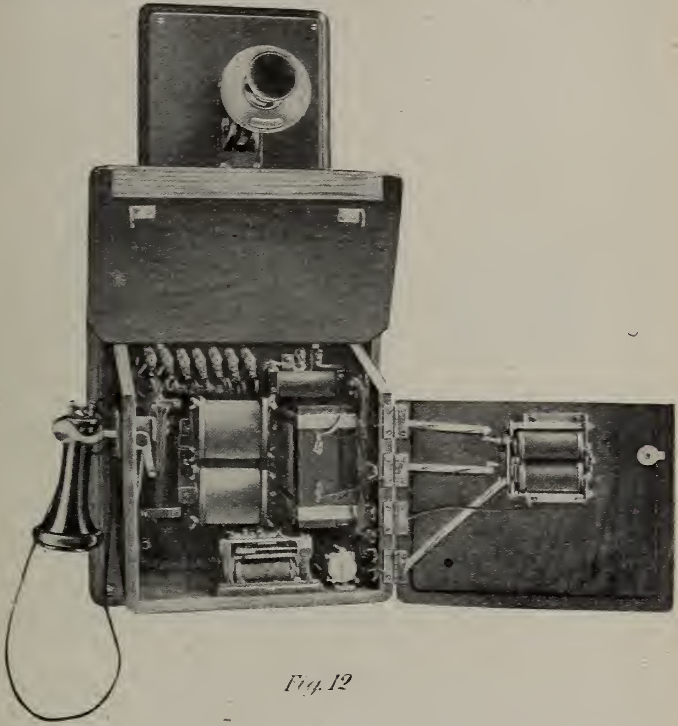

Fig. 12

SUBSTATION SET NO. 266.

It has been found that the necessary current for the purpose above stated can be furnished satisfactorily and economically by a battery of about seven Edison-Lalande cells.

What is known as "Substation Set No. 266" is essentially the same as the No. 236 already described. Slight changes have been made in the circuit wiring and assembly of the parts, as shown in drawing Fig. 10 and Figs. 11 and 12. This type of set is so designed as to permit of the use of different types of battery to supply the talking and ringing currents. By this arrangement, dry batteries can be used for the talking current, and Edison-Lalande or Gladstone for the ringing current.

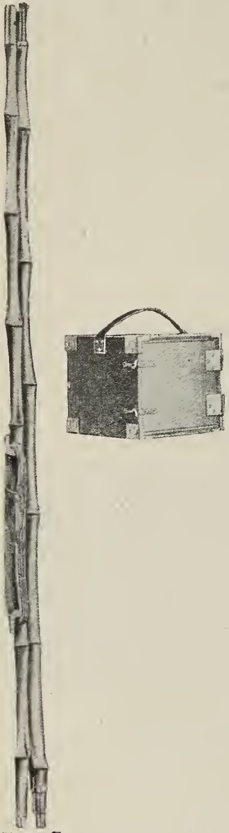

Fig. 13

PORTABLE SET NO. 265.

What is known as "Portable Set No. 265," as its name implies, is so arranged and constructed as to be easily transported. It is supplied with a handle, and when closed, all working parts are protected from external injury. A general view, showing exterior of set, with attachment pole, is shown in Fig. 13. This set is designed primarily for emergency service, and is therefore arranged to send signals, but not to receive them.

With this set a low frequency ringing generator is used for calling, despite the fact that this is liable to cause the vibration of the telegraph relays along the line. This practice is sanctioned for the reason that any occasion that would require the use of the emergency set may be considered as outweighing any inconvenience that would be caused by temporary interference with the telegraph ser-

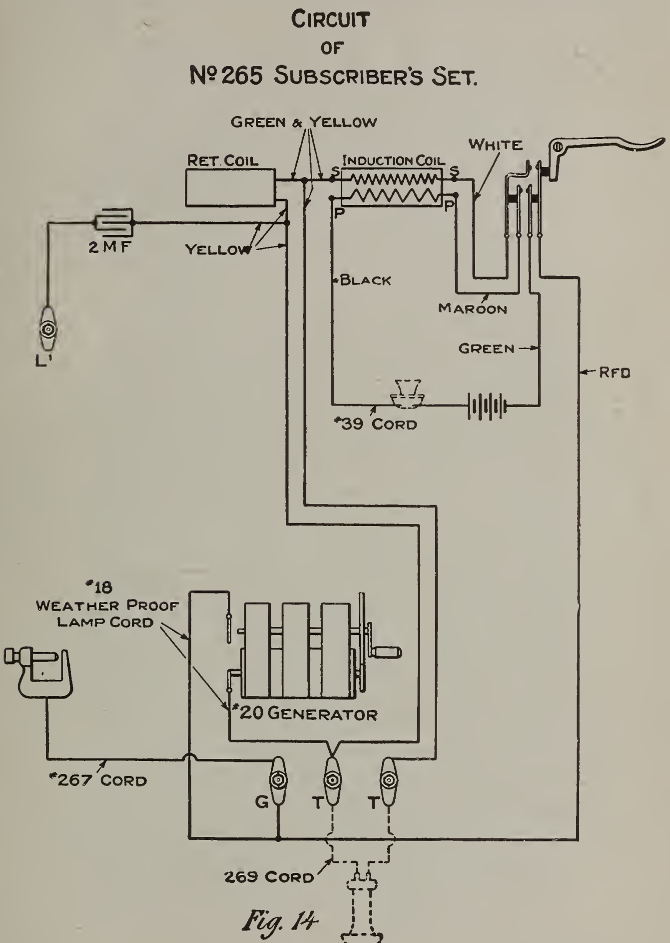

Fig. 14

vice. Moreover, by the omission of the call receiving apparatus and the vibrator and coil for signaling, the apparatus required in the portable set is materially reduced in bulk and weight. For transmission purposes, however, the portable set is nearly as efficient as the station type of set.

In order to use the set there is provided a long

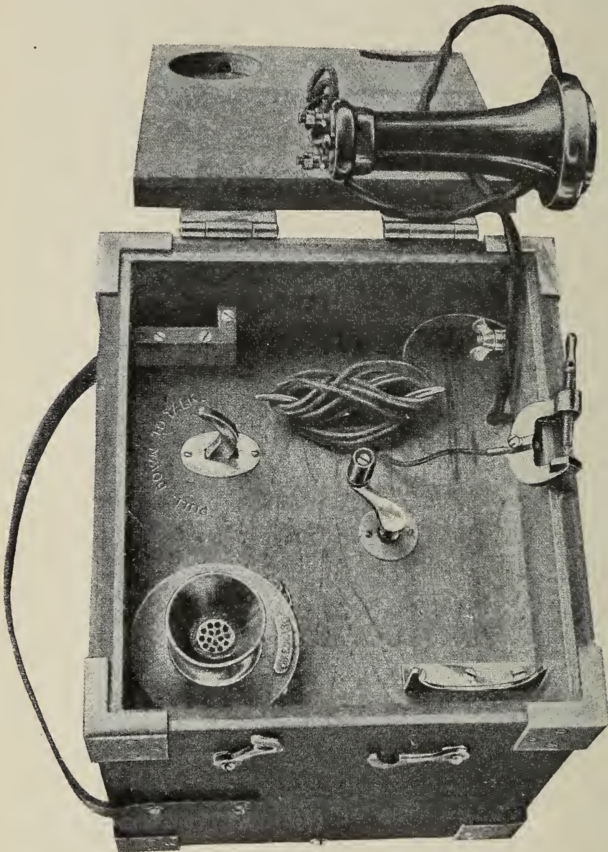

Fig. 15

PORTABLE SET NO. 265.

steel connecting cord and a pole for making connection with the line wire. The pole, for the sake of convenience, is made in sections. It has on the end a galvanized steel hook, arranged with a sprang, to make contact with the line wire without injuring it.

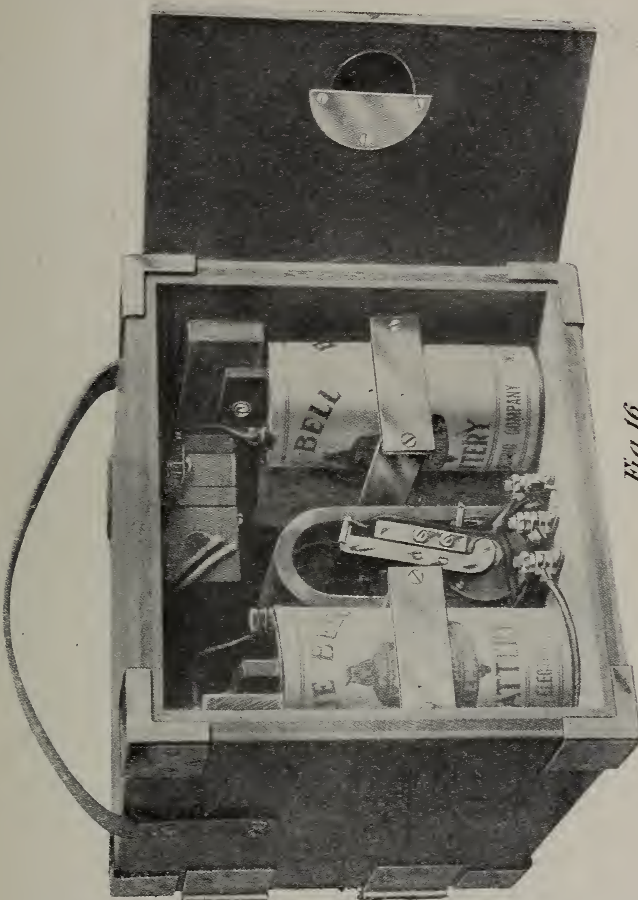

Fig. 16

PORTABLE SET NO. 265.

The earth connection of the portable set is made through a rail clamp of galvanized steel, having a ten-foot steel cord permanently attached to it.

The clamp is arranged to fit rails of different sizes.

The case in which the apparatus is placed is stoutly made and is provided with a strong leather carrying strap.

When the set is to be used it can be supported by a box, a shelf or hook, so as to bring the transmitter to a convenient height.

The set contains a hook-switch, which controls the battery circuit, and must be held down during conversation. The switch is made self-restoring, so that it will be impossible to exhaust the battery after conversation is completed.

The circuit wiring of this set is shown in drawing Fig 14, and the assembling of apparatus in Figs. 15 and 16.

Railway composite apparatus should be protected by approved lightning arrestors, placed as indicated in Fig. 4.

The following brief rules will be of assistance in locating and remedying such troubles as might be encountered in the operation of the system:

1. If transmission is poor, caution the user of the instrument to talk in a firm tone of voice with his lips close to the mouthpiece of the transmitter.

2. If transmission remains poor, look for a relay in the line which is not properly bridged by a condenser, or an exhausted battery.

3. If false signals are received, the polarized relay should be adjusted. Should this fail to remedy the trouble, weaken the retractile spring of the slow-acting relay.

4. If the bell should ring continuously, weaken the spring of the slow-acting relay and shorten the swing of its armature by screwing in the back contact screw.

5. If unable to signal other stations, ascer-

tain whether the vibrator acts when the button is pressed, and, if necessary, readjust it. If one obtains a shock after disconnecting the set from the line by touching the line and ground binding posts of the set with the fingers, while the ringing button is pressed, it indicates that ringing current is being generated. If no shock is felt, the contacts of the hook switch and the push button should be cleaned. If this does not clear the trouble, look for broken wires.

6. If the ringing current goes out to the line, but the bell at the called station fails to respond, the polarized relay at the latter station should be readjusted.

7. If the telegraph line tests grounded, the trouble may be traced either to the arrestor, ground or defective condensers in the telephone set. First the ground wire should be removed from the arrestor. If this clears the ground, then the arrestor should be cleaned or replaced. If the trouble is not in the arrestor, then the line wire should be disconnected from the telephone set. Should this clear the trouble, then the ground may be traced to the No. 22 condenser, which should be replaced. If the ground only occurs when the telephone is removed from the hook, then the No. 29 condenser is defective and should be replaced. Should either condenser be found defective, any available condenser should be inserted between line and telephone set until the condenser in the set can be replaced.

CHAPTER III.

THE AUTOMATIC TELEPHONE.

Some years before the expiration of the Bell patents ingenious inventors secured patents upon an automatic telephone apparatus. Like most inventions, they were at first crude and imperfect, but they have been improved and developed until they have become a practicable and serviceable utility. As the name indicates, in the operation of this telephone the operator at the switch board has been eliminated and the communication between the speakers, no matter how many instruments (stations) there may be in the system, is effected entirely by mechanical means.

The development and practical utility of the automatic telephone entitle it to thoughtful attention. Illustrations are given herewith of its workings in connection with subscriber's station (Figs. 17, 18 and 19); the switch at the central office, which is connected to the telephone by metallic circuits (Fig. 20), and a small automatic switch board showing how the switches are mounted on shelves (Fig. 21).

The system is claimed to be adaptable to exchanges of all sizes, no matter whether the switch board be required to handle the business of one hundred or one hundred thousand or more subscribers. The smallest switch board manufactured is known as the one hundred type; that is to say, it has an ultimate capacity of one hundred lines, though any number less than one hundred may be connected in the beginning and additions made later by installing new switches and telephones as new lines are put into service.

The automatic telephone, and the method of calling, in an exchange of the size mentioned may

Fig. 17

AUTOMATIC TELEPHONE—SUBSCRIBER'S STATION.

be described as follows: The telephone (taking the wall instrument for example) differs from the ordinary telephone only in that it has a calling device mounted on the inside of the telephone (See

Fig. 18) which is connected to the center of a dial on the front of the telephone by a revolving shaft. This calling device may be said to consist in the main of a circuit breaker which, actuated by the dial in rotation, grounds the vertical and rotary lines, thereby energizing the relays and magnets

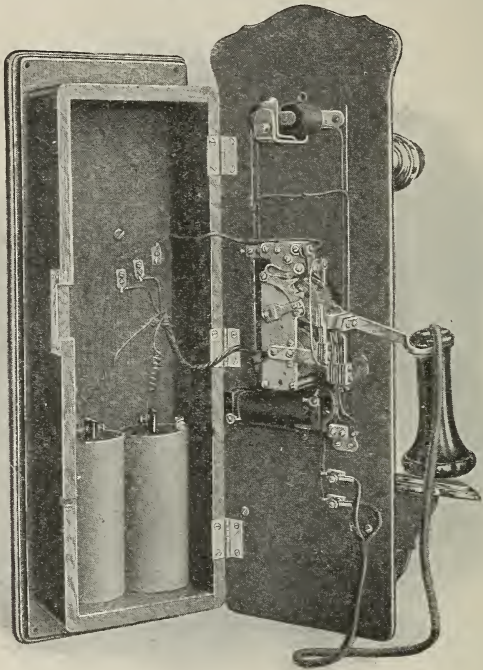

Fig. 18

AUTOMATIC TELEPHONE—INSIDE VIEW SUBSCRIBER'S STATION.

on the switches at the central office in circuit with the telephone. This dial has ten finger holes around the outer edge which are numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 0. Now suppose subscriber No. 36 were to call subscriber No. 25. He first removes the receiver from the hook, then places the finger in hole No. 2 and presses downward, rotating the dial until the finger reaches the stop below. The finger being withdrawn, the dial is restored to its normal position by a spring. The

Fig. 19

AUTOMATIC TELEPHONE—SUBSCRIBER'S STATION.

same operation is then repeated with the finger in hole No. 5, when the ringing button, seen just below the dial, is pushed, thus ringing the bell of telephone No. 25. If that telephone is busy a busy signal will be heard in the receiver.

It is impossible for any subscriber to break in upon the line of two others who are talking, and this is true whether he attempts to get the party

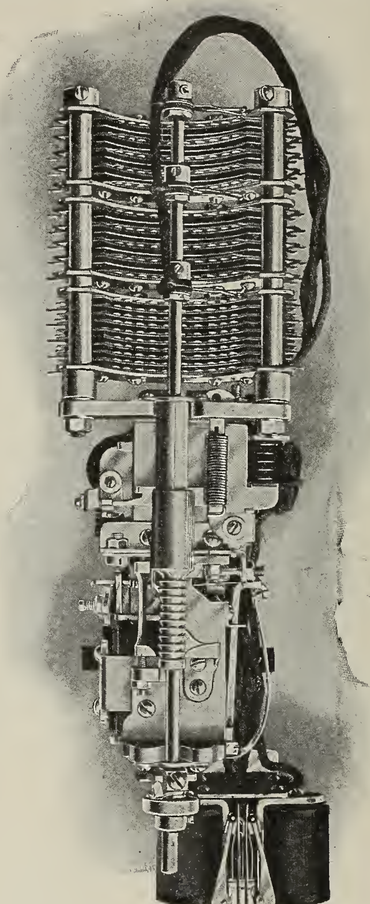

Fig. 20
AUTOMATIC TELEPHONE—SWITCH.

who had made or the one who had received a call.

The switch, as will be seen by Fig. 20, is a mechanism about twelve inches in height and four inches wide, the upper half of which consists of a

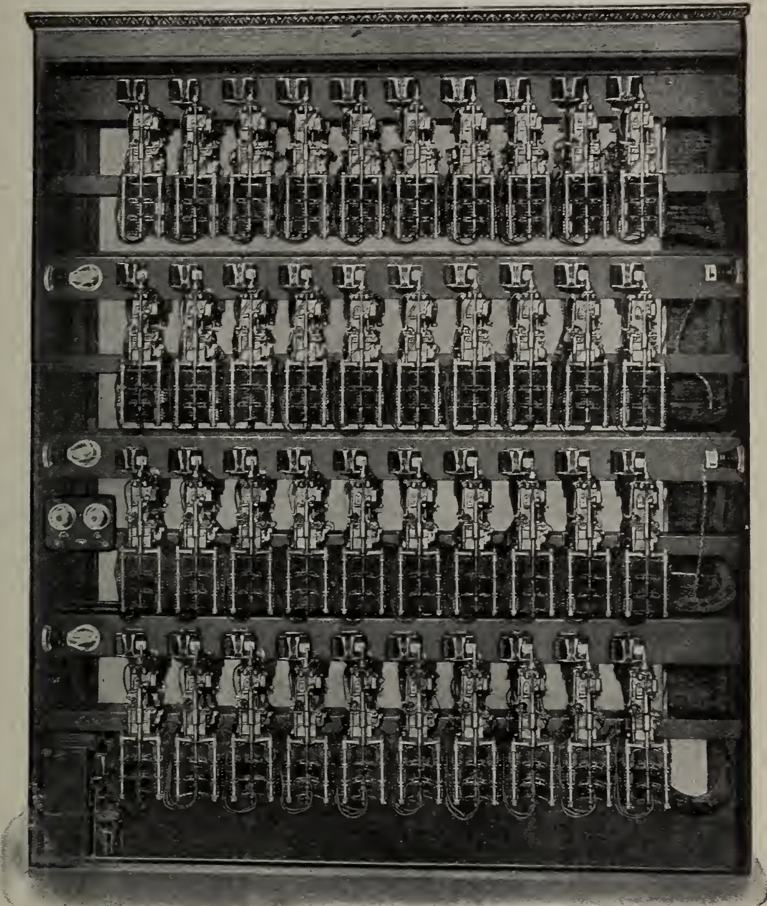

Fig. 21
AUTOMATIC TELEPHONE—SWITCHBOARD.

combination of relays and magnets and springs, the lower half consisting of three banks of contacts arranged in semi-circular formation, the axis of which is a "selector rod" about the size of a leadpencil. Upon this rod are fitted three wipers —one for each contact bank—and the rod is lifted and rotated by the mechanism of the upper half. The contact banks consist of ten layers of contacts, each carefully insulated, ten contacts being placed in each layer. The top bank is known as the "private" bank, while the two lower banks are called "line" banks.

We will say that No. 36 is calling No. 25. When he pulls the dial with the finger in hole No. 2, the calling device on the interior of the telephone grounds the vertical line twice, thus energizing the vertical relay and through it the vertical magnet which lifts the wipers on the selector rod to the second row or layer of contacts. The next movement of the dial with the finger in hole No. 5 energizes the rotary relay, and then the rotary magnet rotates the rod and wipers to contact No. 5 in row No. 2. This contact is connected to the wires leading to telephone No. 25. No. 36 then presses the button on his telephone, which grounds the vertical line and rings the bell of No. 25, if that line is not already engaged. After conversation is finished the hanging up of the receiver grounds both lines simultaneously, which operates the release magnet on the switch and restores the switching mechanism to its normal position.

In a 100 type switch board it will be seen that one switch is required for each telephone, each switch being capable of connecting its telephone to 99 others; and only two revolutions of the dial are required for securing a connection. In a 1,000 type exchange a new feature is introduced which we may call the trunking system. A 1,000 station exchange may be said to consist of ten small exchanges of 100 station type; and these smaller groups are interconnected by what are termed trunk lines. For each telephone in a 1,000 station exchange there is a switch at the central office known as a selector switch, its function being to select a trunk line leading to the hundreds group in which a desired subscriber is located. Here three revolutions of the dial are required to make a call, the first revolution energizing the selector switch. Having secured the line to a desired hundreds group by the first revolution of the dial, the subscriber with the second and third movements operates a switch known as a connector, similar to the one described above in the 100 type switch board, and secures connection with the telephone desired. To illustrate: Subscriber No. 336 calls 225. When he rotates the dial with the finger in hole No. 2 he grounds the vertical line twice and the selector rod on his selector switch is stepped up so that the wipers are on a level with the third row of contacts. The last tooth on the circuit breaker at the telephone then grounds the rotary line and the wipers are instantly rotated to the first contact which is not busy, thus securing the first idle trunk line of the ten which lead to the two-hundreds group. The second movement of the dial energizes a connector switch and lifts the wipers to the second row of contacts, and the third movement with the finger in hole No. 5 rotates the wipers on this switch to the fifth contact in the second row. This contact is connected to lines leading to telephone No. 225. If that telephone is busy the connector releases as soon as it strikes a contact which is engaged and automatically the busy signal is thrown on the calling subscriber's line.

It will be seen that a complete exchange of 1,000 lines would contain 1,000 selector switches and 100 connector switches—ten of the latter for each group of 100 selectors.

In a system of 10,000 stations we really find ten groups of 1,000 lines each, each of these groups consisting of ten 100 line groups. Four revolutions of the dial are required to make a call through this size exchange. The first movement, through a first selector switch, secures a trunk line leading to the particular group of thousands in which the desired subscriber is to be found; the second movement operates a second selector switch which gives a trunk line leading to the desired group of hundreds in the thousands group already selected, and the two last movements of the dial operate a connector switch which completes the connection with the lines leading to the telephone desired. For instance, No. 3336 calls 2225. The first movement of the dial, operating a first selector switch, lifts the wipers on the selector rod to the second row of contacts and the wipers are automatically rotated to the first point in that row connected to an idle trunk which leads to the two thousands group. The second rotation of the dial with the finger in hole No. 2 operates a second selector switch and gives a trunk line leading to the two hundreds groups in the two thousands group already selected. The connector, with which we are familiar in the two smaller types, is operated by the third and fourth movements of the dial and the wipers are lifted to the second row of contacts and rotated to the fifth contact in that row, which is connected to the lines leading to telephone No. 2225.

The merits claimed by its advocates for the automatic telephone are: (1) The service is secret, as every telephone subscriber has, in effect, a private wire over which to talk; (2) connections are prompt, inasmuch as the entire operation is automatic, and when a connection is secured it is impossible for a third party to interrupt; (3) there is no one at "central" to carelessly disconnect the two telephones, or to make mistakes in plugging lines together; (4) delays, mistakes and kindred annoyances due to careless operators or subscribers are done away with; (5) the Automatic exchange is always ready for business, there being no shifting of operating forces, to create possible disorder; (6) in large exchanges there is also said to be a saving in operating expenses, and the larger the switch board the greater the relative economy.

The Automatic telephone is adaptable to the use of railways in connection with the various department offices and at depots, warehouses, shops, yards, signal stations, power houses, interlocking towers and elsewhere. Celerity and accuracy of connections make it particularly valuable. With an Automatic telephone on his desk an official of a railroad has only to turn a dial, press a button and he has the ear of any officer or employe of the company whose desk or office is similarly equipped —and this confidential, with no eavesdroppers. The absolute privacy of communication is undoubtedly an advantage. The Automatic system is in operation on more or less railroads in the directions indicated, and is adaptable for making up and handling trains within prescribed limits.

The practical indorsement of the Automatic telephone by leading telephone engineers in the United States is an assurance that it is to be a permanent factor. Its adoption in the German Empire by the Deutsche Waffen and Munitions Fabriken, and the building of a large factory at Carlsruhe for the manufacture of automatic telephone equipment and its introduction in Berlin, the capital of Germany, is significant of its utility and growing favor. Many other illustrations of this fact might be cited if necessary.

BOOK III

THE WIRELESS TELEGRAPH

CHAPTER I.

WIRELESS TELEGRAPHY—PRINCIPLES AND CONSTRUCTION.

The wireless telegraph we are inclined to consider as one of the contributions which our generation has made to the world's progress. Morse, however, used a wireless telegraph which he operated between Manhattan and Governor's Island in New York harbor. But at that time the line telegraph was new. Our business was not so dependent on rapid communications. His rather crude method of induction between parallel circuits was never perfected. Loomis, in July, 1872, had a patent granted to him for a wireless telegraph in which he used aerial wires, but the accidental charge gathered on the wire and, due to atmospheric conditions, was the only energy he employed to produce his signals.

No further progress was made until careful scientists had, all unconsciously, forged new tools for the wide-awake engineer. Hertz, a German, produced and studied electric waves. He found that he could make electric disturbances which had all the properties of light except visibility. These disturbances take the forms of waves and while being carried by the all-pervading ether do not have losses of energy in the ether, and consequently they will travel to an immense distance. Upon coming in contact with a conductor—such as a straight wire—the waves set up electrical surges upon it, and then energy is used in heating the wire. As this heating effect is small, it cannot readily be observed, and so a practical telegraph could not be made until a sensitive receiver had been found. Branly, a Frenchman, examining these waves in his laboratory, found that if the conducting material upon which the waves fell was in the form of filings, the resistance of the filings was reduced by the electrical surges.

Now appears Marconi, the engineer. A student in an Italian engineering school, this boy of Italian-Irish parentage, accomplished the marvel of practical wireless telegraphy. He produced Hertzian waves, radiated them from an aerial wire, and thus made a practical transmitter. He then filled a tube with Branly filings and made it a part of a similar distant wire. The electrical surges reduced the resistance of the filings. This change in resistance allowed a relay to operate, and he had a practical receiver. The principle of the wireless telegraph is thus of the utmost simplicity. The many increasing complications of the local apparatus are merely for the purpose of increasing the power of the transmitter and the sensitiveness of the receiver.

We will now examine in detail the parts of a wireless telegraph installation with the certainty that if the directions given are followed any one can set up and operate a wireless telegraph station. Men of many nations have contributed to the solution of the problem. There must be included the names of Italians, Russians, Frenchmen, Englishmen, Germans, Japanese and Americans.

Wireless Telegraph for Short Distances, such as Marconi first used, can be made to operate successfully for 15 or 20 miles and for most purposes that is sufficient. Collisions between trains due to errors of train dispatchers and collisions between ships during fogs or the dangers of running ashore when making harbor in thick weather might be easily avoided by its use.

The *transmitter* consists merely of an induction coil whose secondary is connected on the one side to an aerial wire and on the other side to the

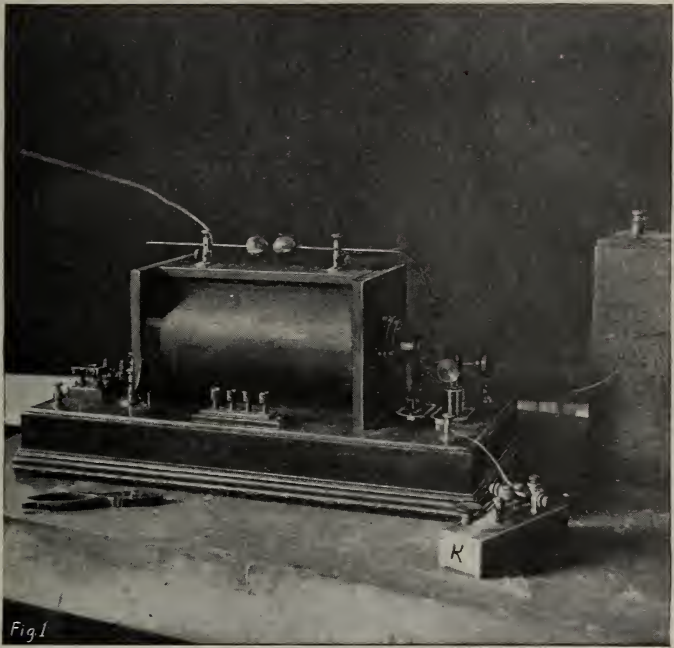

FIG. 1.

INDUCTION COIL.

(This form is suited for simple systems and for medium distance tuned systems.)

ground. Figure 1 shows such an induction coil ready for use. The induction coil need not be a large one. An eight-inch coil is a convenient size. Upon attaching the aerial and ground wires the

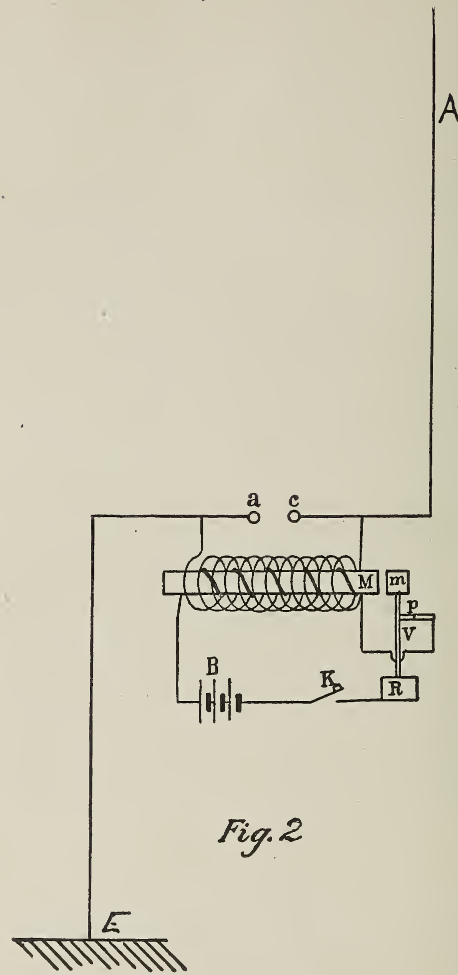

Fig. 2

DIAGRAM OF CONNECTIONS WITH INDUCTION COIL.

maximum spark length obtainable at the discharge balls is greatly reduced. The induction coil should in every case be sufficiently powerful so that a heavy spark at least one-half an inch long can be obtained without a single failure.

The connections are so clearly shown that the diagram of connections given in Figure 2 is scarcely needed. Upon closing the key *K*, a current is sent through the primary winding, causing *M* and *m* to come together, and thereby breaking the circuit at *p*. The high electro-motive force

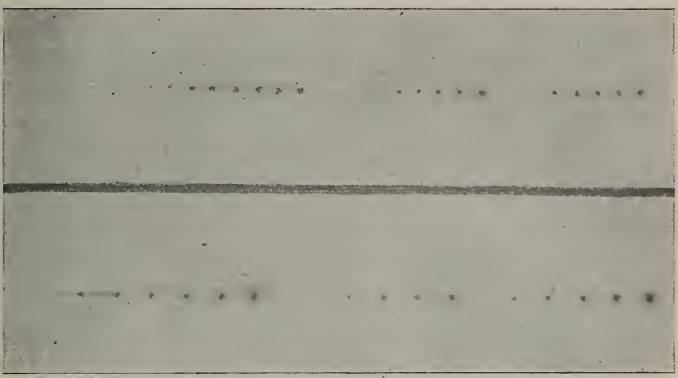

FIG. 3.

ELECTRICAL OSCILLATIONS AT DISCHARGE.

(The same general condition is found in both simple and tuned systems.)

induced upon breaking the primary circuit gives a discharge between the terminals *a* and *c*. As long as the key, *K*, is kept closed the primary circuit at *p* will be automatically opened and closed. Each time the circuit opens a discharge takes place. The spring, *V*, therefore, may make only one vibration while the key is down in sending a dot, but if *K* remains down long enough to correspond to a dash a number of discharges will occur. It must be borne in mind that this discharge is, in each case, a series of oscillations. This fact was first shown by the scientist, Joseph Henry, as early as 1842. A single break of the circuit at *p* will, therefore, cause a series of surges between the discharge balls *a* and *c*.

This has been shown photographically by rapidly passing a sensitive paper between the balls. Figure 3, drawn from such a record, shows the nature of such a discharge. It should be noted that the individual discharges after the first become rapidly weaker. Each group corresponds to a single break of the primary circuit at *p*.

The study of these discharges is of the utmost importance. If, for any reason, there is only one discharge instead of a series of surges, upon breaking the primary circuit *p*, the transmitter will not affect the receiving wire. The *presence of such electrical surges* is always known by the sharp crackling sound accompanying them. The discharge also appears blue white. If there is an arc formed due to the aerial wire being too small or too short then the discharge appears reddish yellow and the receiver will not respond, no matter how carefully it is adjusted.

The accompanying Figure 4 shows *several forms of coherers.* Number 1 and number 2 are well tried and most satisfactory coherers, having side tubes from which the filings for use between the silver terminals are drawn. The silver terminals fill completely the tube and are separated from each other only one thirty-second of an inch. Fine platinum wires come from these terminals and pass through the ends of the glass tubes into which they are sealed. The tubes are then filled, the air exhausted, and finally permanently sealed.

Thereafter they are always constant in condition and reliable in action. The sensitiveness can to some extent be controlled by the number of filings

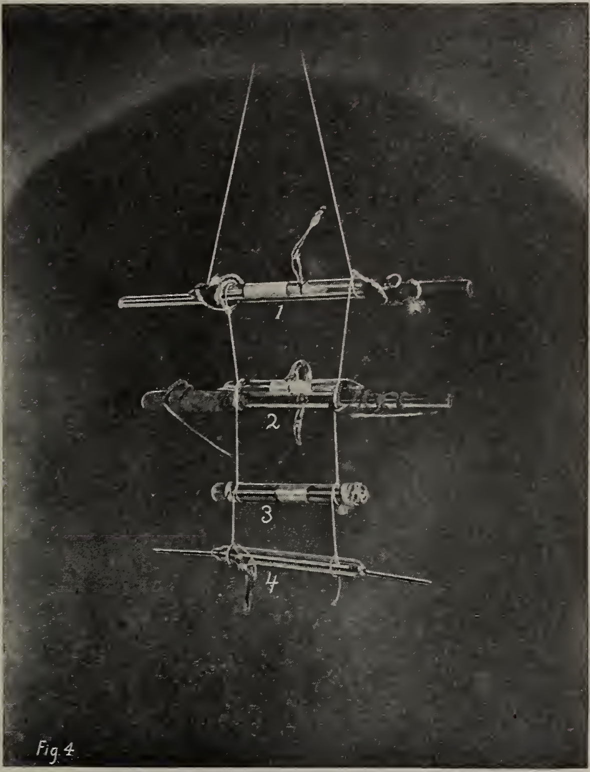

FIG. 4.

COHERERS.

(1) Adjustable American Type, (2) Mercury, (3) Standard, (4) Marconi Form.

used between the terminals. A normal condition is with the terminals half covered. Good coherers may be made of any metal. It is merely necessary to have them thoroughly clean and untarnished except for the faintest trace of oxide. Nickel filings made with a clean, sharp file and permanently sealed in the tube just four hours after making will give a sensitive, reliable coherer. It must, of course, be so arranged that the terminals of silver are also untarnished and that the final heating needed to seal the tube does not also heat the filings or terminals. The particular coherers shown have also 15 per cent of pure silver filings mixed with the nickel, but that has been found to be entirely unnecessary. Number 3 shows a coherer made with iron terminals having a drop of mercury between them. Number 4 shows the form used by Marconi. The opening between the terminals is somewhat V shaped, which makes it possible to adjust somewhat the sensitiveness by rotating the coherer. It is much harder to construct this form than either of the first two, as the final heating necessary for sealing the tube must not heat the terminals or filings. For only a few hours' work it is not necessary to exhaust or seal the coherer.

The *action of the coherer* is explained as follows: The electrical surging on the aerial wire of the receiver caused by the oscillating discharged at the transmitter, causes minute sparks to jump between the separate bits of metal in the coherer. These bits of metal or filings have normally a very high resistance, as they are separated by a minute trace of oxide. The little sparks clean the contacts between the filings and cause a good metallic contact. The resistance then falls to a comparatively low value. The least jar of the coherer tube will move the filings and cause a return to the normal high resistance.

The means used to note the sudden fall of resist-

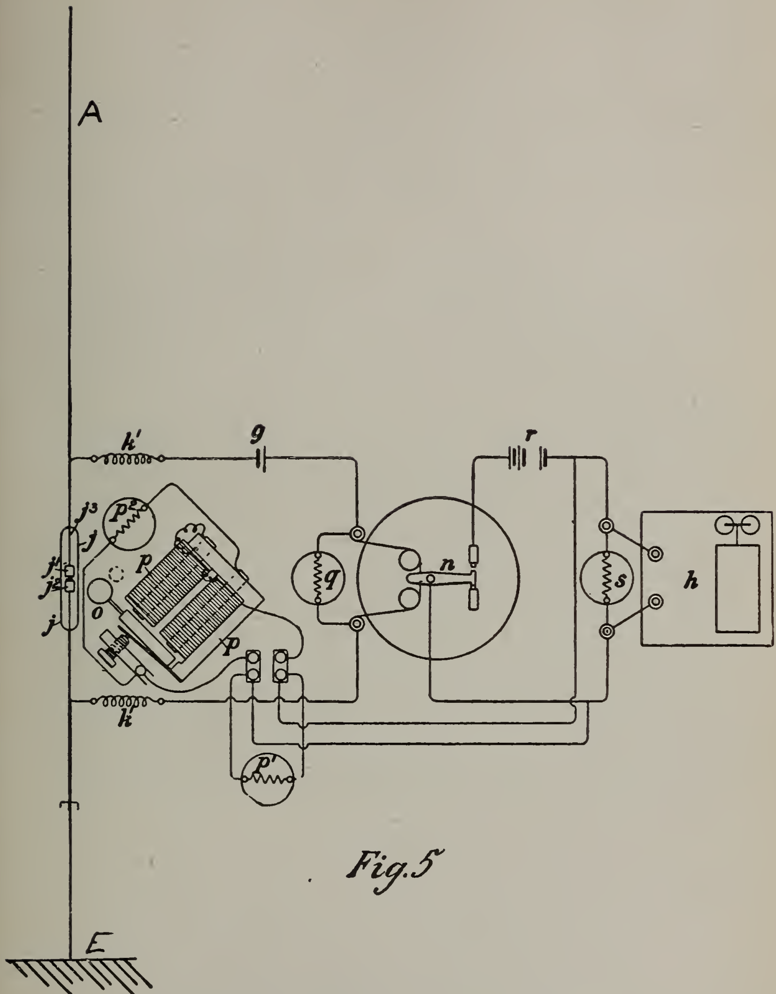

Fig. 5

THE LOCAL CIRCUIT OF A MARCONI SYSTEM.

ance can be readily seen from Figure 5. The signals cause electrical surging on the aerial conductor A. Little sparks jump between the terminals 1 and 2 through the filings of the coherer to the ground and cause the resistance of the coherer to fall. A current then flows from battery *g* through the relay, causing the local circuit to be closed by *n*. The local battery *r* then works the printer *h* and a sounder in parallel with it if desired. But the closing of the local circuit by *n* causes the tapper *o* to strike the coherer *j* and so raises the resistance of the coherer to its normal high value. The local circuit then opens at *n* and the receiver is ready for a new signal. The operation is an elaborate and slow one, so that the speed to be expected is only fifteen words a minute.

There are several *details* of the *utmost importance* to be now noted. Inductive resistances k^1 must be used to keep the signals given by the electrical surges from being shunted around the coherer. The non-inductive resistances q, p^1, p^2 and *s* must be used, otherwise the disturbances caused by the operation of the tapper or other apparatus will cause an electrical disturbance which will operate on the coherer in the same way that the signals do, and so false signals will be produced. A safe guide, and one that must never be neglected, is to use the shunting non-inductive resistances of such values that no sparks shall at any time appear in the local circuit. The operation of the receiving circuit is automatic, but the adjustments must be made with extreme care. Only a very small current can be used through the relay. A single copper sulphate cell must be made to operate the relay, which should be of 750 or 1,000 ohms resistance. No battery having an electromotive force higher than 1.5 volts should be used to operate the relay as otherwise a sensitive coherer will give false signals or may even refuse to decohere—that is, return to a normal high resistance—upon being struck by the tapper *o*.

Figure 6 shows such an arrangement of apparatus. It is to be noted that a relay of the ordinary telegraph type is used. It is very satisfactory if adjusted with sufficient skill. The armature

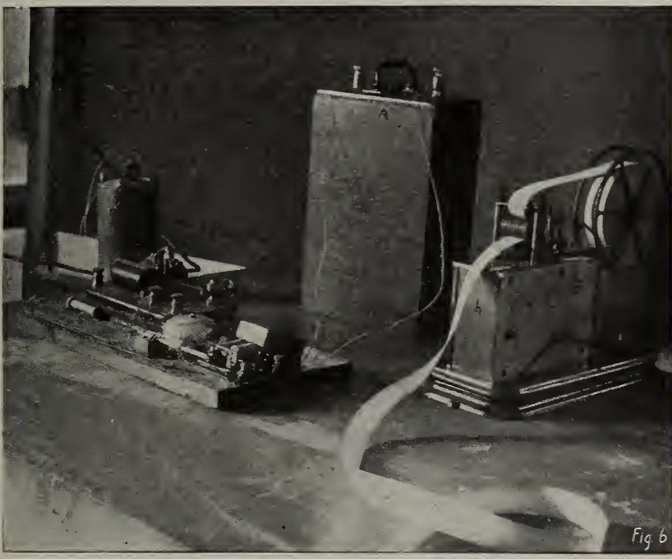

FIG. 6.

SIMPLE RECEIVING APPARATUS.

should be ground to fit the cores, and held as near to them as possible. The pivots should be carefully polished and oiled. For use on ship board a counterweight may be fitted to the armature so as to lie below the base, thus allowing rolling motion of the relay without disturbing the adjustment of the instrument. The methods of adjusttion by means of another operator located at the distant office. The orders for this connection are given over what is known as an order wire which permits the operator at the orignating end to speak directly into the ear of a trunk operator at a distant office. The connection then, instead of being made directly, will be put up over a trunk line. The same signals as described are used with the exception that the originating operator receives all the disconnect signals and the act of her removing the plug from the trunk line automatically dis-

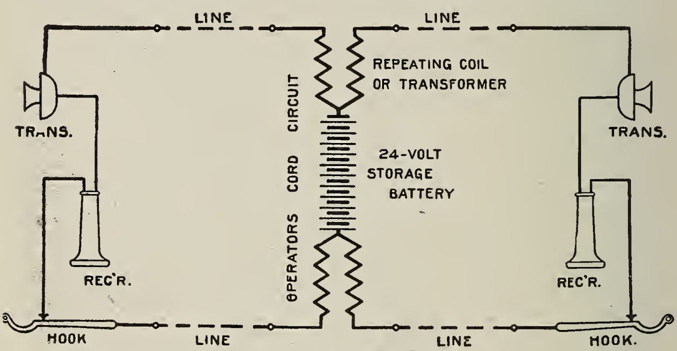

Fig. 1

DIAGRAM SHOWING METHOD OF CONNECTING TWO SUBSCRIBERS' LINES

plays a lamp in front of the trunk operator at the distant office, which signifies to her that the trunk line is no longer in use. The operators at the distant office who put up these trunk connections do nothing else. They never talk to the subscribers.

"The method of connecting together two subscriber's lines through a modern common battery switch board may be clearly understood by reference to the diagrams of connections shown in Figs. 1 and 2.

"There are two principal systems of common

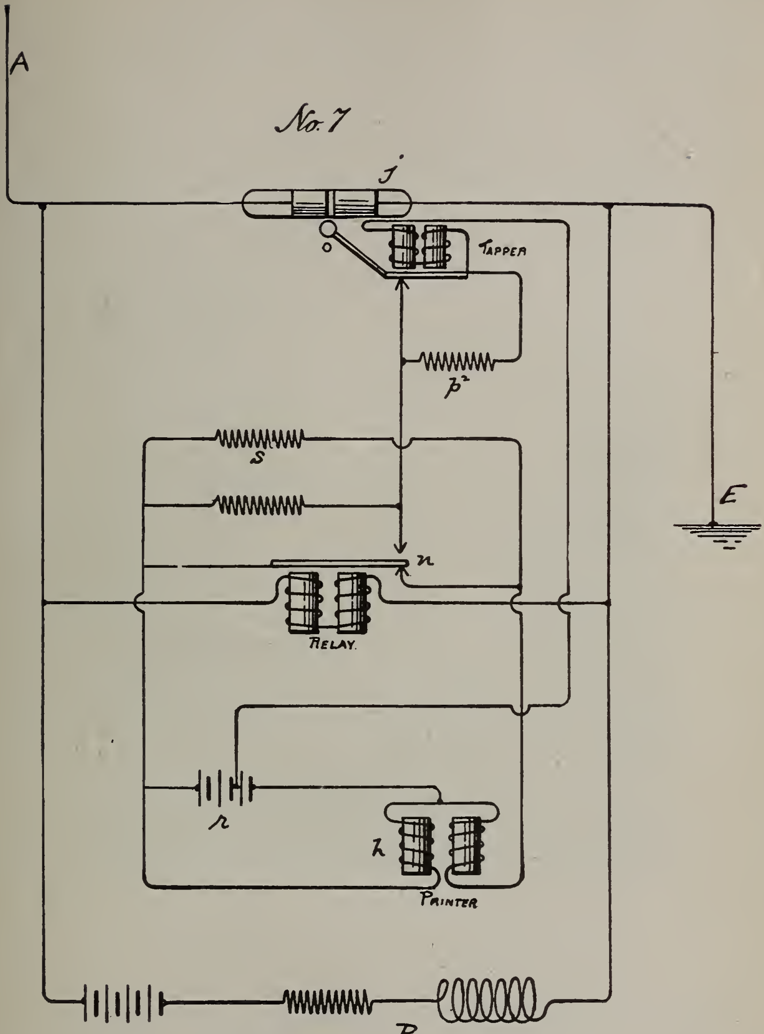

Fig. 7

AN AMERICAN METHOD OF CONNECTING THE LOCAL CIRCUIT.

assists the coherer in its receipt of signals, while the breaking of the current flow through the coherer by the tapper does not give rise to the false

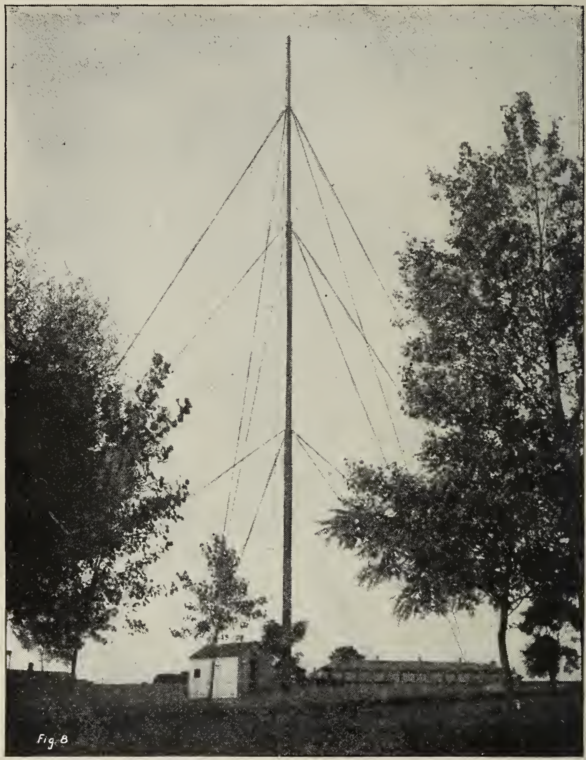

FIG. 8.

STATION ON GOVERNOR'S ISLAND.

signals so objectionable in the case of the method shown in Figure 5.

This early wireless telegraph system was so successful that Major General Brooks recommended its adoption at all of the army posts in his department. It was also installed between posts in San Francisco harbor and has according to the

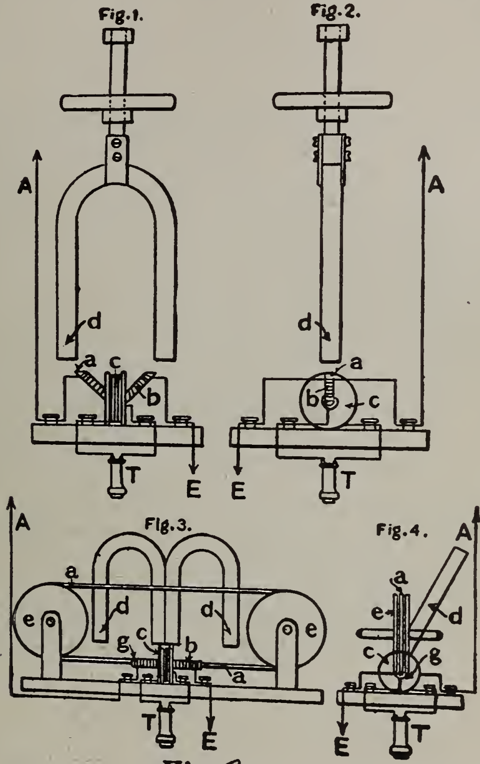

Fig. 9

DIAGRAM OF MAGNETIC RECEIVER FOR WIRELESS TELEGRAPHY.

(English Patent 10,245 of May 3, 1902.)

last report of the Chief Signal Officer, been since then in continual operation. A general adoption would require a special appropriation by Congress, and that body has not yet seen fit to provide the necessary funds.

The station on Governors Island is shown in Figure 8. The aerial wire is shown. It does not, of course, touch any of the guy ropes and must also be carefully insulated from the pole and building. The beautifully tapered pole is 150 feet

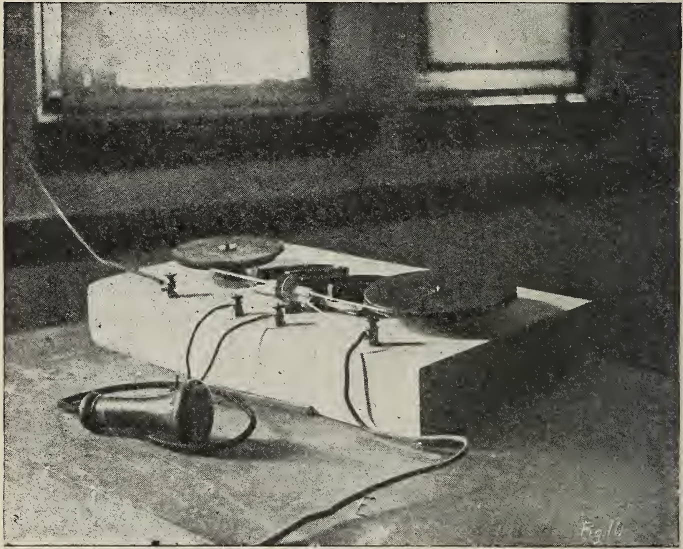

FIG. 10.

MODEL OF MAGNETIC RECEIVER.

high, and is made by bolting together many two-inch planks.

Another method known as the *magnetic receiver* will now be shown. It is not yet possible to use a printer in connection with it, and so it is not looked on with much favòr abroad. A diagram of the connections published by the British patent office is shown in Figure 9. The aerial wire *A* is connected to one end of the simple coil of one layer at *g*. From the other end *b* of the coil, a wire is run to the ground. The short coil of 80 ohms resistance at *c* has a telephone receiver *T* connected to its terminals. The electrical surges from *A* through the windings *g b* to the ground *E* produce induced currents in *c* which are audible in the telephone under certain conditions only. A cable of about 100 No. 40 iron wires, *a*, must continuously pass through the coil *g b* and just where the oscillatory currents due to the signals pass around the wire, it must be in a magnetically unstable condition due to the presence of the permanent magnets *d*, whose like poles are together. The same result may be produced by rotating the magnet and keeping the core stationary. The method preferred is that in which a movable core is used.

The signals then reduce the magnetization of the wire at the instant of its instability, and each group of electrical surges such as shown in Figure 3 produce a single movement of the telephone diaphragm. A dot, therefore, gives a single click in the telephone and a dash gives a series of clicks. American operators have no difficulty in reading the signals. Figure 10 shows a photograph of a model of such a receiver, whose simplicity of connection and operation is so admirable. The patent is issued to Marconi, who deserves great praise for his many brilliant adoptions of the scientific work of all countries to the solution of the problems of wireless telegraphy.

CHAPTER II.

LONG DISTANCE WIRELESS TELEGRAPHY.—ADAPTABILITY TO RAILWAY NEEDS.

Long distance wireless telegraphy makes use of the same local receiving circuits already examined. By long distance is meant distances of more than 100 miles. The differences between the methods for short and long distance telegraphy must be looked for in the more complex transmitting and receiving wires. Also instead of a simple induction coil, the transmission must now be accomplished by the aid of a powerful transformer. Such a transformer is shown in Figure 11. It will step up an alternating current from 100 volts to 60,000 volts, and at that high potential will deliver 10 kilo-watts of power. It has a closed magnetic circuit and is completely oil insulated.

If this powerful transformer can be made to set a closed circuit into oscillation there will be produced a long succession of oscillations whose reduction of intensity or alternation will be very gradual. If an illustration such as Figure 3 were shown for this case, then possibly 50 or more discharges would appear in each group. Such oscillations have been studied with great care by the scientists and the conditions necessary for their production are well known. The engineers have accepted the results and found a method by which they can cause these powerful and long-continued oscillations to be radiated out into space. This result is accomplished by tuning the aerial wire to respond to the oscillations of the closed powerfully oscillating circuit. The analogy of the sympathetic sounding of stretched strings, such as piano wires,

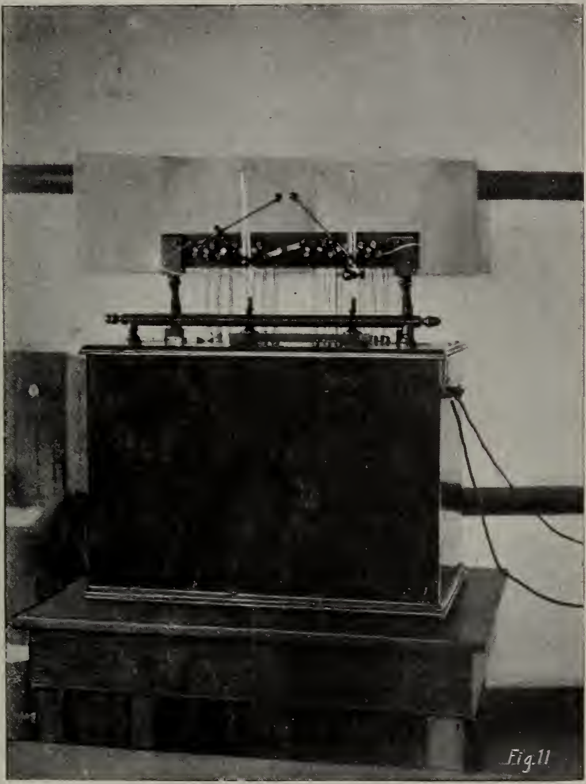

FIG. 11.

POWERFUL TRANSFORMER FOR USE ON LONG DISTANCE TUNED CIRCUITS.

applies with great exactness. Just as the note to which a piano wire will respond depends on the weight of the wire, upon its length and upon its stretch, so the electrical oscillation to which a conducting wire will respond depends on its resistance, its self-induction and its capacity.

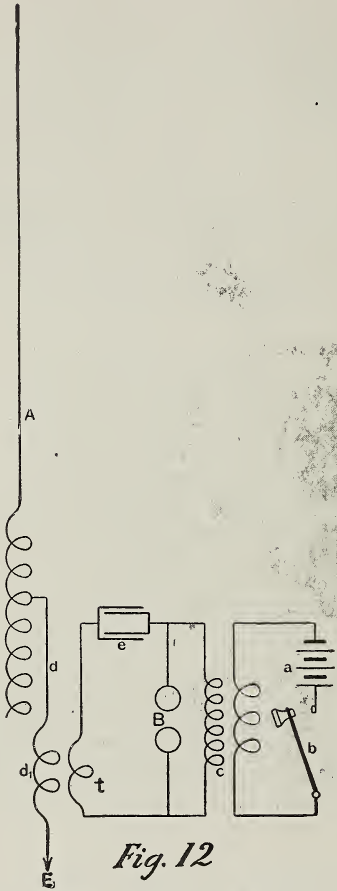

Fig. 12

TRANSMITTING SYSTEM ARRANGED FOR TUNING AERIAL WIRE.

Each of the three electrical constants depends in the case of any particular conductor upon its material, its shape and position. It is possible, therefore, to so alter the aerial wire as to have it respond at will to any electrical oscillation desired. Figure 12 will show the essential parts of such a transmitting system arranged for tuning the aerial wire. The transformer *c* is a powerful instrument, such as that shown in Figure 11. The battery *a* is intended to represent an alternating current machine. Upon closing the key *b* there is thus produced on the terminals of the secondary a very high difference of potential. This charges the condenser *e*, and when the potential has reached its final high value, there is a discharge started across the spark gap *B*. The condenser *e* has then stored in it a large amount of energy which it discharges by means of a long series of electrical oscillations. These pass through the primary of an induction coil and to and fro between the balls at *B*. The local oscillating circuit is, therefore, merely the condenser *e*, the inductive winding *t* and the spark gap *B*. The winding *c* of the first transformer does not take part in this oscillatory discharge. It merely serves to charge the condenser once during each comparatively slow alternation of the alternating current dynamo at *a*. Now the winding *d* is acted on by *t*, and if the connection to the aerial wire *A* by means of *d* is at the right place on the spiral shown, the wire *A* is thrown into a most violent electrical disturbance. The whole wire becomes visible. All neighboring objects, including the spectators, may have electrical discharges playing over their surfaces. There is no question when the proper position of *d* has been found. The operation, therefore, in tuning the transmitting wire merely consists in moving *d* until the aerial wire is thrown into electrical resonance with the oscillating circuit. An ordinary induction coil can also be used with the oscillating circuit and a tuned aerial wire, but for such an extreme distance as that between the American and British coasts only the most powerful transformers will answer.

The aerial wire, also, instead of being a simple wire as that shown in Figure 8 is made of a large

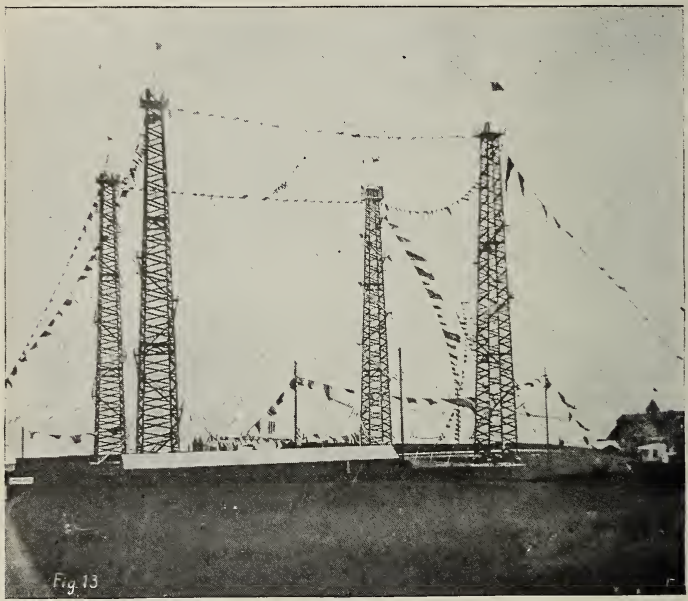

FIG. 13.

EXTERIOR OF STATION AT POLDU USED BY MARCONI IN HIS TRANSATLANTIC SIGNALING.

connection of wires which are hung from immense towers. Figure 13 shows such a station located at Poldu, on the British coast. The aerial wires all joined together at the bottom are hung from the lines outlined by flags between the top of the towers. Another station located at Cape Cod has made it possible for a traveller when crossing the ocean, to be constantly informed by wireless telegraphy of the news of the world.

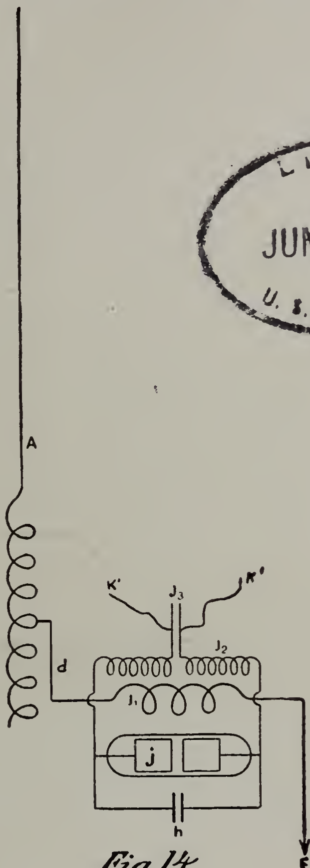

Fig. 14

TUNED RECEIVING CIRCUIT.

The receiving circuits and apparatus already explained will readily receive the messages sent from tuned transmitting stations. The tuning of the transmitting circuits merely makes it possible to send more powerful signals, but otherwise does not affect in the least the nature of the action at the receiving station. This fact should be carried in mind when reading the claims of certain wireless telegraph companies.

Tuned receiving circuits are arranged in the same way as tuned transmitting circuits. Figure 14 shows an arrangement used by Marconi. The transmitter being tuned emits powerful radiations of a definite frequency that is of a certain number of oscillations per second. If anywhere these electrical oscillations passing through space chance upon a conductor which responds to oscillations of the same frequency, then the conductor is sure to respond by having comparatively violent oscillations induced on it. These oscillations affect the coherer or magnetic receiver in its circuits, and thereby reproduce the signal. Obviously any other conductor having different electrical constants would not respond as readily, and so its recording local circuit might not be affected by the presence of the electrical oscillations. At great distances from the transmitter the arriving signals are not able to appreciably affect any but receivers which have been tuned to respond to the same frequency of oscillation.

The method of tuning the receiving wire is indicated in Figure 14. The position of the connecting wire *d* determines the tuning. It has been found to be a very simple matter to tune an adjustable receiving wire so as to receive tuned oscillations, whether the transmitting station wished it or not. The question is immediately raised, "is it possible to have a secret wireless telegraph service." From the nature of the problem it is not possible to keep the transmitted signals from affecting any properly tuned receiver. The tuning of a receiver is readily accomplished by shifting the connection of *d*. The knowledge of the presence of unauthorized receiving wires can not reach the transmitting

FIG. 15.
EXTERIOR OF MARCONI STATION AT LIZARD, ENGLAND.

station due to any disturbance caused by them. It is therefore necessary to trust to a code for the transmission of messages when secrecy is desired.

In the receiving circuit shown in Figure 14, the second coil *j* should be noted. The coherer *j* is not affected directly by the signals, but a small induction coil is interposed. This method is claimed to be more reliable than the simple method shown in Figure 5. If the circuit containing the

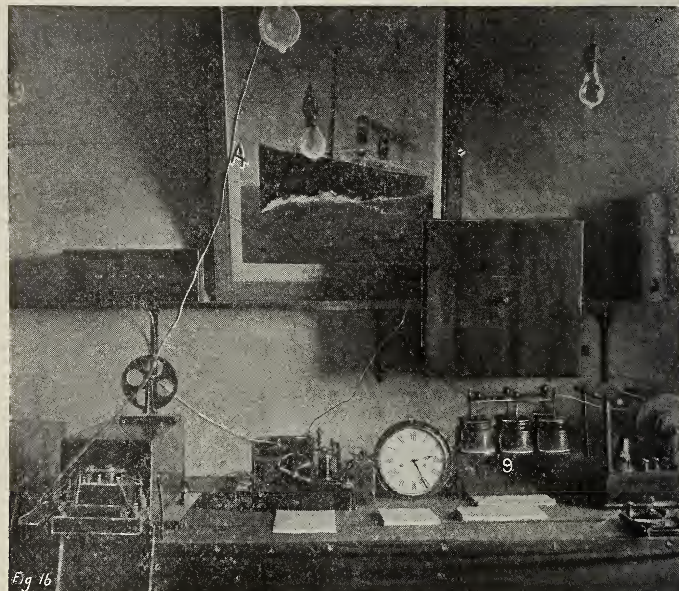

FIG. 16.

INTERIOR OF MARCONI STATION AT LIZARD, ENGLAND.

induction coil j^2, the condenser j^3 and the condenser h is also tuned to respond to the oscillations induced on the resonating aerial wire, then the presence of receiving transformer j^2 is probably of advantage.

Figures 15 and 16 show the interior and exterior of a station at Lizard, in the south of England. It is used only for distances of medium length as it employs an aerial wire which is only doubled and uses an induction coil instead of the powerful transformers used in the trans-atlantic station at Poldu. The aerial wire *A* is shifted from the receiving apparatus to the transmitting apparatus by hand, instead of automatically. The condensers *e* are seen near the induction coil. The wires marked K^1 K^1 in Figure 14 are connected to the local receiving circuit at the retardation coils marked K^1 K^1 of Figure 5, and so the rather complicated receiving circuit is not shown again.

Another method of considerable merit can not be well omitted as it is the only practical method yet proposed in which *a ground connection* is *not* absolutely *required.* It is known as the Braun system, and its points of novelty can be seen from Figure 17. The transmitting station has a transformer or powerful induction coil at *C.* This charges the condensers *e,* which in turn furnish the energy for a powerful and long continuing oscillation in the circuit *B t* and *e.* This oscillation induces an oscillation on the aerial wire *A,* which is connected to one terminal of the coil *d.* The other terminal instead of being connected to the ground has attached to it another wire A^1 which, having the same constant as *A,* allows the formation of powerful oscillatory currents which strongly radiate electrical waves into space.

At the receiving station there is an aerial wire A^2, which exactly corresponds to the transmitting wire *A.* To this wire are attached the coil j^1 and the condensers *h,* which form a local resonating circuit of the same period as the aerial wire. To this circuit is also attached a wire A^1, which is equal to A^1 at the transmitting station. Small coil j^2 is inductively acted on by the coil *j.* To j^2 is

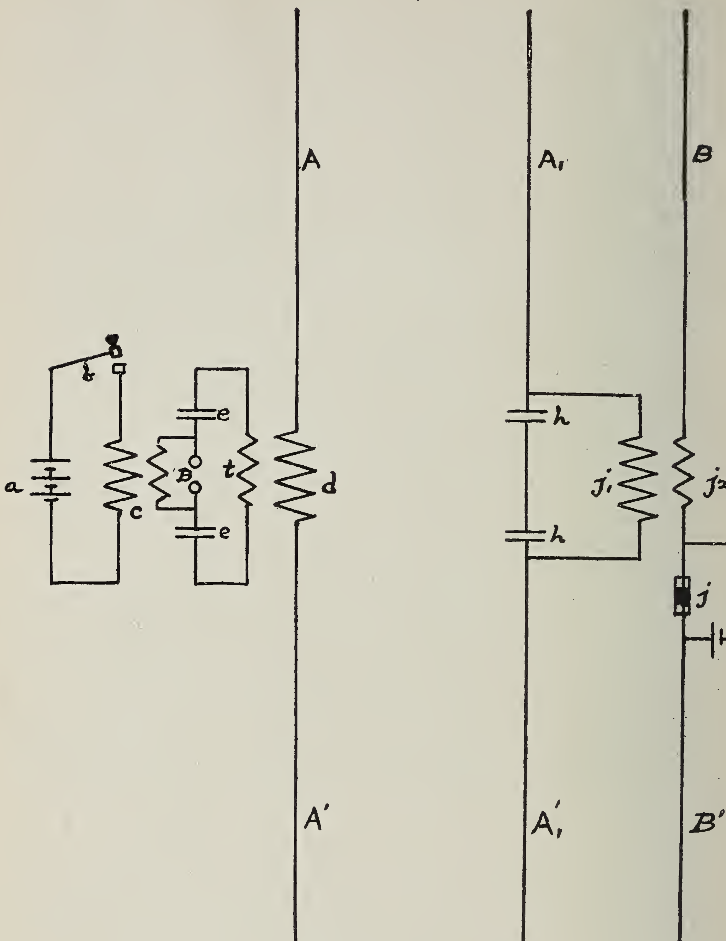

Fig. 17

BRAUN SYSTEM.

attached again two wires *B* and B^1, which again have the same constants as *A* and A^1. The electrical waves falling on *A*, thus set up sympathetic oscillations in the closed circuit including *j* and *h*, which again set up sympathetic oscillations in j^2 and the attached wire *B*. These final oscillations now act on the coherer *j* which is made to record their presence automatically in exactly the same way as that discussed in connection with Figure 5.

When an aerial wire is attached to the ground it will respond when the electrical waves reaching it are four times the length of the wire. We have experimental as well as theoretical reasons for thinking that the electrical waves used in wireless telegraphy are never more than four times as long as the aerial transmitting wire. If a few spiral twists are put in the aerial transmitting wire the wave length is, however, increased. This fact is made use of in tuning both the transmitting and the receiving stations, as is shown in Figures 12 and 14. In the Braun system, where no ground is used, there must be a length of wire below the induction coil *d* which is equivalent to the aerial wire. The wave length is again four times the length of the aerial *A*, and consequently twice the length of the whole wire. It has been pointed out that the length of wire below the receiving transformer *j* must be equivalent to the length of the aerial wire. The length can be made equivalent by shortening the wire and at the same time increasing the diameter. The wire then takes the form of a rather short cylinder in a practical installation. Figure 18 shows such a receiving station, and the cylinders corresponding to the wires A^1 and B^1 of Figure 17 are shown. It is obvious that the tuning of the transmitting wires can be accomplished in the same way. A cylinder having the same electrical effect as the wire A^1, which is below the transmitting transformer, is used connected in place of A^1 of Figure 17.

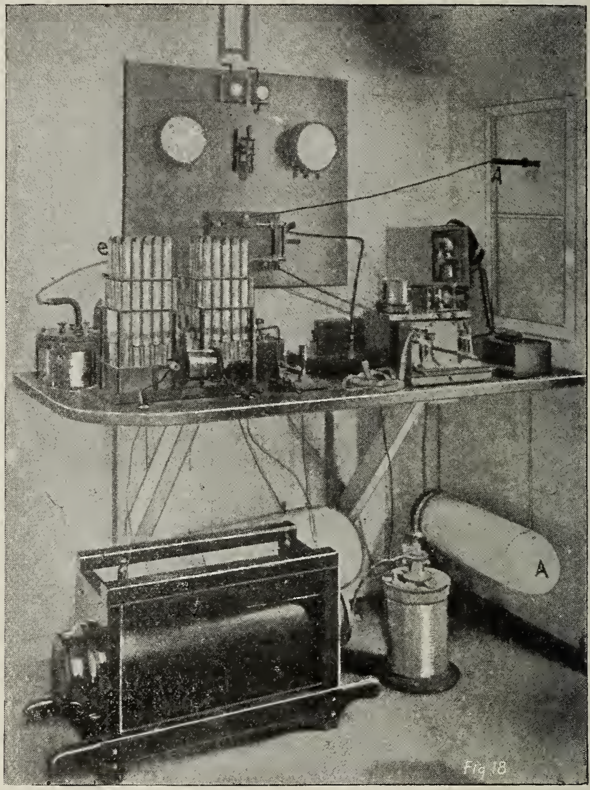

FIG. 18.

INTERIOR OF BRAUN STATION.

The successful operation of any wireless telegraph station requires the utmost painstaking care and patience. The tuned systems have two possible advantages over the untuned systems. First; they can be used for greater distances, due to an increased radiating power of the transmitter and an increased sensitiveness of the receiving apparatus. Second; several messages can be sent simultaneously. The rate at which any one receiving instrument can be used is dependent on the type of the responder employed. The coherer can be used at about 15 words a minute. All claims of a higher speed when a coherer is used are not to be credited. The magnetic receiver, shown in Figure 9, is not limited in speed. In that case the transmitting station imposes the limit. Powerful transformers or induction coils can not be used very rapidly. It requires an appreciable time to operate the transmitter and produce each signal. A possible 25 or 30 words a minute can be taken as the limit over medium distances. It is therefore seen that one set of instruments cannot handle a large business. In the case of the tuned systems it is possible to send several messages simultaneously between any two points. A transmitter using a certain length of aerial wire, and sending out, therefore, electrical waves of a certain length, will affect any tuned or untuned receiver that is *close* to it. If, however, the receiving station is so far away that an untuned receiver will not be affected, it is possible to tune a receiver to respond to the transmitter. Another transmitter which emits electrical waves of another wave length will then not affect the first tuned receiver, but a second receiver can be tuned to receive its signals. These two receivers can even be connected to the same aerial wire, but must both have their separate tuning spiral shown in Figure 14, at the base of the aerial wire. Under specially favorable

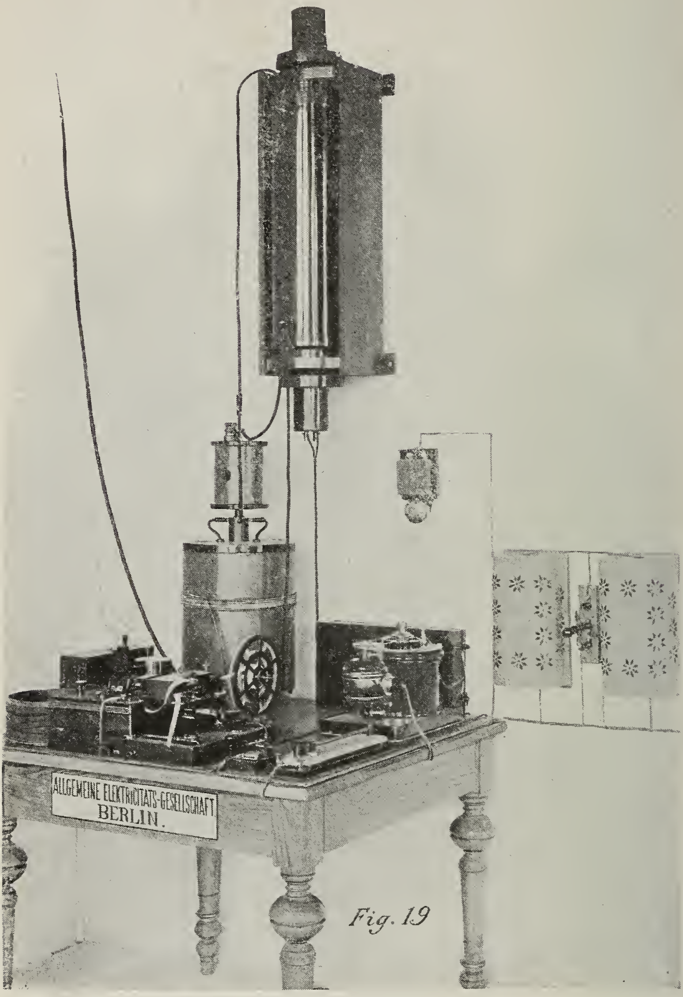

FIG. 19.

GERMAN WIRELESS TELEGRAPH INSTRUMENTS.

conditions, four messages have been simultaneously received. The theorists have computed that thirty instruments might possibly operate at the same time. It is obvious that wireless telegraphy can not at present interfere seriously with the immense business carried by the regular lines or ocean cables.

In Figure 19 is shown another set of German wireless telegraph instruments. On the left of the picture are shown the spirals which are used in tuning the system. These instruments are now used on one of the German railroads as a part of their regular equipment. In Belgium, also, trains have been equipped,but the instruments of a French company are used. They have met with great success and are principally employed in dispatching the business of the travelers. In case of emergency it is hoped that the train can be controlled by the orders transmitted in that way. To the general public it will seem that the safety of railroad travel will be greatly increased by having the dispatcher in constant control of the passenger trains.

There are many other wireless telegraph systems in use. Germany, England, America and indeed nearly every civilized nation of the world has one or more operating companies. A table of the patents controlled by four of the most importance at present is given. As can be readily understood from the number of patents issued, each of them has many points of novelty, but in every case the methods employed are merely those that have been discussed in the preceding pages. Wireless telegraphy has become a most important factor in oceanic travel. The next problem is its universal application to our railroad service. Many collisions occur in a manner which future perfected methods will render impossible. Both the railroad management and the traveling public are ready to welcome any device to increase the safety of the trains. It is certainly possible to equip every train with wireless telegraph instruments so that they can notify all trains both in front and behind them just where they are and how fast they are running. The very inadequate light waves of the head light can be supplemented by the electrical waves which, passing over hills, through tunnels and across curves, will continually, with their silent and invisible presence give the engineer entire confidence that he has the right of way and a clear track.

The American is justly proud of his stupendous business undertakings, nowhere shown better than in the development and growth of our railroad systems. We should add to this the most perfect of safety devices, so that we may be able to point proudly, not only to our high speed heavy trains, but also to the personal comfort and entire safety of the traveler. Towards this most desirable end we may confidently expect a great advance when we have universally adopted on our railroads a perfected wireless telegraph.

CHAPTER III.

PATENTS COVERING AND BOOKS ON WIRELESS TELEGRAPHY.

Patents.

Marconi Wireless Telegraph Co. of America.—The following United States patents, issued principally to Marconi, are controlled by this company.

No. 668,315	No. 647,009
" 11,913	" 650,109
" 676,332	" 650,110
" 586,193	" 624,516
" 647,007	" 627,650
" 647,008	

The American De Forest Wireless Telegraph Co.—The following patents controlled by them were issued principally to De Forest.

No. 708,072	No. 710,354
" 710,355	" 700,250
" 754,904	" 716,000
" 716,203	" 716,334
" 720,568	" 730,246
" 730,247	" 730,819
" 748,597	" 749,131
" 749,436	" 749,435
" 749,434	" 750,180
" 750,181	" 749,178
" 749,371	" 749,372
" 758,517	" 759,216

Gesellschaft fur Drabtlose Telegraphie.—This company is controlled by the Siemens Halske Co., of Berlin. It does not control any important American patents. The German patents issued to Slaby, Arco, Siemens or Braun are as follows:

No. 116,113	No. 152,054
" 129,892	" 115,081
" 130,723	" 111,578
" 127,730	" 109,378

No. 131,584	No. 121,959
" 130,122	" 117,489
" 126,273	" 142,792
" 131,586	" 147,398
" 113,285	" 148,001
" 149,458	" 143,605
" 143,301	" 136,641
" 150,149	" 149,350

National Electric Signalling Co.—The Fessenden United States wireless telegraph patents controlled by this company are as follows:

No. 706,735	No. 727,326
" 706,736	" 727,327
" 706,737	" 727,328
" 706,738	" 727,329
" 706,739	" 727,330
" 706,740	" 727,331
" 706,741	" 730,753
" 706,742	" 731,029
" 706,743	" 742,779
" 706,744	" 742,780
" 706,745	" 12,115
" 706,746	" 12,168
" 706,747	" 12,169
" 715,043	" 753,863
" 715,203	" 753,864
" 727,325	" 754,058

Books on Wireless Telegraphy.

Slaby, A., "Die Funkentelegraphie," 1901.

Braun, T., "Drahtlose Telegraphie durch Wasser und Luft," 1901.

Turpain, A., "Les Applications Pratiques des Ondes Electriques," 1902.

Boulanger, J., et Ferrie, G., "La Telegraphie sans fil et des Ondes Electriques," 1902.

Prasch, A., "Die Telegraphie ohne Draht," 1902.

Arldt, C., "Die Funkentelegraphie," 1903.

Righi, A., und Dessau, B., "Die Telegraphie ohne Draht," 1903. (Published first in Italian.)

Broca, A., "La Telegraphie sans Fil," 1903.

Maver, Wm., Jr., "Wireless Telegraphy," 1903.

INDEX.

[EXPLANATORY NOTE.—This volume is divided into three books: I., *"The Telegraph"*; II., *"The Telephone"* and III. *"The Wireless Telegraph."* Each of these books is paged from 1 up. The Roman numerals that precede the page number given in this index refer to the particular book in this volume to which the item refers. Thus an item

Magnet........................I, 29

would denote a reference to page 29 of the book *"The Telegraph"; an item,*

Repeating Coil................II, 15

would denote a reference to page 15 of the book *"The Telephone"*; and an item

Induction Coil...............III, 29

would denote a reference to page 29 of the book, *"The Wireless Telegraph.*]