(No Model.) 2 Sheets—Sheet 1.

A. W. ERDMAN.

METHOD OF AND APPARATUS FOR RELAYING TELEPHONIC MESSAGES.

No. 592,769. Patented Nov. 2, 1897.

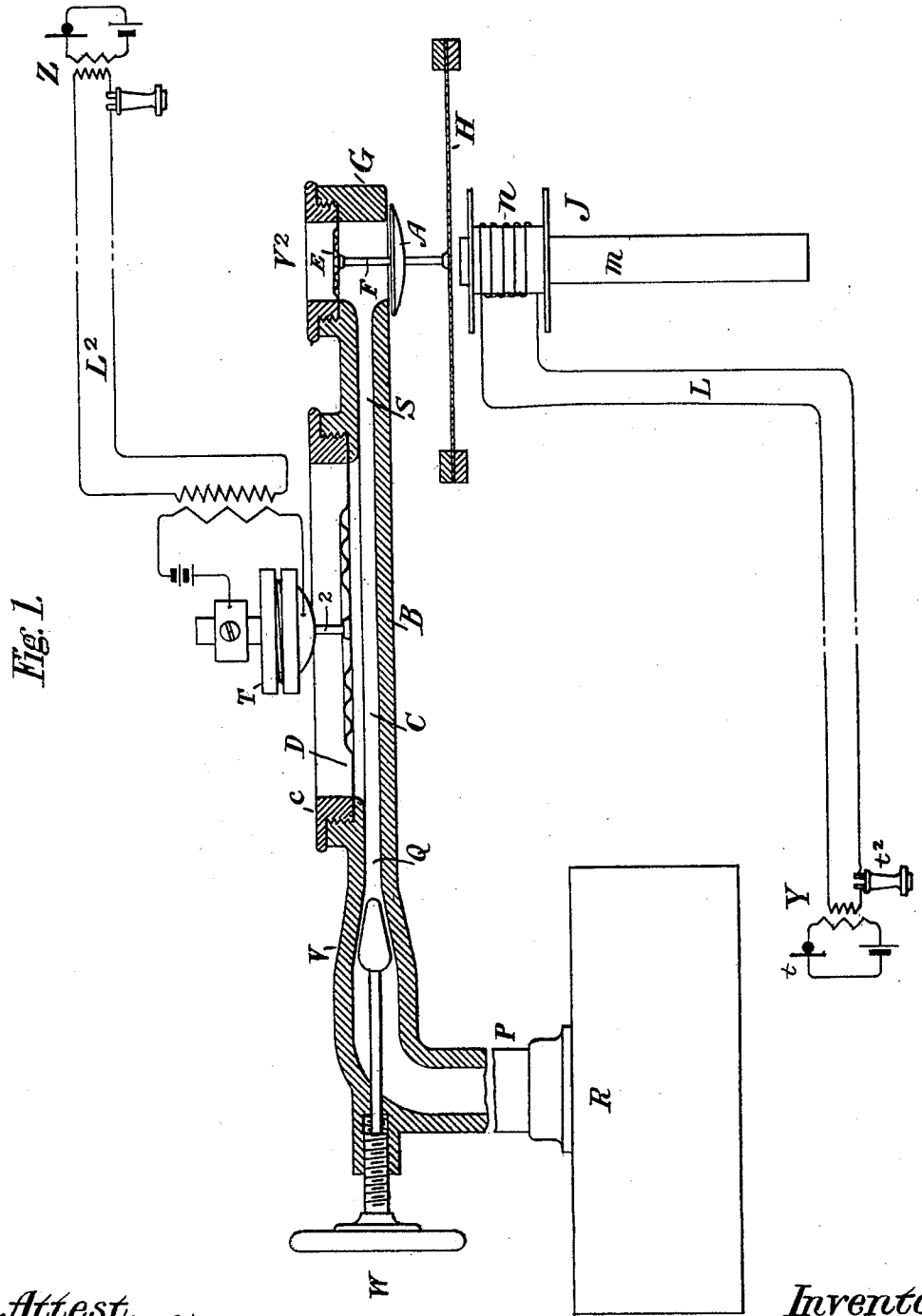


Fig. 1.

Attest,
Rud. Lüis,
W. R. Edelen.

Inventor,
Albert W. Erdman,
by Tolles & Mauro,
his attorneys.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.) 2 Sheets—Sheet 2.

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Fig. 2.

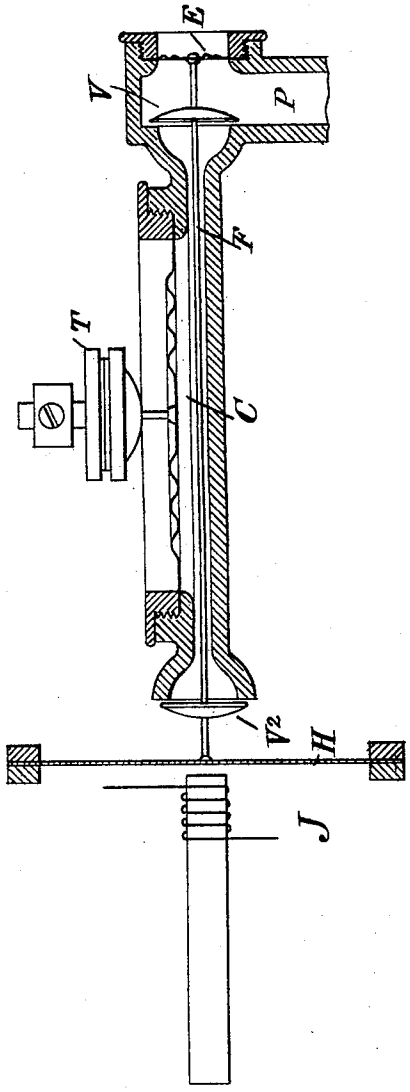
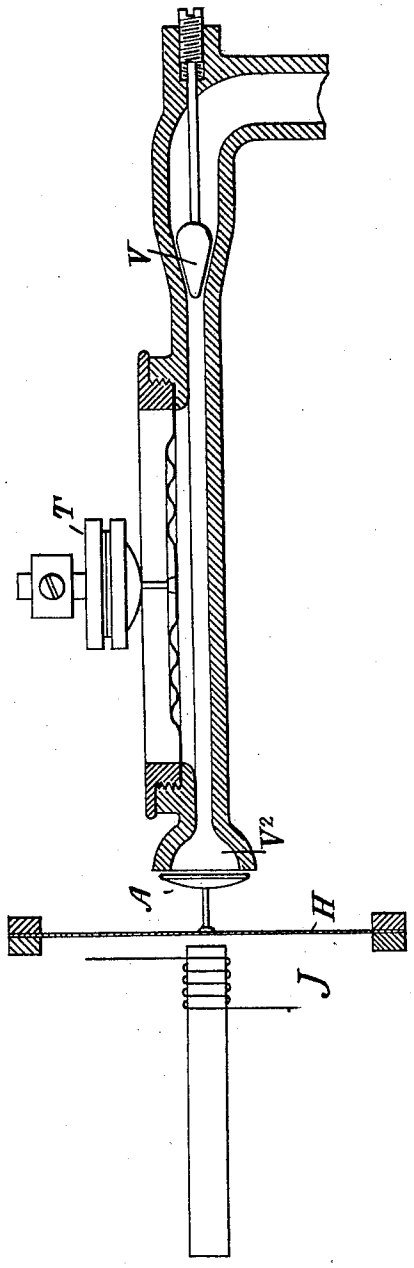


Fig. 3.



Attest.
Ruw Lewis
W. R. Edelen.

Inventor,
Albert W. Erdman,
by Foster & Freeman,
his attorneys.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

ALBERT W. ERDMAN, OF MILBURN, NEW JERSEY, ASSIGNOR TO THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY, OF NEW YORK.

METHOD OF AND APPARATUS FOR RELAYING TELEPHONIC MESSAGES.

SPECIFICATION forming part of Letters Patent No. 592,769, dated November 2, 1897.

Application filed July 6, 1897. Serial No. 643,571. (No model.)

To all whom it may concern:

Be it known that I, ALBERT W. ERDMAN, residing in Milburn township, in the county of Essex and State of New Jersey, have invented a certain Improved Method of and Apparatus for Relaying Telephonic Messages, of which the following is a specification.

This invention relates to speaking-telephones, and particularly to a method of and apparatus for repeating or relaying such transmission from one line or circuit to another, whereby voice-currents originated and circulating in one of the circuits may be reproduced with reinforced strength in the other for the purpose of effectuating and improving transmission between two stations which are a great distance apart.

The invention consists in a repeating or relay apparatus placed at an intermediate station entered by both circuits and so constructed that its receiving element connected in one of the circuits shall be caused to operate its transmitting element, which is connected with the other circuit through the intermediation of a third element characteristic of this invention—viz., a current of air or gas circulating in an appropriate channel or chamber under the control as to its flow and pressure of the said receiving element and itself controlling the said transmitting element by means of the varying pressure it exercises on the wall of the chamber within which it flows.

It also comprises an improvement in the art of speech transmission, or a method of efficiently effectuating the repetition of telephonic messages from one circuit to another, which, broadly stated, consists in transforming the voice-current undulations or electrical vibrations, which in the first circuit represent the sonorous vibrations of the transmitted vocal or other sounds, into mechanical vibrations in the receiving element of the relay apparatus, in causing these to control the flow, and consequently the pressure of a current of air or other gas or aeriform fluid, in causing such pressure-vibrations to reproduce and amplify the mechanical vibrations producing them, and in causing the mechanical vibrations so amplified to set up in the second circuit electrical vibrations which are a reproduction or facsimile copy of those of the first circuit, whereby the sounds uttered before the transmitter of one circuit may be reproduced without material loss of volume or quality by the receiver of the other.

The action of the relay apparatus may be resolved into three steps, namely: first, transforming the electrical undulations or vibrations of the incoming telephonic current into similar or corresponding mechanical vibrations; second, amplifying or building up these mechanical or mass vibrations by applying them to a device which varies the flow, and therefore the pressure, of a current of air or other gas flowing through a chamber or channel covered or closed by a flexible diaphragm or its equivalent, the amplifications appearing in the motion of such flexible diaphragm as it responds to the varying pressure within the chamber; third, transforming the amplified vibrations of the said diaphragm into electrical undulations or vibrations in the outgoing or relayed telephonic current, or, as we may say, into voice-currents, which, like those of the first circuit, represent the sonorous vibrations of the originally uttered and transmitted sounds, but which flow in the second circuit and operate the distant telephone-receiver thereof.

In the drawings which illustrate this specification, Figure 1 is a view, mainly in section, of a relaying or repeating apparatus embodying the principles of my invention and associated at an intermediate station with the approximating ends of two telephone-circuits leading, respectively, to two other stations distant from the said intermediate station in different directions. Figs. 2 and 3 are similar views representing modified structures based upon the same principles.

Referring in the first place to Fig. 1, R symbolizes a reservoir of compressed air or other gas or aeriform fluid maintaining a constant pressure supply at the reducing-valve V of a supply-pipe P by any suitable arrangement of supply-pump and pressure-regulating valves or like supply and regulation apparatus, which, being well understood, I do not deem it necessary to indicate.

The reducing-valve V is placed in the supply-pipe at a point between the reservoir R

and an air-chamber or expanded channel C and is adjustable to any amount of valve-opening by any suitable regulating device, such as the hand-wheel W. The air-chamber C is preferably formed with a circular basin B, which has its upper side closed or covered by the flexible diaphragm D, the same being held in place by the screw-gland *c* or in any other preferred way. The vibratory diaphragm D thus forms a flexible or movable wall or side of the air-chamber and is in operative relation to a resistance-varying or current-varying medium T, one electrode of which may be attached to the center of its upper surface at 2, the back electrode being supported in any suitable way—for example, as in the standard granular carbon transmitters which are in commercial use. The said diaphragm and current-varying medium thus associated constitute, indeed, just such a transmitter and form the transmitting element of my repeating device.

The air-chamber C communicates through the passage Q and the reducing-valve with the supply-pipe P, and by means of the passage S with the interior of the body or casing G of a balanced valve V^2, which valve comprises the said casing G, the flexible septum or diaphragm E or its equivalent, the movable part of the valve A, and its actuating-rod F.

J is a telephone receiving instrument constituting the receiving element of the relay apparatus, *m* being its magnet, *n* its coil, and H its diaphragm or armature. The actuating-rod F of the balanced valve is fixed centrally to the moving part or valve-gate A and is secured at one end to the flexible valve-diaphragm E and at the other to the diaphragm H of the receiving element J, so that any vibrations set up in the latter can be imparted to the moving part of the valve.

L is the first or transmitting main telephone circuit or line leading into the repeating-station from a distant telephone-station Y, where it is provided with the usual transmitter *t* and receiver t^2 and connected at said repeating-station with the receiver J.

L^2 is the second or receiving main telephone circuit or line leading from the repeating-station, where it is associated with the transmitting element, comprising the diaphragm D and resistance-varying medium T of the relay apparatus, to a distant telephone-station Z, likewise fitted with telephones similar to those at station Y.

The operation of the relay apparatus may be thus described: The electrical undulations of the incoming telephone-current are in the receiving portion of the apparatus transformed into the mechanical vibrations or motions of the diaphragm H thereof. These vibrations of the said diaphragm are imparted to the valve-gate A of the balanced valve V^2 through the rod F. The motion of said valve-gate is, however, unaffected by the internal pressure of the current of air within the valve-casing, because the pressure upon the internal surface of the gate is balanced by the pressure upon the internal surface of the flexible diaphragm E. This feature of operation enables the valve-gate to be set in motion by a feeble force unaffected by the air-pressure within the valve-casing G for a considerable range of pressure-variation. The mechanical vibrations of the diaphragm H are imparted to the diaphragm D through the intermediation of the pressure-vibrations of the gaseous or aeriform current, within the chamber of which the latter forms a flexible or vibratory wall, and in process of such transfer are amplified or built up.

The mode in which the requisite air variations are produced within the chamber C may be explained with greater facility by assuming a particular case. Let us suppose the constant pressure of the current of air or other gas in the supply-pipe delivered by the reservoir to be ten pounds per square inch in excess of the atmospheric pressure and that with a certain fixed opening of the reducing-valve V and a normal opening of a certain definite amount of the balanced valve V^2 the pressure of the gaseous current flowing through the chamber C is one pound above that of the atmosphere. Then it is evident that if the ratio of the amount of valve-opening of the reducing-valve to that of the balanced valve is varied the pressure of the air within the chamber will also and accordingly be varied. Thus if the balanced-valve gate A is moved so as to reduce the amount of its opening from the normal the pressure within said chamber rises, and if, *per contra*, the extent of opening is increased the internal pressure falls. These pressure-variations within the chamber, as shown, depend upon and correspond in period and character with and are proportional to the motion of the valve-gate A, and since the motion of the valve-gate corresponds, as also shown, with the electrical undulations or vibrations of the incoming telephonic current the pressure-variation exerted upon the flexible diaphragm D and the motion of the same resulting therefrom necessarily also corresponds in period, relative proportion, and character with the undulatory vibrations of such incoming telephonic current. Finally, the transferred and amplified mechanical vibrations impressed upon the diaphragm D are transformed into corresponding or similar electrical undulatory vibrations in the outgoing or relayed current of the second telephonic circuit, so that the said relayed current experiences changes copying those of the current of the first circuit, and these, acting upon the receiving-telephone at the distant station, reproduce the spoken message there.

In must be understood that my invention is not in any wise restricted to any particular form or structure of relay apparatus and that it may be embodied in any form based on principles herein stated. For example, pistons

working in cylinders may take the place of the flexible diaphragms D and E of the air-chamber and balanced valve, respectively, without any departure from such principles; nor would these principles be departed from were the reducing-valve V omitted and the supply regulated by properly proportioning the area of the supply-pipe. Again, the balanced-valve device is susceptible of considerable variation in structure, and, indeed, in function, for whereas in the form so far particularly described the ratio between the amounts of opening of the reducing-valve and the balanced valve determining the pressure within the chamber is variable by the changes in the extent of opening the latter, it is obvious that by so arranging it that the reducing-valve opening varies at the same time that the balanced-valve opening does, the former increasing when the latter is decreasing, and vice versa, a greater variation in the ratio between the two will ensue, and the pressure-variations within the chamber will be correspondingly greater.

Such an arrangement as that last indicated is to be found in the modification shown by Fig. 2. In this modification the valve V, controlling the admission of the gaseous current from the supply-pipe P to the chamber C, and the valve V^2, controlling the pressure-variations, are both secured to and operated by the rod F, which in turn is actuated by the diaphragm H of the receiving element J, the whole system being balanced by the flexible septum or diaphragm E, which is placed behind the gate of the valve V. In this modification it is evident that the same diaphragm motion which tends to narrow the aperture of valve V^2 will open the valve V more widely, and vice versa.

Fig. 3 exhibits another modification in form of my relay, wherein the gate A of the pressure-controlling valve V^2, movable to and fro by the diaphragm H of the receiving element J, is not provided with any balancing device. In this form the reducing-valve is retained and occupies the same position as in the form first described herein.

The first and last forms nearly resemble one another, the chief difference between them being that whereas in the first form the action of the valve-gate A was unaffected by the internal pressure in the last form the said valve-gate works in opposition to the internal pressure, and a part, therefore, of the energy imparted to it by the diaphragm H would be expended in overcoming such opposition.

Instead of employing air or gas under compression and rarifying it down to the atmospheric pressure or thereabout I may, if I so elect, without departing from the spirit of my invention, by substituting a vacuum-pump for a supply-pump, in connection with the reservoir R, draw the aeriform fluid through the relay and expand it from the pressure of the atmosphere, or even from a pressure less than that of the atmosphere, down to the still lower pressure. While I am enabled by such a change to work with a gas of less density than that of the atmosphere at normal pressure rather than with one at a greater density, it is evident that the same underlying principles are involved and utilized and that I still avail myself of a gaseous column or current interposed between two surfaces capable of mechanical vibration for the purpose of causing pressure changes in such gaseous body to transfer the vibrations of one of the said surfaces to the other and to amplify them in process of such transfer and of thereby relaying the voice-currents concerned in electrically transmitting speech from one telephonic circuit to another.

I claim—

1. The method of repeating or relaying the electrical transmission of speech between two circuits, which consists in transforming the electrical undulations of the voice-currents in the transmitting-circuit into similar mechanical vibrations; in causing these to correspondingly vary the flow and thereby the pressure of a current of air or gas; and in causing the said air-pressure vibrations to correspondingly vary the resistance, and thereby the current, of the receiving-circuit, substantially as described.

2. An improvement in the art of electrically transmitting speech, which consists in transferring the sonorous electrical vibrations of one telephonic circuit to another, through the intermediation of a current of air whose rate of flow and pressure is controlled by the transmitting-circuit, and controls the receiving-circuit, substantially as described.

3. The hereinbefore-described improvement in the art of transmitting speech electrically, and in repeating telephonic messages from one circuit to another, which consists in transforming the undulatory voice-currents of one telephone-line into similar mechanical vibrations; causing these to correspondingly vary the velocity or amount of flow and thereby the pressure of an air or aeriform current; causing the said air-pressure variations to reproduce the said mechanical vibrations in greater amplitude but identical in form; and causing these last-named vibrations to act upon the current of a second telephone-line, and thereby to produce therein electrical vibrations corresponding in form to those of the first line; substantially as described.

4. In a telephone relaying or repeating apparatus, the combination of an air chamber or channel; a diaphragm or its equivalent forming a flexible or movable wall or side of said chamber; means for establishing a current of air or aeriform fluid through said chamber or channel; a valve for said chamber controlling the flow of the said aeriform-current, and thereby the pressure exercised by it on the said diaphragm; a telephone-receiver associated with one telephonic circuit, and having a diaphragm or armature attached

to the said valve and adapted for the operation and control thereof; and a current or resistance varying medium mounted upon the air-chamber diaphragm, and actuated thereby, to serve as the transmitter of a second telephonic circuit; substantially as described, and for the purposes specified.

5. In a telephone relaying or repeating apparatus, the combination of an air chamber or channel with ingress and egress openings, a diaphragm or its equivalent forming a flexible or movable wall or side thereof; an air or gas supply system connected by a pipe with the ingress-opening of the said chamber; a reducing-valve in the said pipe to regulate the amount and normal pressure of supply; a balanced valve controlling the egress-opening of said chamber and thereby the flow and internal pressure of said air or other gas; a telephone-receiver in one telephonic circuit having its diaphragm or armature attached to the said valve and adapted to actuate and control the same; and the variable-resistance medium of a telephone-transmitter in another telephonic circuit mounted upon or associated with the said air-chamber diaphragm; substantially as and for the purposes specified.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 25th day of June, 1897.

ALBERT W. ERDMAN.

Witnesses:
HARRY H. BRIGHAM,
ALFRED E. HOLCOMB.