No. 791,655. PATENTED JUNE 6, 1905.

H. E. SHREEVE.

TELEPHONE CURRENT REINFORCER OR RELAY.

APPLICATION FILED JULY 8, 1904.

2 SHEETS—SHEET 1.

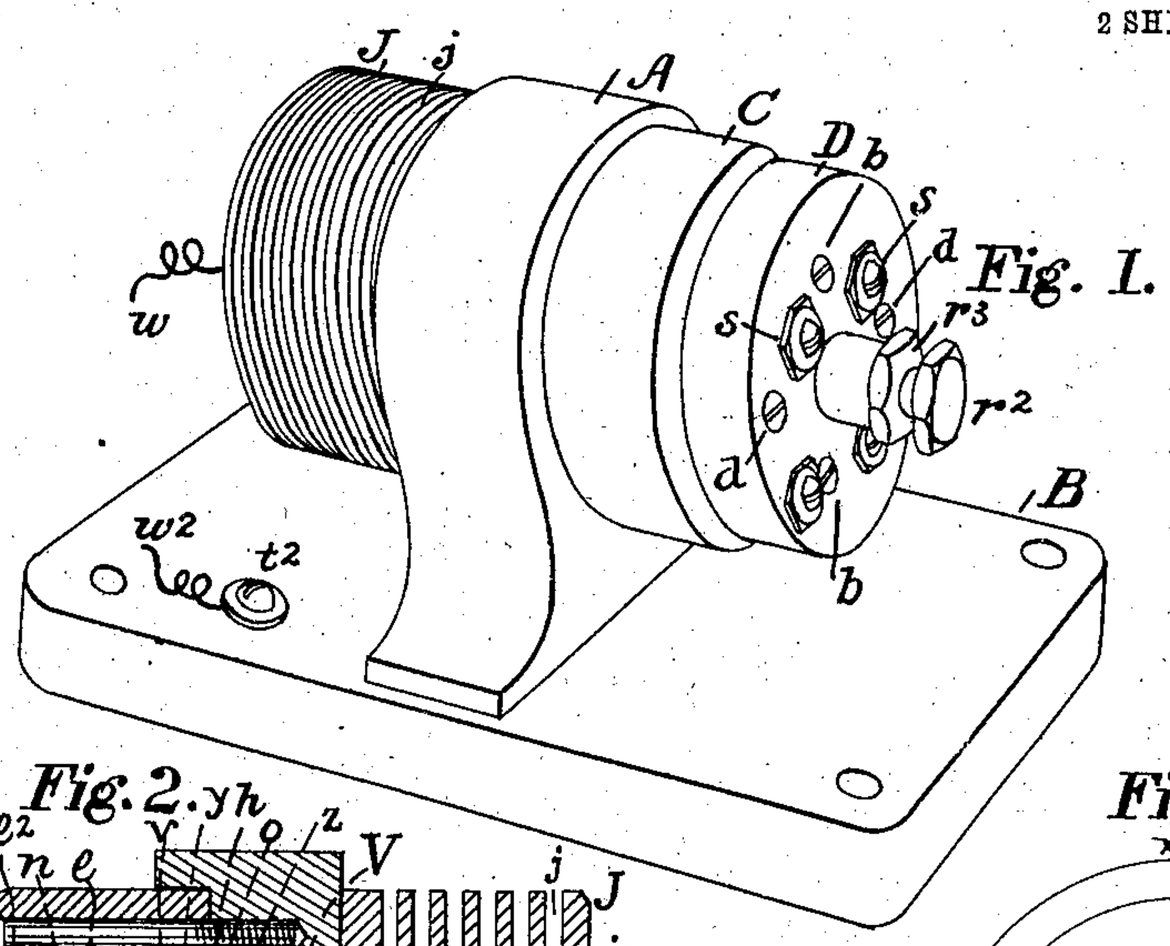


Fig. 1.

Fig. 2.

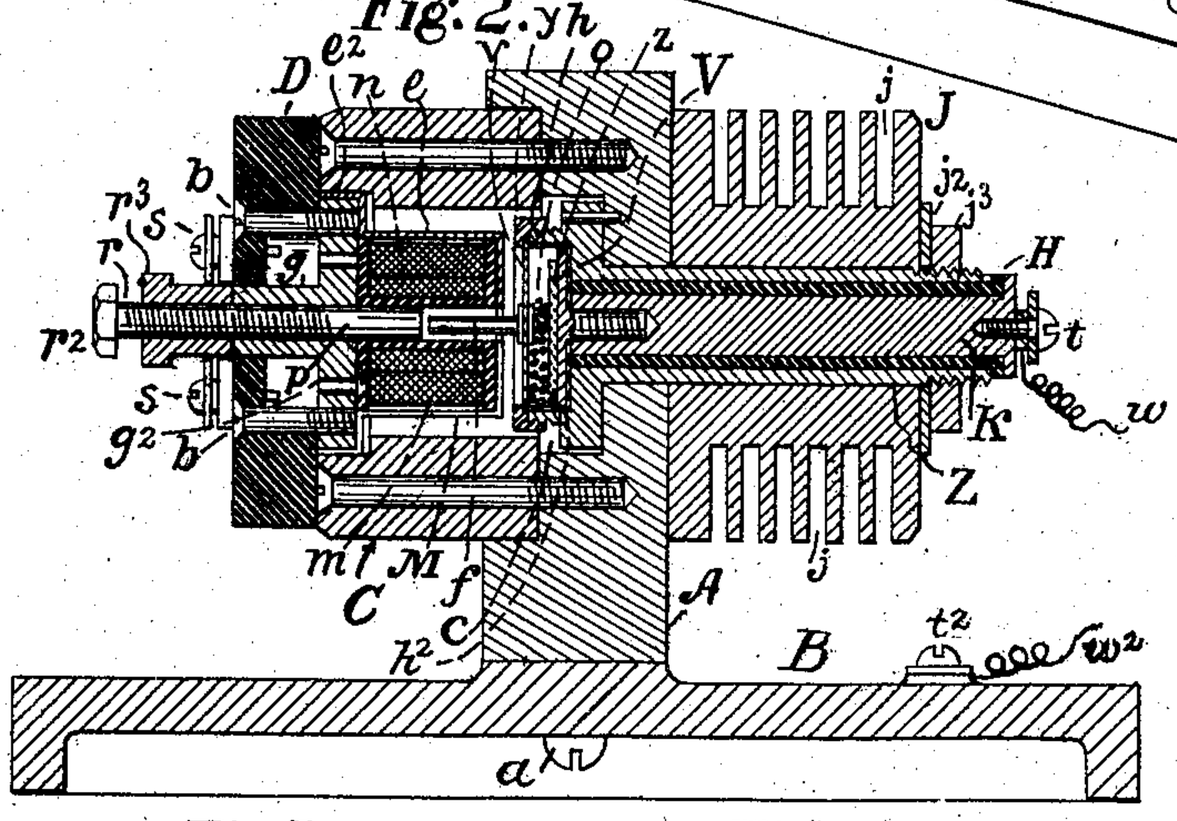


Fig. 3.

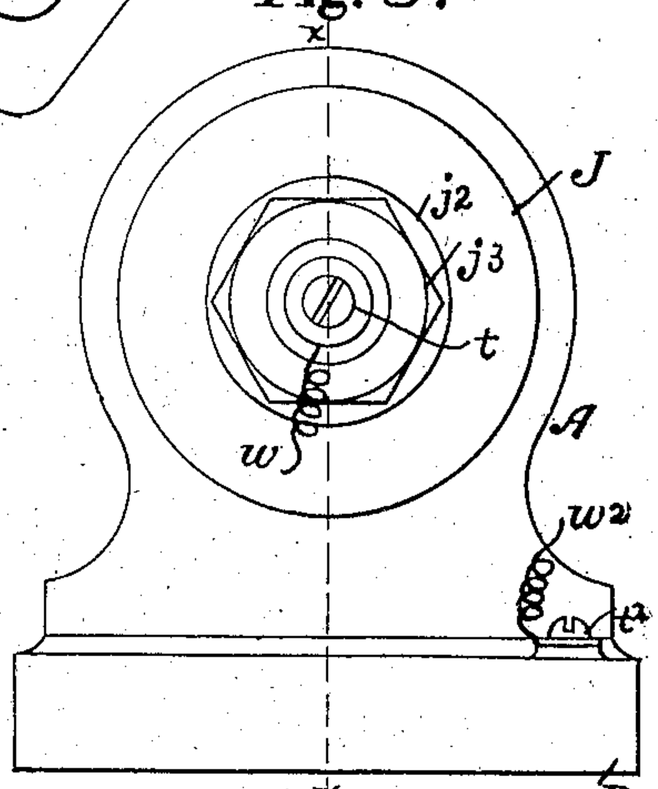


Fig. 5.

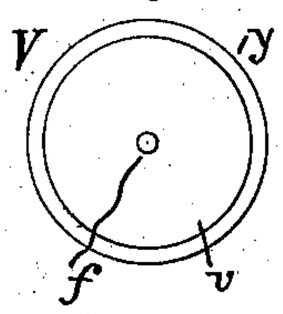


Fig. 4.

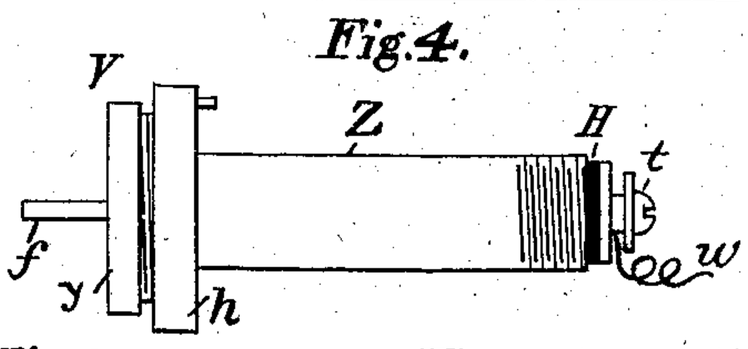


Fig. 6.

Fig. 7.

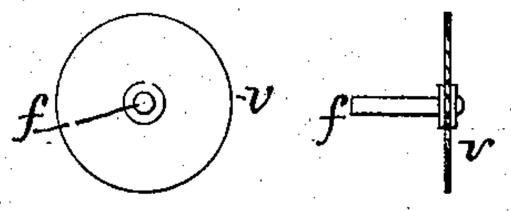
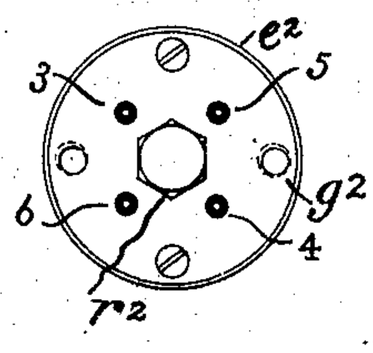
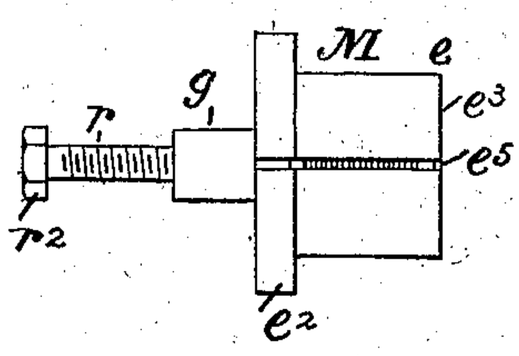


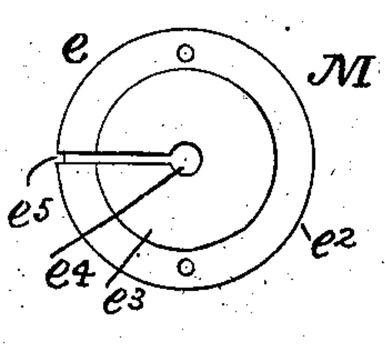
Fig. 8.

Fig. 9.

Fig. 10.







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2 SHEETS—SHEET 2.

Fig. 11.

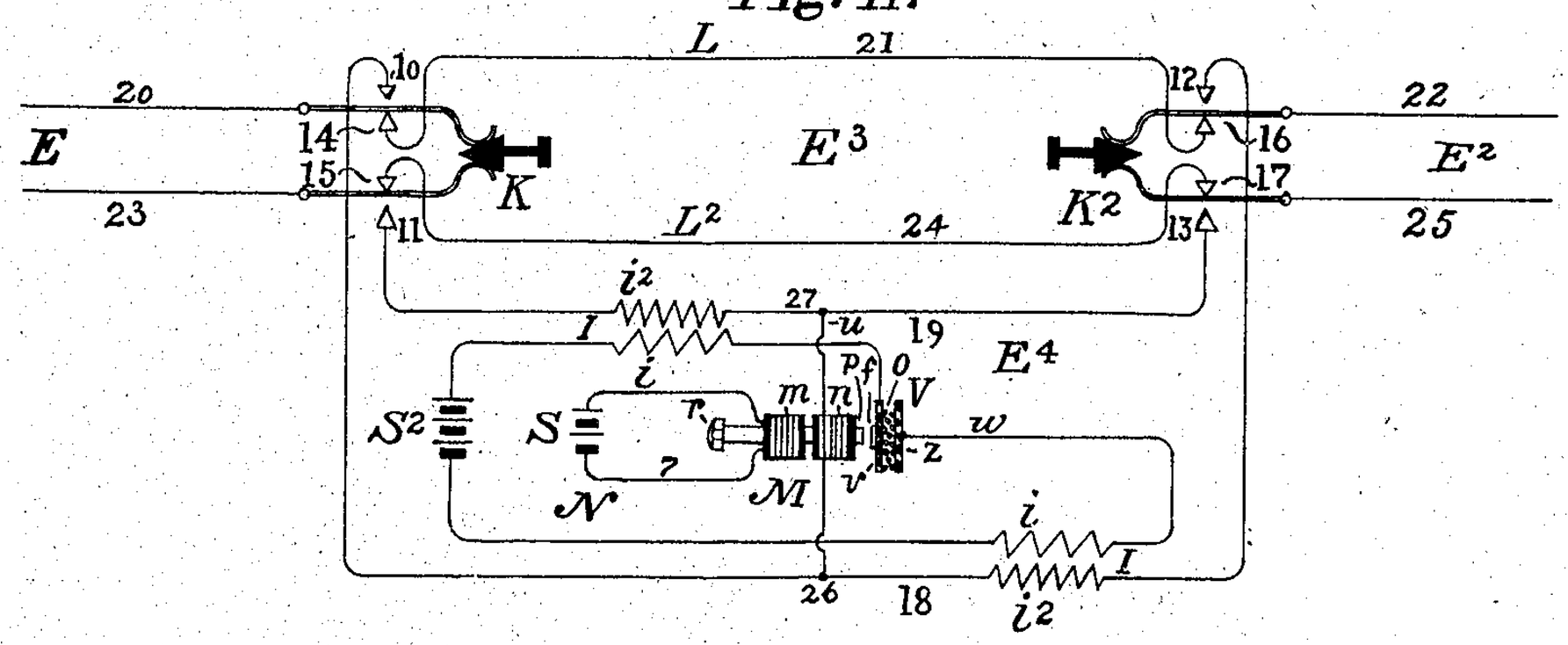


Fig. 12.

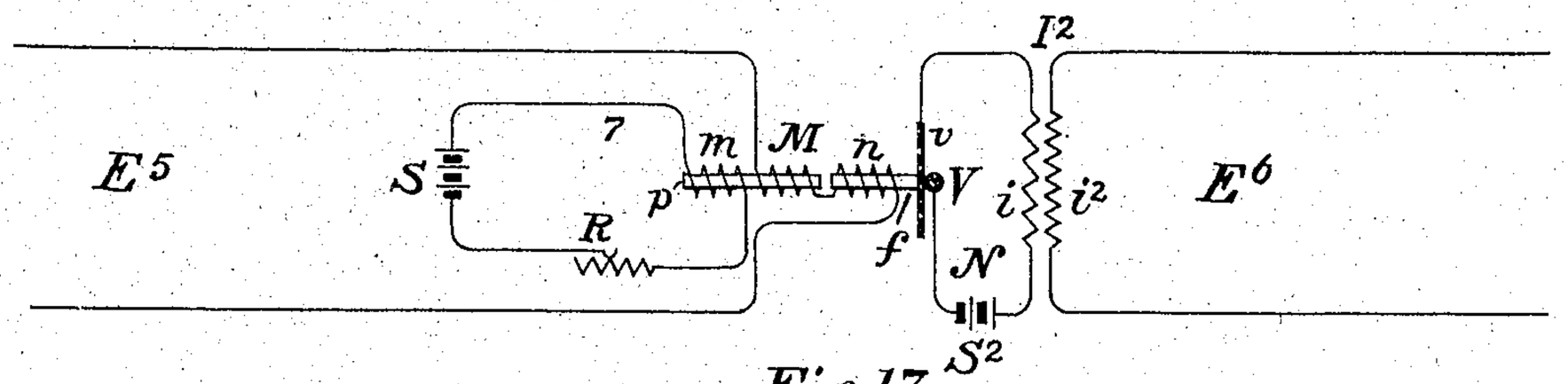


Fig. 13.

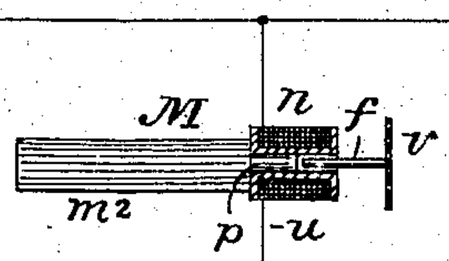
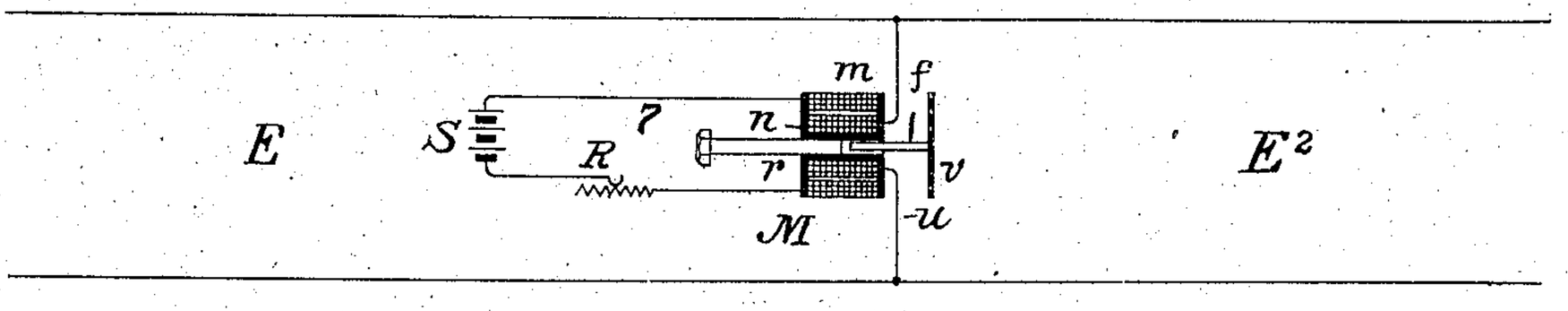


Fig. 14.



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No. 791,655. Patented June 6, 1905.

UNITED STATES PATENT OFFICE.

HERBERT E. SHREEVE, OF NEWTON, MASSACHUSETTS, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TELEPHONE-CURRENT REINFORCER OR RELAY.

SPECIFICATION forming part of Letters Patent No. 791,655, dated June 6, 1905.

Application filed July 8, 1904. Serial No. 215,811.

To all whom it may concern:

Be it known that I, HERBERT E. SHREEVE, residing at Newton, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Telephone-Current Reinforcers or Relays, of which the following is a specification.

This invention relates to the speaking-telephone and telephonic transmission, and more particularly to means for reinforcing or strengthening the electrical currents concerned in such transmission.

Telephone-currents even in short circuits have no strength to spare, and in talking over long telephone-lines they become so enfeebled in consequence of the increased resistance of the conductor and of leakage and other unavoidable losses that their effect upon the receiving-telephone is correspondingly weakened and the reproduced conversation so faint and indistinct as to render the hearing and apprehension of the communication difficult and laborious, thus imposing a serious limitation upon the distance to which commercial transmission is at present possible. It is therefore most desirable that some way or means of reinforcing or renewing the current at the receiving end of the line or of enabling it to act upon the receiver with increased power, effectiveness, and accuracy shall be found.

Various attempts have from time to time been made to devise electromechanical apparatus capable of replenishing the current at some intermediate point of the circuit or adapted to transfer the messages of one telephone-circuit to another, and thereby either to increase the length of line that can be operated satisfactorily or under other conditions to enable the receiver to reproduce the transmitted message with increased loudness. These efforts, however, have uniformly been unsuccessful and unproductive of practical result, and it is a fact that nothing of the kind is in practical or commercial use at the present time in connection with telephone-circuits anywhere, for though in some instances the sounds reproduced by the receiver actuated by the replenished current have, indeed, been characterized by increased loudness such increase has invariably been at the expense of clearness and has always involved the loss of quality and the consequent introduction of so much distortion as to render the utterances of the receiving instrument inarticulate and unintelligible.

The objects of the present invention are to effectively reinforce or renew the talking-currents traversing the line in such manner as to virtually compensate for their losses, to thereby so maintain their strength and assist their action at the receiving end of a long circuit that they shall be enabled to act upon the receiving-telephone and cause it to operate for the reproduction of the transmitted sounds or conversation with substantially the same vigor, loudness, and clearness as would be the case if the circuit connecting the transmitting and receiving instruments were direct and very short, or, in other words, to obtain the capability of retransmitting the message at any convenient intermediate point of the circuit or chain of circuits extending between the original transmitter and the ultimate receiver with renewed energy and without sacrifice of quality and generally the efficient and satisfactory transmission of conversation telephonically under practical and commercial conditions for greater distances and through longer circuits than has heretofore been practicable.

In carrying out my invention I employ and adapt for connection at any point between transmitting and receiving stations of a telephone-circuit or series or sequence of circuits an organization comprising a variable receiving-magnet responsive to the talking-currents of such transmitting-station and a variable-resistance medium mounted in operative relation to the said receiving-magnet to be acted upon thereby and arranged to forward the talking-currents with renewed energy and without impairment of their quality characteristics to such receiving-station for the more perfect operation of the receiving instrument there.

In the development of this invention it has

been found important (keeping in mind the character, delicacy, and minuteness of the forces engaged, the smallness of the motion, and the functions to be exercised) that the inertia of the moving parts shall be as small as possible, that the magnetizing and magnetization-varying forces shall be so organized and disposed that the maximum effect of the latter upon the former shall occur at the strongest part of the common field, that the maximum effect of both may be concentrated directly upon the active or movable member of the transmitting medium, and preferably upon the most sensitively mobile part or point thereof, and that provision shall be made to facilitate the expeditious dissipation of the heat developed in and by the operation of the transmitting medium. These principles are exemplified by the present invention and in its receiving and transmitting elements, which are closely associated in a single instrument.

The receiving factor comprises a magnet constituting the required initial magnetic field, a magnetization-varying coil to be connected with the main circuit of the original transmitter to receive the talking-current thereof and encompassing the end of the magnet, which thus serves as a fixed core or pole-piece entering said coil to have its magnetization varied thereby, and a short and light piece of iron which forms a movable pole-piece whose end is closely adjacent to that of the fixed pole-piece in the magnetic field. The transmitting factor closely confronting the said coil is a variable-resistance microphone and has a movable contact or electrode, which instead of being actuated by a vibratory diaphragm in the usual manner is attached directly to the light movable pole-piece of the receiving part of the apparatus, which thus constitutes a direct magnetic connection between the receiving-magnet and the transmitting medium, and by this arrangement the diaphragm is dispensed with, the inertia of the moving parts reduced to a minimum, and the requisite motion imparted to the movable electrode of the transmitting medium directly from the variable field and preferably from the center of the varying-coil, and therefore from the most effective part of said field.

The magnet establishing the initial field may be either an electromagnet of any construction or form excited by a separate magnetizing-coil in a special local circuit or a permanent magnet such as that of the ordinary and standard telephone-receiver. An electromagnet is, however, to be preferred for this purpose, since in association with it an adjustable resistance may be included in its local circuit to regulate the strength of its current, and thereby the strength of the magnet, and thus of the initial field, to any desired degree. Furthermore, I find it of distinct advantage to provide that the electro-magnet shall be of tubular form, having an iron shell, with the magnetizing and varying coils arranged concentrically therein, to surround the fixed core or pole-piece, the said magnetizing-coil being preferably outermost and the iron shell or casing arranged to entirely inclose both coils except at their front center, where an opening or perforation is provided to receive the movable pole-piece attached to the transmitter-electrode, which, passing through said opening into the varying-coil, constitutes a portion of the magnetic circuit of the receiving-magnet. For the avoidance of eddy-currents the iron shell may be slit longitudinally down one side and to the center of its front plate.

The variable-resistance-transmitting medium is of the "Hunnings" and "solid-back" types, wherein a mass of granular carbon is held inclosed in a flat chamber or hollow button between rigid and vibratory conducting-disks, (usually of carbon,) which respectively constitute contact members or electrodes, one of which is vibratory or movable, the mechanical connection of the latter with the light movable pole-piece of the receiving-magnet being made at its center, that being the point or part most sensitive and most readily mobile and having the widest range of motion.

By inclosing the working parts of the apparatus and particularly the transmitting element thereof in a metal casing possessing, or in connection with, considerable mass and radiating-surface and with which such working parts are in heat-conducting relation an effectual means is provided for the prompt and continuous removal and dissipation of the heat, which during the operation of the instrument is generated in the transmitter-button by the passage of the local-circuit current through the variable-resistance material and which if retained and permitted to accumulate acts to deprive the carbon granules of their microphonic property, and thus seriously impairs the operation of the transmitting medium.

In the drawings accompanying this specification, Figure 1 is a perspective view showing the external appearance of a form of apparatus embodying the invention which has been made and successfully used. Fig. 2 is a vertical longitudinal section of Fig. 1, taken on the line *x x* of Fig. 3, showing the preferred construction and arrangement of the parts. Fig. 3 is an end view of the apparatus shown by Figs. 1 and 2. Fig. 4 illustrates the mounting of the transmitting medium with the movable core of the receiving-magnet attached to its movable electrode, Figs. 5, 6, and 7 showing, respectively, the end view of the said medium and its mounting and separate side and front views of the said electrode and the core attached thereto. Figs. 8, 9, and 10 show in detail rear, side, and front views of the tubular magnet preferably employed in the receiv-

ing medium. Fig. 11 is a diagram showing the electrical connections of the renewer or reinforcing apparatus when associated with a telephone-circuit at an intermediate point thereof. Fig. 12 illustrates a modified arrangement for establishing the initial field of the receiving medium and an alternative circuit arrangement for the apparatus as a whole. Fig. 13 illustrates still another mode of constituting the initial magnetic field of force, and Fig. 14 is a diagram of the manner of supplying the initial field for the form of electromagnet illustrated by Figs. 1 and 2.

Referring to the drawings, and for the present more particularly to Figs. 1 to 10 and 14, the working parts are inclosed in a cylindrical metal casing C, screwed or bolted to a chambered and centrally-bored metal standard A, which in turn is mounted upon a metallic base B, to which it is secured in any desired way, as by screws *a*, which pass through said base and into the lower edge of the standard. The outer end of the casing-cylinder C is closed by a disk D, of hard rubber or like material, secured to its edge by screws *d*. M is the variable magnet constituting the receiving factor or medium of the instrument, and V the variable-resistance-transmitting medium. The former (illustrated by Figs. 2, 8, 9, 10, and 14) is in this instance an electromagnet of the tubular or iron-clad type, having a fixed iron core or pole-piece *p*, a movable iron pole-piece *f*, an inclosing iron shell *e*, a magnetizing or exciting coil *m*, and a magnetization-varying coil *n*. It is attached as a whole by screws *b* to the insulating-disk D, which has binding-screws *s* to serve as terminals for the said coils and is centrally perforated to receive a threaded iron socket *g*, through which passes the shank *r* of the fixed core *p*. The magnetizing-coil *m* and varying-coil *n* are concentrically disposed within the iron shell *e*, the said magnetizing-coil being preferably outermost. The shell itself is closed in front by the plate e^3, which, however, may, as shown, be an extension of the substance of the shell spun or struck up from the cylindrical part thereof and has for a heel-plate the thick disk-formed base g^2 of the socket *g*, being provided rearwardly with a flange e^2, overlapping and closely clasping the edge of said base-plate, so that both coils are entirely inclosed by the said shell with the exceptions of a small opening or aperture e^4 at the center of the front plate, forming a passage for the movable pole-piece *f*, and a longitudinal slit e^5, extending from the said aperture and down the side of the shell to prevent the development and circulation of eddy-currents and consequent waste of energy. The fixed core *p* may, as shown, be fitted at its outer end with a bolt-head r^2 and jam-nut r^3 or other means for turning it and holding it in place, and its shank *r* is threaded to correspond with the internal thread of its socket *g*. Entering the coils through said socket, it passes to or nearly to the center thereof, and being magnetized by the coil *m*, which receives energy from the battery S in the local circuit 7, Fig. 14, it acts to establish the initial magnetic field. R is a rheostat or adjustable resistance connected in the local circuit 7 to regulate the strength of the magnetizing-current, and by thus providing the receiving medium of the apparatus with an electromagnet separately excited by a special source in local circuit and with such means of current regulation the magnet may readily be regulated to produce the desired power. The movable iron core or pole-piece *f* is a short piece of small-sized iron rod and is attached at one end to a movable part of the associated transmitting medium in a manner presently to be explained, and being thereby elastically supported it passes loosely through the aperture e^4 and, as best shown in Fig. 2, into the forward end of the inclosed coils *m* and *n*, extending to a point about the center thereof, so that its inner end nearly reaches but does not touch that of the fixed core *p* in the concentrated field at the center of said coils. The distance between the ends of the fixed and movable cores may, it is evident, be accurately adjusted by turning the former in its threaded socket *g*. The magnetic system of the receiving agency when constructed as shown and described constitutes, it will be seen, an approximately complete magnetic circuit having fixed and movable or vibratory pole-pieces at the center of exciting and varying coils, and thus at the point of highest magnetizing power and at the most effective part of the magnetization-varying field and whose only substantial gap in the continuity of its iron is that which is formed by the space between said poles. The magnetization-varying coil *n* is designed to be connected with the main circuit or circuit-section E and to be excited by the voice-currents flowing therein and proceeding from the original transmitting-station of such circuit. It encompasses both pole-pieces and is adapted to vary the initial magnetization and mutual attraction of both, and consequently to throw the movable core or pole-piece into vibrations corresponding to such attraction variations and to the electrical variations or voice-currents of the circuit. The ends of the windings of the coils *m* and *n* pass through insulated apertures 3, 4, 5, and 6 in the socket-plate g^2 and then to the terminal binding-screws *s* on the exterior of the non-conducting disk D, whereby they may be attached to the local and main circuit conductors, respectively. The transmitting medium V, closely confronting the forward end of the magnet M, is suitably mounted within the casing C, the metal standard A, which closes one end of said casing, being recessed at *c* for its reception. It mainly consists of a metal chamber or hollow button *h*,

in type and form substantially identical with that employed in standard telephone-transmitters having a non-conducting internal periphery h^2 and forward and back contact members or electrodes v and z, with granular carbon o inclosed between them. The electrodes are insulated from each other at their edges by the said peripheral non-conductor, and the metal-containing case has an elongated stud or sleeve Z, passing through the central bore of the standard A to form its support and containing a rod k, insulated by a non-conducting bushing H and terminating externally in a binding-screw connection t. The back electrode z is a carbon plate fixed to the end within the chamber h of the insulated rod k and is itself insulated from the metal case or its attached stud. Its connection with the primary circuit N of the transmitting medium is formed through the said insulated rod k and by means of the conductor w, attached thereto. The forward and movable electrode v, also preferably carbon, is a thin plate held in place to close the chamber h on its side toward the magnet by the ordinary clamping-ring y, which screws over the threaded exterior of the said chamber h. This electrode having considerable elasticity is readily vibratory and is in electrical connection with the said primary circuit N through the metal chamber-casing, the stud Z, the standard A, and the base B, to which the conductor w^2 of said circuit is attached at the screw t^2. As indicated by the diagram, Fig. 11, the local circuit N includes the source of renewed energy S^2 and the primary winding of the induction coil or coils I. The movable electrode v is rigidly attached at its center to the outer end of the movable pole-piece f, and thus forms the external elastic support of the said pole-piece and receives motion therefrom without the intervention of any diaphragm. In an apparatus of this class sensitiveness to slight moving forces and celerity of action is more important than a relatively wide range of motion, such as would be produced by a vibratory diaphragm or armature interposed between the receiving and transmitting media, and I have found that by dispensing with the diaphragm and by securing the light movable pole-piece f of the magnetic system directly to the center of the light and thin movable electrode v of the transmitting medium the requisite sensitiveness and celerity of action is attained, while, moreover, the actuating forces being imparted to the pole-piece f, and as a consequence to the movable electrode, directly from the varying field are enabled to exercise maximum effect. J is a radiating block or mounting centrally bored to slide over the projecting end of the elongated stud Z of the transmitter-case, having considerable mass and scored or ridged, as at j, to increase its surface. It is held in place upon said stud by the washer j^2 and nut j^3, and being in metallic contact with the said stud and also with the heavy metal standard A, base B, and casing C it coöperates with these parts to conduct away from the variable-resistance button the heat generated therein during operation and to dissipate the same by radiation.

In telephone current renewing and retransmitting apparatus constructed in accordance with the foregoing description and with which good practical results have been attained the magnetizing or local-circuit coil was formed of two hundred turns of No. 36 wire, while the main line or varying coil wound next to the cores consisted of fourteen hundred turns of No. 40 wire.

The current-renewing apparatus may be associated with telephone main circuits in various ways. One circuit arrangement with which it has been successfully connected and employed is that represented by Fig. 11 and so far as concerns its receiving factor alone by Fig. 14 also. In this arrangement the apparatus is shown as being placed at the middle of a long circuit and between the sections E E^2 thereof, so that it is adapted to be operated indifferently and reciprocally from either end of the line and to renew the transmission according to its direction from either section of the line to the other.

K K^2 represent keys or switches which when in the position shown maintain the direct connection of the circuit through the section E^3 thereof, the renewing or reinforcing apparatus being disconnected. In this position the circuit-conductor L is traceable between the section-conductors 20 and 22 by way of the resting-contacts 14 and 16 of keys K and K^2 and their uniting-conductor 21, while circuit-conductor L^2 in like manner extends between its sections 23 and 25 through intermediate conductor 24 and its terminal contacts 15 and 17.

By moving the keys or switches K K^2 to their alternative position the conductors 20 23 of circuit-section E are transferred from contacts 14 15 to contacts 10 11 and the conductors 22 25 of section E^2 from contacts 16 17 to contacts 12 13, so that the intermediate section E^4 is substituted for E^3. The magnetization-varying coil n of the renewing-apparatus receiving-magnet is connected in a bridge u between points 26 27 of the main conductors 18 and 19 of the said intermediate section E^4 and is thus made common to both of the main sections E E^2 to be operated by the distant transmitter of either one—that is, of the terminal station of either section—according to the direction of transmission at any particular moment of time. The initial magnetic field of the receiving medium may be established by either one of the several plans indicated by Figs. 12, 13, or 14, respectively, but, as hereinbefore stated, preferably by that of Fig. 14. The transmitting medium (indicated conventionally) is included in the local circuit N and

is adapted to have the resistance between its electrodes *v* and *z* varied by the strength variations of the magnet M, produced by the voice-currents in the varying-coil *n*. The primary circuit N also contains the primary windings *i* of induction-coils I, whose secondary windings i^2 are connected one on either side of the bridge *u* and in the conductors 18 19, respectively, so that one winding is in main section E and the other in main section E^2 of the through-circuit.

It is to be understood that the drawings represent the electrical arrangement only and that in practice a single primary winding and two secondaries may be wound over a single core and into a single induction-coil. A coil having a single primary winding of five hundred turns of No. 20 wire with a resistance of about one ohm and two secondaries wound in parallel of twelve hundred and fifty turns and thirty ohms resistance each of No. 29 wire has been found to answer well, as has also a varying-coil for the receiving-magnet formed of fourteen hundred turns of No. 40 wire having a resistance of about one hundred and thirty ohms.

If desired, the apparatus may be employed, as in Fig. 12, in enabling one line-circuit E^5 to retransmit over a second and entirely separate circuit E^6. Thus engaged the varying-coil *n* of the receiving factor or agency M is connected in the said transmitting-circuit E^5 and its transmitting medium V in the primary local circuit N of the battery S^2, together with the primary winding *i* of an induction-coil I^2, whose secondary winding i^2 is wholly connected in the second circuit E^6.

As hereinbefore indicated, while a compound magnet constructed as thus far described has certain advantages it is not essential, and other modes of constructing in accordance with the foregoing principles the magnet system, which constitutes the receiving and retransmitting part of the apparatus, and of producing the initial and varying fields may be adopted without any departure from the spirit of the main invention. For example, while the arrangement of the fixed and movable pole-pieces, which has been specifically described, has in practice been found convenient and effective and has particularly commended itself as being productive of highly-satisfactory results and average ordinary conditions it is evident that the relative length of the fixed and movable pole-pieces and their relation to one another and the varying-coil may be varied within limits of considerable width to suit varying conditions of service, provided always that the latter pole-piece shall in every case be in direct connection with the transmitting medium and that the two poles shall closely confront each other without contact, so that the attraction exercised by each upon the other may readily be varied by the operation of the varying-coil. Such modifications in construction and arrangement are illustrated in Figs. 12, 13, and 11. Fig. 12 illustrates a modification wherein the magnetizing-coil *m* is wound over the hinder part of the fixed core *p*, while the magnetization-varying coil *n* alone is, as in the forms, placed over the adjacent confronting poles of said core and the adjacent movable core *f*, the said poles thus, in this instance also, being close to one another in the center of the varying field. Fig. 13 illustrates another modification of this feature. Here the initial field of the magnetic system M is provided by a permanent magnet m^2, the fixed pole-piece *p* being secured thereto and being magnetized thereby in a well-understood manner. This arrangement requires one coil only—viz., the line or magnetization-varying coil *n*, which encompasses the confronting poles of the fixed and movable cores *p* and *f*, which approach one another at its center, or thereabout. In Fig. 11 the magnetic receiving medium is represented as having the fixed pole-piece *p* extended clear through the bridged varying-coil *n* and to a point flush with or a little beyond the forward end thereof, while the movable soft-iron pole-piece *f* is made very short, but is yet directly attached to and supported solely by the movable contact member of the transmitting member. It may here be mentioned that the said movable contact member or vibratory electrode should be very thin and elastic and that I have found a carbon disk about .01 of an inch thick to answer admirably and to be both strong and flexible. In all cases, however, the magnetic system M of the renewing apparatus may properly be regarded both as a receiving and a retransmitting medium, for by its varying-coil it receives and makes use of the voice-currents of the distant transmitter, and by its movable or vibratory pole-piece set in motion by said coil under the influence of such voice-currents it actuates the transmitting medium to bring a new source of energy into service.

It will be obvious that many changes in details can be made without departure from the spirit and principles of the invention.

Having now fully described the said invention, what I claim as new, and desire to secure by Letters Patent of the United States, is—

1. A telephone-current retransmitting and reinforcing apparatus, comprising a magnet constituting an initial field of force; a receiving or magnetization-varying coil surrounding the pole of said magnet for the variation of said initial field; a variable-resistance transmitting medium; and a magnetic connection of slight inertia extending directly between the said varying magnetic field and the said transmitting medium; the said coil and transmitting medium being organized for connection in different main circuits or circuit-sections respectively; substantially as set forth.

2. A telephone-current retransmitting and

reinforcing apparatus, comprising a magnet constituting an initial field of force; a receiving-coil surrounding the pole of said magnet in such manner that said pole shall be at or near its center, and arranged to receive the varying voice-currents of a main telephone circuit or circuit-section for the development of corresponding magnetic variations in said field; a transmitting medium connecting with a second main telephone circuit or circuit-section and having variable-resistance contact members, one of which is movable; and a magnetic connection of slight inertia extending from the most sensitive and mobile part of the movable contact member of said transmitting medium directly to the center or most active portion of said varying field; substantially as described.

3. A current renewer and reinforcer for telephone-circuits, consisting of a variable-resistance transmitting medium having variable contact members or electrodes, one of which is movable or vibratory; a receiving medium, comprising means for establishing an initial magnetic field, and a main telephone-circuit electromagnetic coil surrounding the said field for the control and variation thereof in correspondence with currents traversing said main circuit; and a light pole-piece attached to the vibratory electrode of said transmitting medium, and mounted within the said coil and magnetic field to constitute a magnetic connection of small inertia between the said receiving and transmitting media; substantially as set forth.

4. A current reinforcing and retransmitting apparatus, consisting of a main-line coil or electromagnetic helix; a magnet having a pole-piece extending into one end of said coil; a microphone or variable-resistance transmitting medium mounted adjacent to the other end of said coil; and an iron core constituting a complementary and movable or vibratory pole-piece of said magnet, secured to one of the contact-electrodes of said transmitting medium and extending therefrom into said coil, and into close proximity to said first-mentioned pole-piece; substantially as described.

5. A telephone-current renewing and reinforcing apparatus, comprising a magnet establishing an initial magnetic field of moderate strength; a receiving-coil surrounding the pole of said magnet in such manner that the said pole shall be fixed at its center, and arranged to receive the voice-currents of a main telephone circuit or circuit-section for the development of corresponding magnetic variations in said field; a transmitting medium having variable-resistance contact members, one of which is movable, associated with a second main telephone circuit or circuit-section; and a light iron core attached to the center of the movable contact member of said transmitter, extending within said coil to the center thereof, the said core forming a complementary pole of said magnet in attractive proximity to said fixed pole, and constituting a magnetic and mechanical connection of small inertia between the said contact member at its most sensitively mobile point and the central and most active part of the variable magnetic field; substantially as set forth.

6. In a telephone-current renewing and reinforcing apparatus, the combination of a low-power magnet establishing a moderately-strong initial magnetic field; a magnetization-varying coil energized by the talking-currents in an associated telephone circuit or circuit-section, surrounding the pole of said magnet in such manner that said pole shall be located at or near its center; a variable-resistance transmitting medium associated with a second telephone-circuit, and having a movable electrode; and means for concentrating the effect of said initial magnetization and the talking-current variations thereof directly upon said movable electrode, for the corresponding operation of said transmitting medium, and the renewal and reinforcement in said second circuit of the original talking-currents; substantially as described.

7. In a telephone-current retransmitting and reinforcing apparatus, the combination with the fixed magnet-pole and varying-coil of a receiving medium, the said pole extending into said coil; and the contact members or electrodes of a variable-resistance transmitting medium mounted to closely confront said coil, one of said electrodes being vibratory; of a light vibratory core serving as a complementary pole for said receiving medium extending into close proximity to said fixed pole; the said vibratory electrode and vibratory pole being directly, and without the intervention of a diaphragm, attached to each other, to jointly constitute a magnetic mechanical connection between the receiving and transmitting media of low inertia, high relative mobility, and high sensitiveness to the magnetic variations of the receiving medium, adapted to be actuated by such magnetic variations and to produce corresponding resistance variations in the said transmitting medium; whereby voice-currents traversing the circuit of said receiving medium may be retransmitted unimpaired in form and with increased effect in the circuit connected with said transmitting medium; substantially as set forth.

8. A repeating or reinforcing apparatus for telephone-lines, consisting of a receiving-magnet and coil; an intimately-associated variable-resistance transmitting medium comprising a rigid fixed electrode, a movable or vibratory electrode, and granular carbon inclosed between said electrodes; and two iron cores attached to said magnet and vibratory electrode respectively, and projecting oppositely into said coil so that their free ends confront each other with a short separating-space, in the interior thereof.

9. In a telephone apparatus for the reinforced retransmission of telephone-currents, the combination of a main-line coil or electromagnetic helix; a low-power magnet having a fixed iron pole-piece or core extending into one end of said coil for the establishment of an initial and variable magnetic field of moderate strength at the center thereof; a transmitting medium comprising vibratory or movable and fixed disk electrodes and granular variable-resistance material held between them; and a second magnetic core or pole-piece secured at one end to the center of the movable electrode of said transmitting medium, extending therefrom into said main-line coil, and having its other end in close adjacency to said fixed pole-piece in the variable magnetic field at the center of said coil; substantially as set forth.

10. In a telephone apparatus for retransmitting telephone-currents with renewed vigor between two main circuits or sections of circuits, the combination with a receiving-electromagnet having independent magnetizing and magnetization-varying coils, adapted for connection in local and main circuits respectively; and a fixed central iron core projecting into said coils; of a variable-resistance transmitting device, comprising contact-electrodes one of which is vibratory or movable; and a complementary iron core or rod attached at one end to said movable electrode, extending at the other end into the magnetic field of said coils to nearly reach the said fixed core, and constituting a connection of low inertia and high sensitiveness between the varying field of said receiving-magnet, and the said transmitting device; substantially as set forth.

11. In an apparatus for reinforcing telephone-currents, the combination of a local-circuit magnetizing-coil; a main-line magnetization-varying coil; a fixed iron pole-piece or core magnetized by said local-circuit coil, and extending into the said main-line coil to establish an initial magnetic field at its center, variable by the action thereof; a transmitting medium comprising vibratory or movable and fixed electrodes and granular variable-resistance material held between them; and a light movable iron core or pole-piece secured at one end to the movable electrode of said transmitting medium, extending therefrom loosely into said main-line coil, and having its other end closely adjacent to said fixed pole-piece in the said variable magnetic field at the center of said coil; substantially, as and for the purposes set forth.

12. A current-renewing telephone apparatus, consisting of a tubular receiving-electromagnet having independent local-circuit magnetizing and main-circuit magnetization-varying coils; a variable-resistance transmitting medium comprising contact members, one of which is movable or vibratory; and a light iron pole-piece or rod attached at one end to the movable member of said transmitting medium, extending therefrom into the concentrated magnetic field of said varying-coil, and constituting a portion of the magnetic circuit of said tubular magnet, and a sensitive connection of low inertia between the said magnetic field and said transmitting medium; substantially as described.

13. In a telephone apparatus for the reinforcement of telephone-currents, the combination of a tubular receiving-electromagnet having independent magnetizing and magnetization-varying coils adapted for connection in local and main circuits respectively; and a fixed central iron core projecting into said coils and to or near to the center of the latter; of a variable-resistance transmitting medium comprising fixed or rigid and movable or vibratory electrodes, and carbon granulations held between them; and a complementary iron core or rod attached at one end to said movable transmitting-medium electrode, and extending at the other end into said varying-coil and to the varying field concentrated at the center thereof, to nearly reach the said fixed core; substantially as set forth.

14. In a telephone current-reinforcing apparatus, the combination with a variable-resistance transmitting medium; of a separately or externally excited tubular electromagnet comprising an iron shell having a front central aperture; and a fixed iron core or pole-piece projecting forward from the base of said shell approximately to the center thereof; a main-circuit receiving or magnetization-varying coil within said shell and encompassing said pole-piece; and a complementary iron core or pole-piece constituting a part of the magnetic circuit of said shell and fixed pole-piece, attached to one of the electrodes of said transmitting medium, and extending loosely through the front aperture of said shell into and toward the center of the said coil, and into close proximity to the end of said fixed pole-piece; substantially as hereinbefore described.

15. In an apparatus, for the reinforced retransmission of telephone-currents, the combination with a variable-resistance transmitting medium; of an electromagnetic and magneto-electric receiving and retransmitting medium, comprising a tubular iron shell having a front central aperture; a fixed iron core or pole-piece projecting centrally forward from the heel-plate or base of said shell toward the middle thereof; a local-circuit magnetizing-coil, and a main-circuit magnetization-varying coil, within said shell and encompassing said pole-piece; and a movable iron pole-piece constituting a part of the magnetic circuit of said iron shell and fixed pole-piece, attached to one of the electrodes of said transmitting medium, and extending loosely through the front aperture of said shell into and toward the center of the said

coils, and into close proximity to the end of said fixed pole-piece; substantially as and for the purposes set forth.

16. In a telephone-current reinforcing and renewing apparatus, the combination of a tubular iron shell centrally perforated through its front plate or wall; a fixed iron pole-piece extending forward interiorly from the rear end of said shell toward the center thereof; a local-circuit magnetizing-coil, and a main-circuit magnetization-varying coil, disposed concentrically within said shell and surrounding said pole-piece; and a complementary movable iron pole-piece extending loosely through the front central aperture of said shell into the center of said coils and near to the end of said fixed pole-piece, to constitute conjointly with said shell and fixed core a nearly complete magnetic circuit with opposing poles separated by a variable gap at the center of said coils; with a variable-resistance transmitting medium having fixed and movable electrodes, the said movable electrode being attached to the outer end of said complementary pole-piece, and adapted to participate in the movements thereof; substantially as specified.

17. In a telephone-circuit current renewing and reinforcing apparatus, the combination of a tubular receiving-electromagnet, comprising a cylindrical iron shell centrally perforated through its front plate or wall; a fixed iron pole-piece extending forward into said shell from its rear end to or toward its center; a local-circuit coil to develop an initial magnetization, and a main-circuit coil to vary the same, disposed concentrically within said shell and surrounding said pole-piece, the said magnetizing-coil being outermost; with a movable iron pole-piece extending loosely through the front central aperture of said shell into the center of said coils and near to the end of said fixed pole-piece to constitute conjointly with said shell and fixed pole-piece a nearly complete magnetic circuit with opposing poles separated by a variable gap at the center of said coils; and a variable-resistance transmitting medium having a movable or vibratory electrode attached to the outer end of said movable pole-piece and adapted to participate in the movements thereof; whereby the magnetic changes produced by the action of the magnetization-varying coil are enabled to act directly through a connection of slight inertia upon the transmitting medium, dispensing with an intermediate vibratory diaphragm; as set forth.

18. In a telephone retransmitting and reinforcing apparatus the combination with a variable-resistance transmitting medium having a movable or vibratory electrode; of a movable iron pole-piece attached to said movable electrode; and a tubular actuating-electromagnet for said pole-piece; comprising an iron shell having a front plate centrally perforated to receive said movable pole-piece, said iron shell being slit longitudinally down its side and to the center of its front plate; a magnetization-varying coil within said shell; and an iron pole-piece fixed to the heel-plate of said shell and extending forwardly therefrom toward the center of said coil, and into inductive relation with the inner end of said movable pole-piece; substantially as and for the purposes set forth.

19. The combination in a telephone retransmitting and reinforcing system, of an electromagnetic receiving device comprising a magnetizing-coil establishing an initial magnetic field, a main-circuit magnetization-varying coil adapted by the passage of voice-currents therein to vary said initial field accordingly, and fixed and movable magnetic cores in operative relation to said coils and to one another, and responsive to such variation; and a variable-resistance transmitting medium having a movable electrode attached to said movable core to be actuated thereby; with a local circuit containing the magnetizing-coil of said receiving device; and an adjustable resistance therein, for the regulation of said initial field; substantially as set forth.

20. In a telephone-current-reinforcing system and apparatus, the combination with a transmitter comprising fixed and movable electrodes, and granular carbon held between them to constitute a variable resistance; a light iron core or pole-piece attached to the movable electrode of said transmitter and projecting outwardly therefrom; and a compound separately-excited receiving-magnet comprising a magnetizing-coil, a main-line varying-coil, and a fixed iron core or magnetic pole-piece, the said pole-pieces projecting into opposite ends of the said main-line coil and terminating in close proximity to one another at or near the center thereof; of a local circuit containing the said magnetizing-coil; and an adjustable resistance in the said local circuit whereby the strength of the initial magnetization may be regulated; substantially as described.

21. A telephone-current-reinforcing system and apparatus, consisting of a main circuit; a bridge between the conductors thereof; a local circuit; a magnetizing-coil in said local circuit; a magnetization-varying coil associated with said main circuit and connected in the bridge thereof; a fixed iron pole-piece or core excited by said magnetizing-coil and extending into the said varying-coil, to establish an initial magnetic field variable by the action thereof; a transmitting medium comprising vibratory or movable and fixed electrodes; electrical connections between said transmitting medium and a second main circuit or main-circuit section; and a complementary and movable iron core or pole-piece, mounted loosely within said bridged varying-coil, with one end adjacent to the end of said fixed core

in the said variable magnetic field of said coil, and having its other end attached to the movable electrode of said transmitting medium, and adapted thereby to actuate the same in conformity with the variations of said magnetic field, and to cause the same to establish reinforced currents corresponding to such variations in said main circuit.

22. In a telephone-current renewing or reinforcing apparatus, the combination with a transmitting medium comprising carbon granulations held between electrodes; of an extended radiating-surface in metallic connection with said transmitting medium for dissipating heat from said carbon granulations; substantially as described.

23. In a telephone-current-reinforcing apparatus, a transmitting-button, comprising electrodes insulated from one another in a metallic frame, and carbon granulations held between said electrodes to constitute a variable resistance; in combination with heavy metal blocks or mountings of great mass and external surface surrounding and inclosing said transmitter-button, and in contact with the metallic frame thereof, to serve as a heat-radiator therefor, and to conduct away and dissipate the heat generated in said button by and during its normal operation; substantially as set forth.

24. The combination in a telephone retransmitting and reinforcing apparatus, of a magneto-electric receiving part; a variable-resistance transmitting part actuated thereby; and a heavy metallic casing inclosing the whole and in contact with the metallic parts thereof, the said casing being of large mass and provided with large radiating-surface, and constituting a heat-radiator for the collection and dissipation of the heat developed in and by the normal operation of the said transmitting part; substantially as set forth.

25. A telephone-current renewing and reinforcing apparatus, comprising a fixed magnetic pole or magnetized core producing an initial magnetic field of moderate strength; a magnetization-varying coil surrounding the end of said core for the variation of said initial field; a variable-resistance transmitting medium; a magnetic connection of low inertia established between the said transmitting medium and the said varying magnetic field; and means for dissipating heat from said transmitting medium; the said coil and transmitting medium being adapted for connection in different main circuits or circuit-sections respectively; substantially as set forth.

26. In a telephone-current renewing and reinforcing instrument, the combination with a receiving-magnet comprising a tubular iron shell having a front central aperture, a fixed iron core projecting forward from the base of said shell toward the center thereof, and a main-circuit magnetization-varying coil within said shell and round said core; an associated transmitter-button comprising fixed or rigid and movable or vibratory electrodes held apart and insulated from each other in a metallic frame with granular carbon between them, to constitute a variable-resistance medium; and a complementary iron core or rod secured to the vibratory electrode of said transmitter and extending therefrom through the front aperture of said iron shell to the center of said coil and into close proximity to the end of said fixed core; of a metal heat collector and radiator surrounding and in contact with said receiving-magnet and transmitting-button and comprising a heavy metallic casing therefor, a metal extension-block scored or rigid to increase its radiating-surface, and a metallic standard or base-plate, the said block and standard being secured to or integral with said casing; whereby the heat developed in and during the operation of said transmitter-button may be conducted therefrom and dissipated by radiation; as set forth.

27. A telephone reinforcing apparatus, consisting of a heavy metallic casing and standard, said casing being recessed vertically and perforated horizontally; a granular variable-resistance chamber and fixed electrode rigidly supported within said recess, and provided with a hollow shank or stud containing an insulated rod, fitting within and passing through said perforation, the chamber and fixed electrode being conductively connected with said shank and insulated rod respectively; a heavy metallic radiating-block channeled or scored to provide increased heat-radiating surface and mounted upon said shank in contact with said metallic casing; a movable front electrode for said variable-resistance chamber in conductive connection therewith; a magnetic receiving device comprising a magnetized fixed core, a magnetic complementary and movable core secured to said front electrode, and a main-circuit varying-coil, all mounted in front of said casing-recess within a heavy metal inclosing ring secured to the face of said casing; the metal casing, standard, radiating-block and inclosing ring, being arranged to conduct away and dissipate the heat developed in said variable-resistance chamber, during the operation thereof; as described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 5th day of July, 1904.

HERBERT E. SHREEVE.

Witnesses:

GEO. WILLIS PIERCE,

JOSEPH A. GATELY.