THE ROWLAND MULTIPLEX SYSTEM OF PAGE-PRINTING TELEGRAPHY.

To the constantly-increasing list of page-printing telegraphs must now be added that of the late Prof. Henry A. Rowland, one of America's most brilliant physicists. The invention is based upon new electro-physical principles, and for that reason merits the consideration of scientific telegraph engineers.

In the Rowland system an alternating current is employed which is altered in a number of different ways, any one of which is used for sending signals over a line. In Fig. 1 an alternating current is diagrammatically shown, which has had certain of its waves modified in six different ways. The minus half-wave 2 at E has been reversed; minus half-wave 4 at A has been cut out; the positive half-wave at B has been cut out; the two half-waves at C and D have been increased in height; and at F a positive half-wave has been turned into a negative half-wave. If the alternating current were traced on a chemical treated paper, these modifications of its half-waves could be interpreted as six different signals. In the Rowland system, such cut-out positive and negative half-waves are employed. A signal, however, is made to consist of a pair of cut-out half-waves which are not adjacent. It, therefore, happens that wave groups can be formed, which are a very important feature of the invention. The half-waves can be divided into groups, A, B, C, D and X, leaving an extra half-wave between each group. If out of each group two or more of its half-waves be cut, a signal can be made to consist, not of one cutout half-wave, but of a combination of half-waves cut out from a group. For example, if the half waves 1 and 3 are cut out from group A, this could be interpreted to mean one thing; while if the half-waves 1 and 4 were cut out, this combination would mean another thing. In practice the signals are made up by cutting out any two half-waves not adjacent. From a group of 11 half-waves, it is possible to obtain a total of 45 different signals, any one of which can be sent over the line during a time in which the current makes 11 alternations. The system in practice makes use of five groups of waves with one extra half-wave between each group.

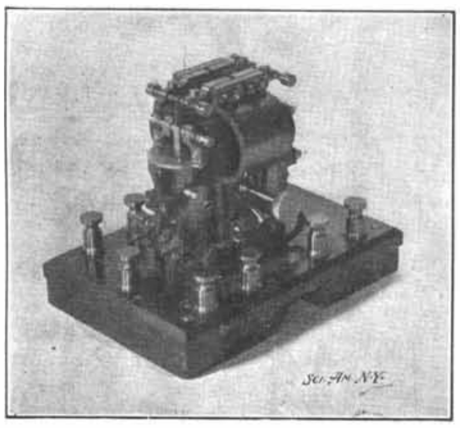
Prof. Rowland found that he could employ profitably about 208 alternations of the current per second. Hence, 52 half-waves, illustrated in Fig. 2, will pass over the line in one-quarter of a second; or in other words, any group of waves will be repeated four times each second. Thus four operators utilizing the groups, A, B, C, and D, can send four different signals each quarter of a second. Hence 960 different signals can be transmitted over the line in one direction in one minute, following one another so rapidly that the four different operators apparently send their signals simultaneously. It follows that the system is, therefore, a multiplex system. Its total capacity for one wire is four different signals each way in one-quarter of a second. Or in other words, 1,920 signals can pass over the line in a single minute. Professor Rowland developed his system so that numerals, letters of the alphabet, and some extra signs are automatically printed in such a manner that each operator by writing on an ordinary Remington keyboard prints at the end of the line on a page eight inches wide. The pages of printed matter have the general appearance of an ordinary sheet of typewritten matter. Forty words per minute is an ordinary speed for a practised operator, so that altogether eight operators can print over an ordinary telegraph line at the rate of 320 words per minute.

As in all systems of telegraphy, it is essential that certain parts of the rotating mechanism at each end of the line shall operate in unison. At first sight it might seem that since an alternating current is employed in the Rowland system, synchronism could be easily secured simply by passing the current through a small single-phase motor. But experience has shown that this is not sufficient on account of a phenomenon which engineers call the "pumping" of two machines which otherwise run synchronously. This "pumping" must be entirely eliminated. By employing a device called a mechanical "damper," Prof. Rowland succeeded in securing wonderfully perfect synchronism. Fig. 3 shows the method which he employed. Fixed to the shaft, S, of a single-phase alternating-current motor of small size is an aluminium wheel, A, in which is cut a small channel, C, filled with mercury. If the speed of the rapidly-revolving shaft and its wheel be subjected to oscillating increase and decrease, the mercury, on the other hand, will tend by its inertia to revolve at a uniform velocity. A friction is, therefore, produced between the mercury and the walls of the aluminium channel when their speeds are unlike. The oscillation or "pumping" is thereby dampened, and the rotation of the shaft becomes smooth and uniform. The device is simple but effective. Without it perfect synchronism would be impossible.

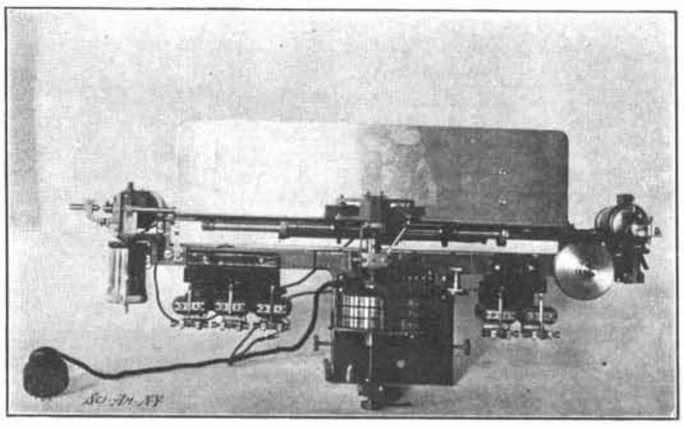
The synchronizer itself consists of a small alternating single-phase, four-pole motor of special design. The armature is made of four flat coils without iron and has a diameter of about three inches. Synchronism is maintained by local currents. The line current of from 30 to 70 milliamperes has only one function to perform, and that is to keep the two tongues of a polarized relay of a special design in constant vibration. In a novel method of making contacts one of these tongues is made to complete the local circuits which print the characters, while the other tongues serve to send positive and negative local currents through the coils of the synchronizer in a manner to preserve the synchronism.

The operation of cutting out the waves for transmitting the cutout wave signals over the line is performed on ordinary Remington keyboards, so constructed that the keys can be depressed only at intervals corresponding with the passage of 52 waves over the line, or at intervals of about one-quarter of a second. The locking device which times the depression of the keys is called the "clapper," and unlocks the keys four times per second, that is, each operator can cut out four different special combinations, and so send four different signals over the line in one second. Each of the four keyboards can cut out only waves of the group which is assigned to it. The manner in which this is done can best be explained by reference to Fig. 4. The four keyboards are represented by K_1, K_2, K_3, K_4. Each keyboard is supplied with eleven insulated contact springs 1, 2, 3, etc. To the frame of each keyboard is attached the negative terminal of a direct current 110-volt circuit. When any one of the 41 keys, belonging to a keyboard, is depressed, contact is made with some two of the 11 contact springs. The contacts made will be the combination which corresponds to the letter marked on the key. C is a so-called commutator or "sunflower." It is similar in construction to the commutator of a small dynamo and has 52 segments insulated from one another. There are four sets of segments, which are connected respectively to the eleven contact springs of the keyboards, K_1, K_2, K_3, K_4. The remaining eight segments are some of them entirely insulated, while others are connected to devices for cutting out waves used for automatic signals, but which are not shown in the diagram. In other words, the segments are divided up so as to correspond with the groups of half-waves shown in Fig. 2. The group A is connected to the contact springs of keyboard K_1, the group B to the contact springs of keyboard K_2, etc. Corresponding to the half-waves between the groups, A, B, C, etc., there are insulated segments which are shown in cross-section in the diagram. A brush or trailer, t, travels around the commutator C in synchronism with the dynamo Da, being geared to its shaft. This trailer passes from the center of one segment to the center of the next, while the current from the dynamo Da, makes half a wave. When the brush is at the middle point of a segment, the current from the dynamo is supposed to be passing through zero value.

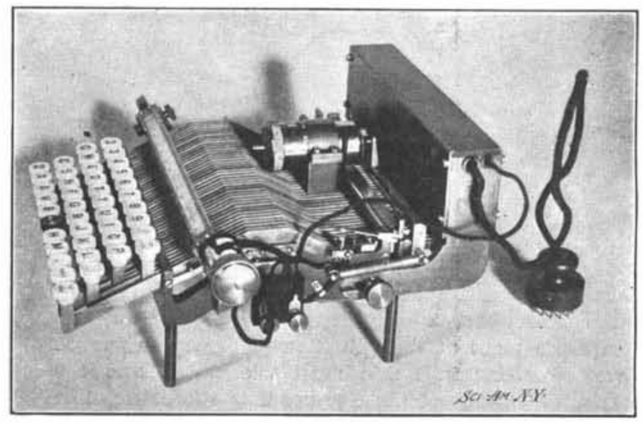
If the key be now depressed on keyboard, K_1, contact with the frame of this keyboard will be made with two of the contact springs, as, say, 7 and 11. When the trailer, sweeping around the commutator, reaches segment 11, which is connected to contact spring 11, the current from the 110-volt circuit flows momentarily from the positive pole through the coil, C, of transmitter, Ta, to the trailer, t; from there to the segment 11, thence to the contact spring 11, to the frame of the keyboard and back to the negative terminal. This current causes the transmitter, Ta, to draw back its armature, A, and thus break the dynamo circuit at P which goes to the relay and line, and at the same time the line is connected at N_1 to earth. Immediately, when the trailer passes off from segment 11 the spring



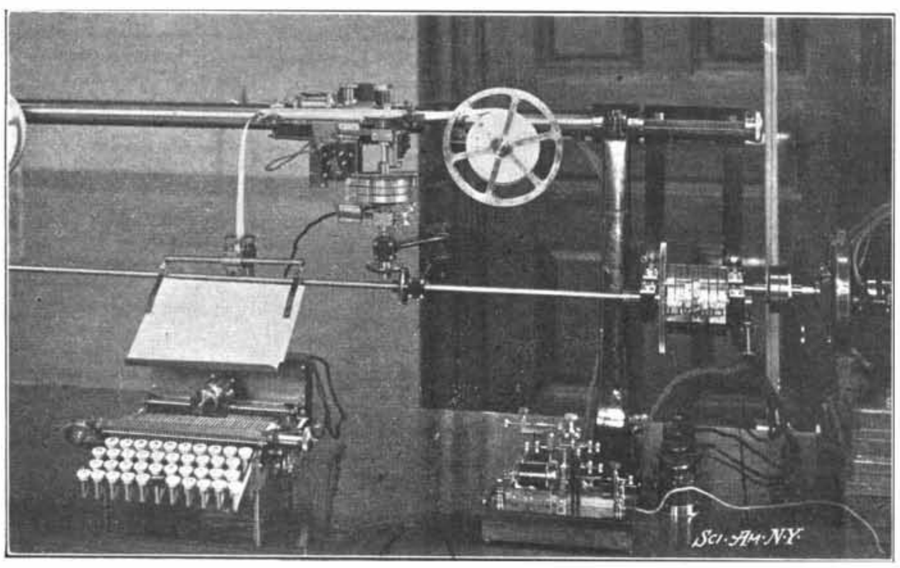
Main Line Relay.



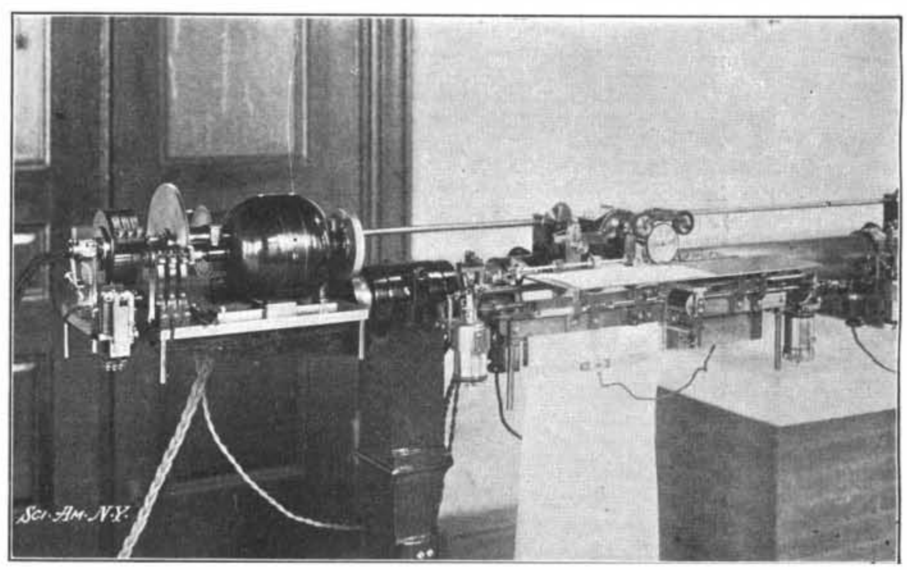
Printer, Showing Combination Commutator and Distributing Relays.



A Transmitting Keyboard.



Keyboard, Home Recorder, Transmitter (Main Line) and Sending Commutator.



Synchronizer, Receiving Commutator, and One Printer.

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S_1, pulls the armature *A* back, completing the line circuit with the dynamo, *D*. Thus, a half-wave of group A (see Fig. 2) has been cut out of the line circuit. When the trailer arrives at segment 7, the same operation is repeated, because the contacts which are made at the keyboard continue for a period equal at least to the time that the trailer takes to pass over the 11 segments which are connected to that keyboard. In like manner the operators on keyboards K_2, K_3, K_4 can cut out, by depressing some one key, any two waves from the groups of eleven which belong to them. An insulated segment is placed between each two groups of eleven waves, so that, in case the last half-wave of one group and the first half-wave of another group are cut out, there will be an interval of a half-wave between these occurrences. This is found to be necessary for the proper operation of the main line relay at the receiving station.

From the manner in which these half-waves are cut and the signal sent over the line, it is evident that each operator works independently of the other, and that no conflict between the signals which are sent by each can possibly occur. It is likewise evident that four entirely different and independent signals can be sent in one direction in the one-quarter second during which the trailer passes around the commutator. Thus, it becomes clear how eight different and totally independent signals can be sent over the line in one-quarter of a second or 1920 a minute.

The operation of cutting out the waves at the other end of the line is precisely the same. The signals which are sent over the line appear at the distant end merely as two momentary pauses in the otherwise constant vibration of the tongues of the main line relay. It now becomes necessary to show how these transient signals are translated into a readable record and then into printed characters. Since the two ends of the line are in all respects alike, any description will apply to the one as well as to the other.

Referring to Fig. 5, *L* is the main line, and *RA* the main line polarized relay. This relay has two insulated tongues which vibrate synchronously with the alternating current waves arriving over the line, *L*. The tongue *ts* controls the synchronizer, *S*, which operates in the manner described above. The tongue, *tp*, has the functions to be described. *C* is a "receiving" commutator, practically identical in construction with the "sending" commutator. Sweeping around this commutator, which has 52 segments, there is a brush, or trailer, *tr*. This trailer is connected by gearing to the rotating synchronizer, *S*, but with a speed reduction of 13 to 1. The commutator may be rotated through a small angle, giving an adjustment, so that when the trailer, *tr*, is in the center of a segment the relay tongue, *tp*, is at that instant against either a left-hand or a right-hand contact. *R* is a resistance of several hundred ohms, to the terminals of which is connected a 110-volt direct-current circuit. *A* is a bank of small polarized relays, called the "selecting" relays. There are, in reality, four such banks of 11 relays each. Only one bank, however, is here shown. Each of these four banks corresponds to a keyboard at the sending end of the line. One terminal of each of these relay coils is connected to a segment in one of the groups of 11 segments of the commutator, *C*. The other terminals or "tails" of all the coils of all the relays are connected with the insulated tongue *tp* of the main line relay, *RA*. As the tongue of this relay vibrates between its contact points and the trailer travels over the commutator segments, synchronously with the vibrating tongue, the 44 relays will receive, in succession, momentary currents through their coils. The relays 1, 3, 5, etc., of each bank will receive a current through their coils in one direction, and the relays 2, 4, 6, etc., a current in the opposite direction. Thus, the tongues of the relays of even number would receive an impulse in one direction, and those of an odd number in the opposite direction. The windings, however, of relays of odd numbers are reversed, and this makes the tongues of all the relays receive, in succession, an impulse in the same direction as the trailer passes over the segments of the commutator to which they are attached. Thus, while the current on the line is unmodified, the tongues of all the "selecting" relays will receive an impulse in the same direction once each time the trailer makes a complete revolution. These repeated impulses, together with the magnetism in the tongues of the relays, hold them against their back-stops and away from the contact points, *A*, *B*, *C*, etc.

The cutout wave on the line will now be indicated in the following manner. When the wave is cut out, the main line relay tongue, *tp*, will at that instant cease to vibrate and will remain against the contact point which the previous wave had carried it. The trai in the meantime passes on to a segment such that, it

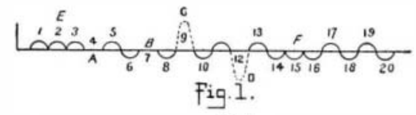


Fig. 1.

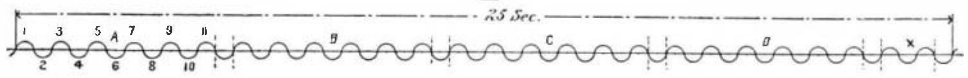


Fig. 2

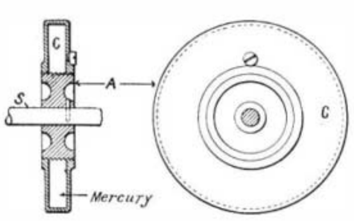


Fig. 3.

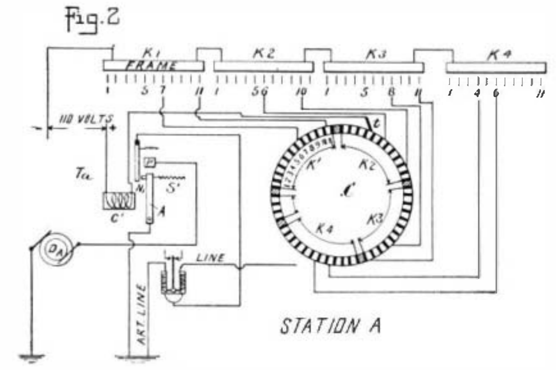


Fig. 4.

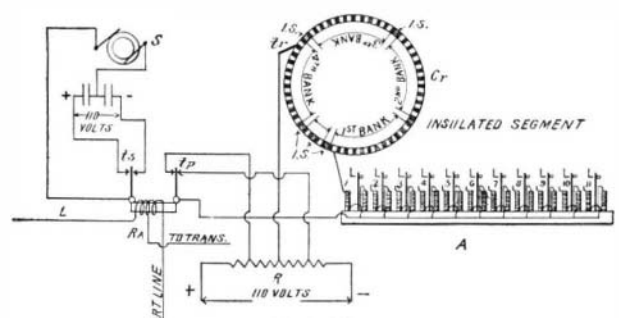
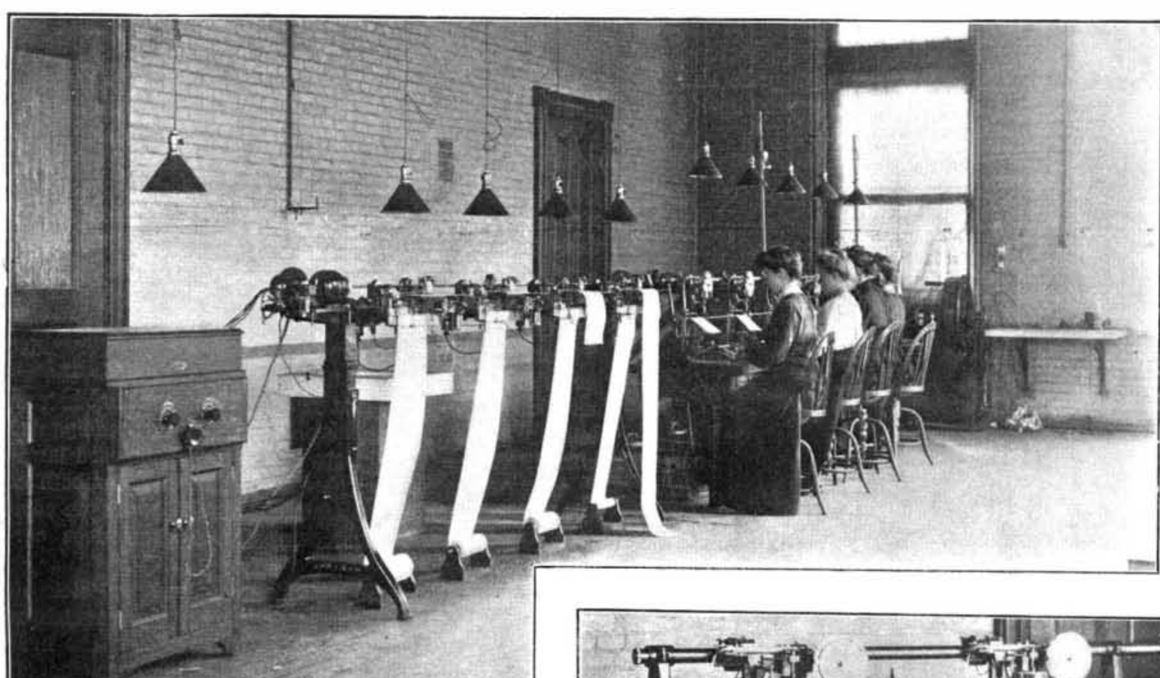
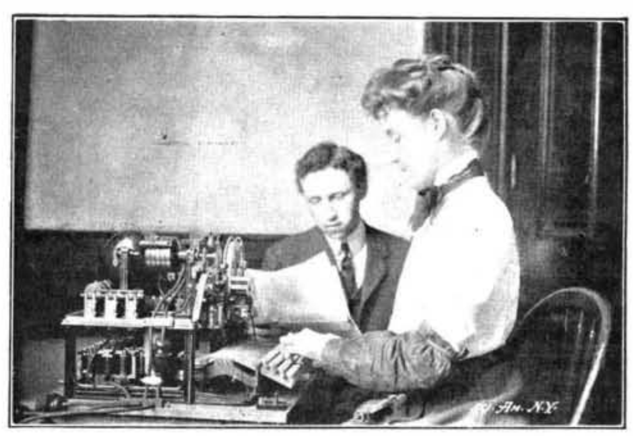


Fig. 5.

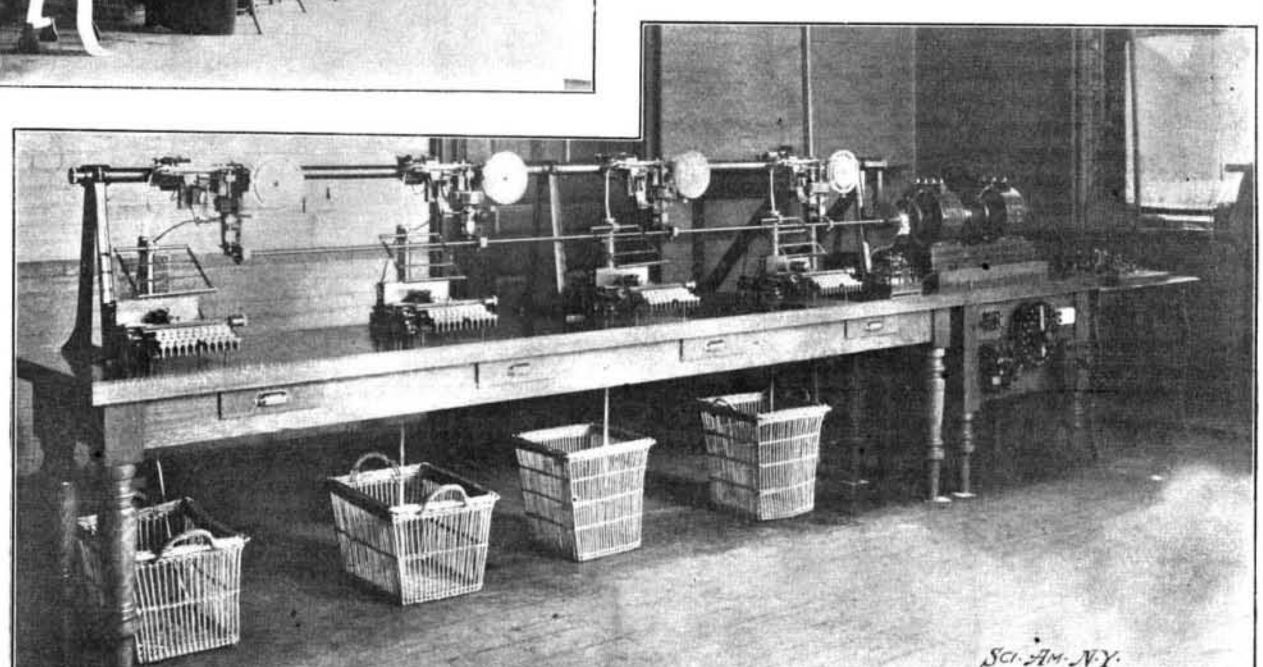
THE ROWLAND SYSTEM OF PAGE PRINTING TELEGRAPHY



General View of Transmitters and Printers.


Transmitting a Message.


Receiving a Message on the Page-Printer.



A Group of Keyboards. Main Line Relay and Transmitter to the Right.

THE ROWLAND MULTIPLEX PAGE-PRINTING TELEGRAPH.

the main line relay tongue had been carried over, the selecting relay attached to that segment would have received an impulse to take it against its back-stop. Now, however, this selecting relay will receive a current through its coils in a reverse direction to what it would have received had the main line relay tongue continued to vibrate. Its tongue will, therefore, be thrown against its contact point, and will remain there until the trailer has made a complete revolution. When the trailer returns to the segment to which the relay is attached, unless some wave is again cut out, the relay will receive an impulse which will return its tongue to its backstop again. Thus, waves which are cut out at the far end of the line are reproduced at the near end by the tongues of the selecting relays which correspond to the wave cut out, being thrown against their contact points, *A*, *B*, *C*, etc., and there remaining during one revolution of the trailer. As each of the four keyboards at the far end of the line operates a corresponding bank of 11 selecting relays at the near end, the depression of any key of the keyboard, which cuts out two waves, will cause two relay tongues in the bank corresponding to that keyboard to be thrown against their contact points. A practised observer could readily interpret the cutout wave signals sent over the line by merely observing the movements of the tongues of the selecting relays. Tongues 1 and 3 sent over might be interpreted to mean *A*. 1 and 4 to mean *B*, etc., through the 45 possible combinations given above. But in the present system these signals are automatically translated into ordinary figures and letters of the alphabet which are printed upon a sheet of paper eight inches wide. It now only remains to show how this is accomplished.

The page-printer, by which the 41 different characters are printed in type, comprises essentially a light type-wheel of steel, about 2 inches in diameter, on the circumference of which 41 characters are engraved. This type-wheel revolves continuously at the end of a horizontal shaft which turns synchronously with the trailer. A light paper carriage carries the paper fed from a roll beneath the type-wheel when new lines are made. Devices are employed for thrusting the paper forward to make lines, and sideways to space letters. Back carriage devices return the paper to a position where a new line of print is to start. A small printing magnet operates a hammer which strikes the paper up against the lower side of the wheel rim, at the moment when the character to be printed has turned to its proper position above the hammer. A set of four polarized relays, called "distributing" relays, serve the purpose of making contacts at proper moments for sending current to the printing magnet to print, to a liner magnet to line the paper, to a spacer magnet to move the paper sideways, and to a back magnet which allows the carriage to return the paper to the proper position when beginning a new line.

In keyboards of the latest page-printers, contacts are electrically made. Fifty-six waves are divided into four groups. Of the waves in each group eleven are used for the printing; one wave in one of the groups is used for finding the letter; and three waves, one taken from each of the remaining groups, are reserved for purposes of signaling. The signaling can be effected in a number of ways. Morse instruments, one at each end of the line, can be worked duplex at a slow speed. It is preferable, however, to place at each end of the line, in addition to the four page-printers, a small page-printer, both of which print simultaneously at the rate of fifteen words a minute each. While the eight printers of the duplex system are in operation with the transmission of telegrams, the two stations can correspond with each other regarding business of the office, for the purpose of correcting errors. The system may, therefore, be called, with propriety, a "decaplex" system. In the later machines an additional important feature has been embodied whereby it is rendered possible to record at the sending station all messages which are transmitted.

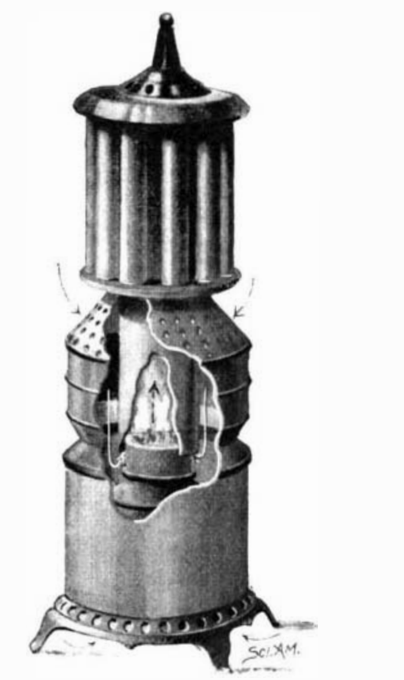
It is claimed that the octoplex system can transmit to greater distances without relaying than other multiplex systems hitherto known. It has been successfully operated under government tests over a line of 550 miles; it is anticipated that it will work perfectly without relaying between New York and Chicago. Methods were, however, devised by Prof. Rowland for automatically relaying the messages.

Whatever may be the various applications of the Rowland system, and they are many, the octoplex capacity can be distributed in any convenient manner, that is, in place of having 8 operators, and a speed of 40 words per minute each, the number of operators can be doubled and the speed of each halved; or any number of operators can be employed with the limitation that the aggregate speed of the apparatus shall not exceed that of the eight operators at 40 words. In cases where branch lines radiate from a central, these lines may be 300 miles or longer. Or in cases of slightly different apparatus, placed at the terminal of the branch, these branches may have any length up to the maximum of the system. Way station lines may have any length up to 300 miles.

In this description it has been attempted only to give a bare outline of the features of Prof. Rowland's remarkable invention. Much more might be said of the many ingenious devices used and the new mechanical features employed. Throughout the apparatus is the practical embodiment of beautiful physical principles and mechanical devices. One very important characteristic is the natural way in which the system divides itself into distinct units. If one unit becomes deranged, another may be immediately substituted without stopping the operation of the rest of the apparatus.

SUBSTITUTES FOR COAL IN HEATING AND COOKING.

Although the strike in the anthracite coal fields is happily ended, it will take a few months to bring the supply up to the demands of the public, and consequently the price of hard coal is likely to remain at

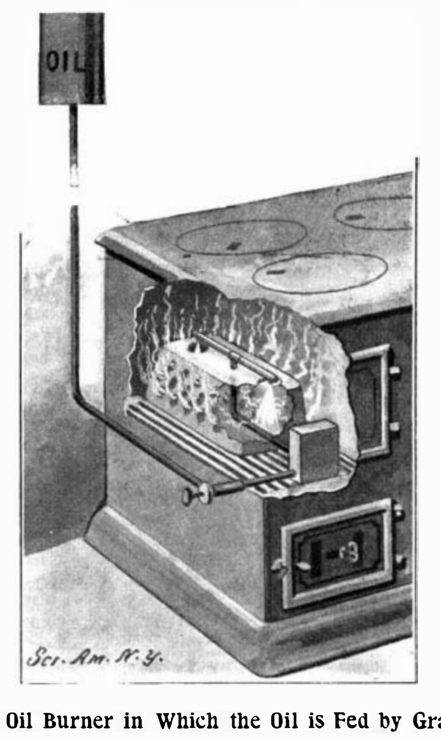


A Type of White Flame Wick Heater.

a figure which will cause the majority of the "house-keeping" public to look around for a cheaper fuel than coal at anywhere from $9 to $12 a ton. The Scientific American has investigated the problem with results which are tabulated below.

1. Electricity can hardly be considered as a factor, for two reasons; first because but a very small proportion of the populace are situated so as to be able to have the current delivered to their houses, second because the cost of heating by electricity would be so very high as to preclude the possibility of its general adoption.

2. Soft coal, apart from its very high price and the difficulties in the way of getting it, requires such radically different treatment from hard coal in order to burn it, that its adoption as a substitute for anthra-



Range Oil Burner in Which the Oil is Fed by Gravity.

cite will necessarily be limited. In burning soft coal it must be remembered that, because of the much greater quantity of gas contained in it, care must be taken not to overload the fire box. In starting the fire, the grate must not be filled more than half full, and the fire must be replenished a little at a time. Air must be permitted to reach the fire from above as well as from below, and this may be accomplished by opening the broiling door or by slightly opening one of the lids at the back of the stove.

Owing to the large amount of unconsumed carbon which passes into the chimney, the latter will require careful attention, since the flues—at least in modern houses—are usually built for the burning of hard coal, and being of rather small area, they are very likely to become choked with soot. If the chimney should catch fire, the fire may be quickly extinguished by throwing a handful of common roll sulphur upon the glowing coals in the grate, closing down all the openings to the stove and covering the top of the chimney. The gas produced by burning sulphur—sulphur dioxide—does not combine with carbon, and therefore the fire in the chimney will be quickly put out. The chimney must be kept closed up until well cooled.

Chimneys which are provided with a hole at the bottom for cleaning purposes may be easily cleaned by dropping a pailful of pebbles down from above. These carry most of the soot down with them to the bottom, whence the matter is easily removed. The main precautions to be observed are to maintain a moderate fire, and to put on only small quantities of coal at a time.

3. Gas seems but a broken reed to lean upon, since the companies are utterly dependent upon the coal supply. Moreover, for heating a house from a basement furnace gas is very expensive. A talk with a representative of one of the largest gas stove manufacturers brought out the fact that when used in a hot-air furnace—a furnace by the way *specially* constructed to burn gas—it would cost as much to heat a house by gas as it would to heat it with a coal furnace burning coal at $20 per ton, and this, taken in connection with the cost of installation of the special furnace, would preclude the adoption of this means of heating to any appreciable extent.

The economy which the gas cooking stove exhibits when compared with an ordinary range is entirely dependent upon the fact that in cooking with the gas stove nearly the whole of the heat produced by the gas is utilized, whereas with the range much of the heat produced is used to raise to a high temperature a large mass of iron; further, a fire once started in a range must burn for a considerable time after one is through cooking, while the consumption of fuel in the gas stove ceases directly you are through. It will therefore be quite evident that though the range burns by far the less expensive fuel, such a great proportion of the fuel energy is wasted that the gas stove is able to show an economy of operation just as long as the heat is required concentrated upon a particular place, and as long as the time during which the heat is actually required is comparatively small. The problem of house heating does not, however, conform to either of these conditions. In this case the heating of a large mass of metal is a positive advantage, as it gives a greater radiating surface, and since the heat must also be constantly maintained it is quite evident that the range, using as it does the cheaper fuel, is the more economical.

4. Oil stoves being entirely independent of the coal supply for the production of their fuel, naturally present a more promising field for investigation than anything we have thus far considered. They may be roughly divided into two classes; first, those which use a wick, and burn with a white or yellow flame, and second, the wickless or blue flame oil stoves. The latter are to be recommended as the more efficient heaters. An understanding of the principles of combustion will make this last point clear.

The process of combustion is in a chemical sense nothing more than the union of the oxygen of the atmosphere with some material for which it has such an affinity or attraction that the union is accompanied with light and heat. Now, kerosene is composed largely of two substances, hydrogen and carbon, for both of which oxygen has an attraction, though hydrogen combines at a much lower temperature than does carbon.

In lighting an ordinary kerosene lamp or wick oil stove this is what takes place: You apply a match to the wick, which is saturated with kerosene; the heat vaporizes a little of the oil, the hydrogen in the oil combines with the oxygen of the air, and the heat produced by this union heats the carbon of the kerosene white hot, and thus we get the familiar whitish-yellow flame of the kerosene lamp. The carbon does not, however, thoroughly combine with the oxygen, and in consequence a great deal of the heating possibilities of the flame is lost, though the flame serves as a fair illuminator.

In the blue-flame oil heater a different condition of affairs exists. The kerosene, which is stored in a reservoir, is permitted to flow slowly into a vaporizing device, from which it passes to a burner. In one of the stoves shown the vaporizing device is a circular trough, made of cast iron, which is heated to a very high temperature. This vaporizes the kerosene and the vapor thus produced is compelled to pass between two walls of red hot metal while at the same time heated air is caused to act upon it. The temperature to which the vapor is raised by this means is so great that *both* the hydrogen and carbon are compelled to combine