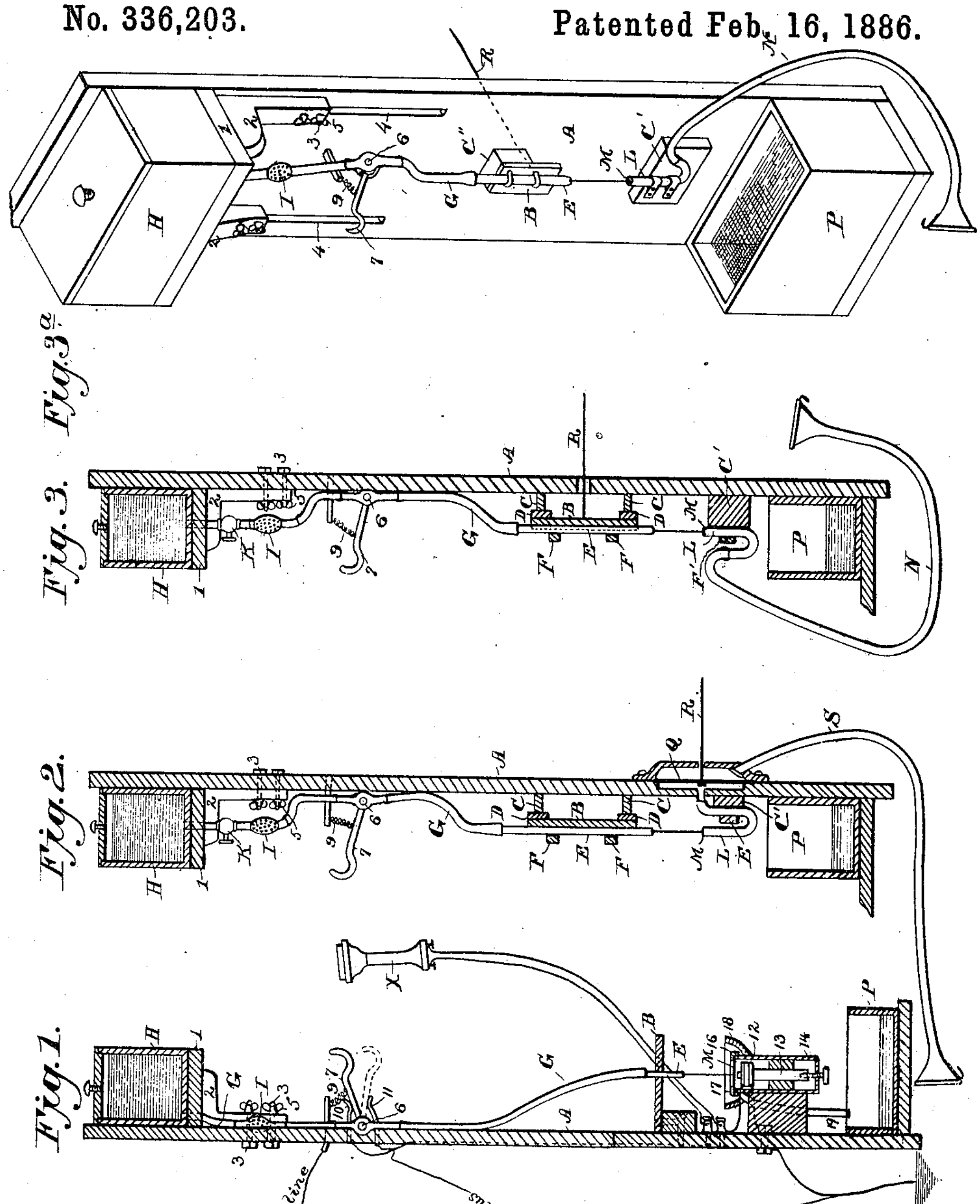
(No Model.) 3 Sheets—Sheet 1.

C. A. BELL.

METHOD OF AND APPARATUS FOR TRANSMITTING, REPRODUCING, AND RECORDING SPEECH.

No. 336,203. Patented Feb. 16, 1886.



Witnesses
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his attorney.

(No Model.)

3 Sheets—Sheet 2.

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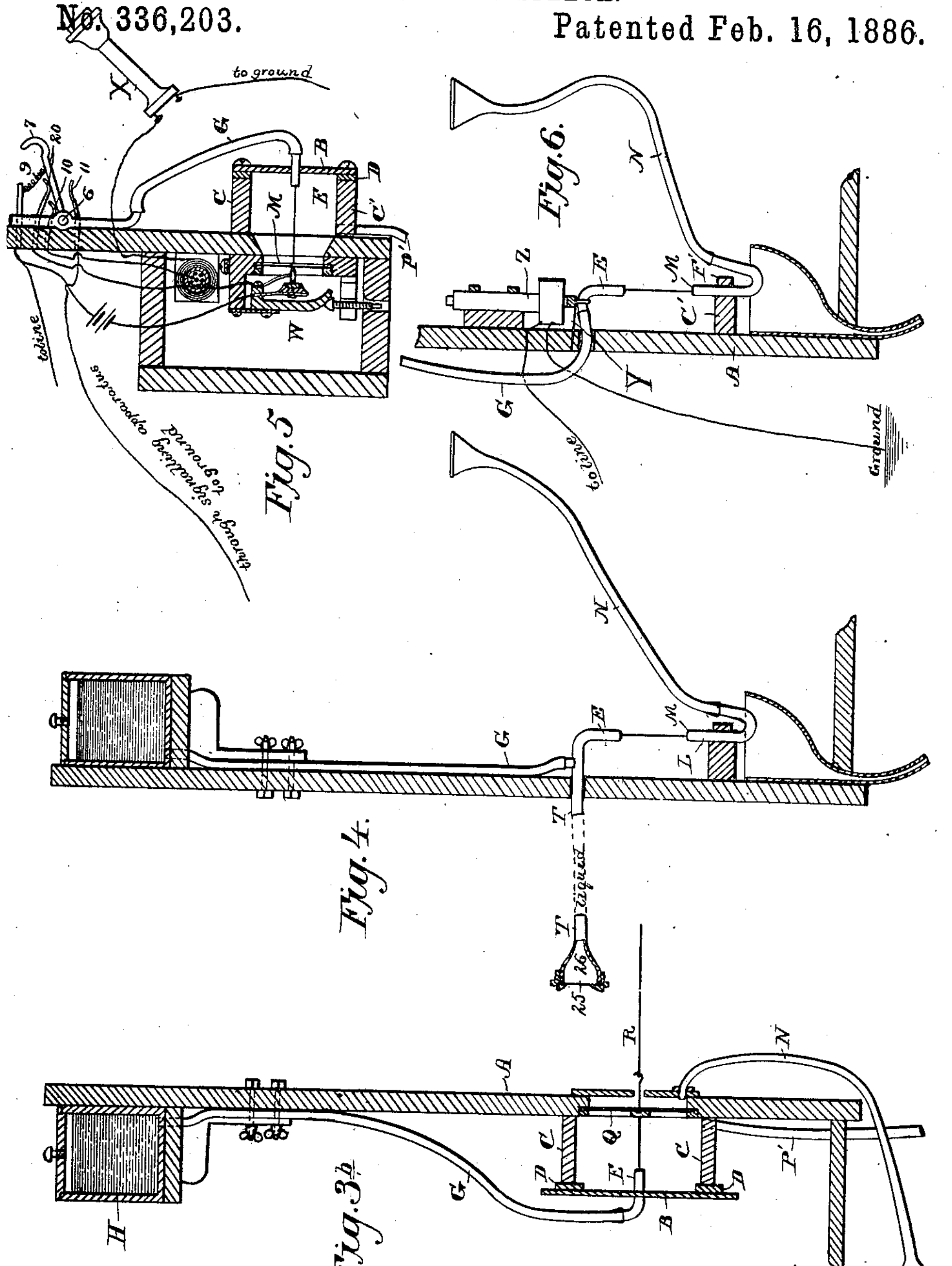

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(No Model.) 3 Sheets—Sheet 3.

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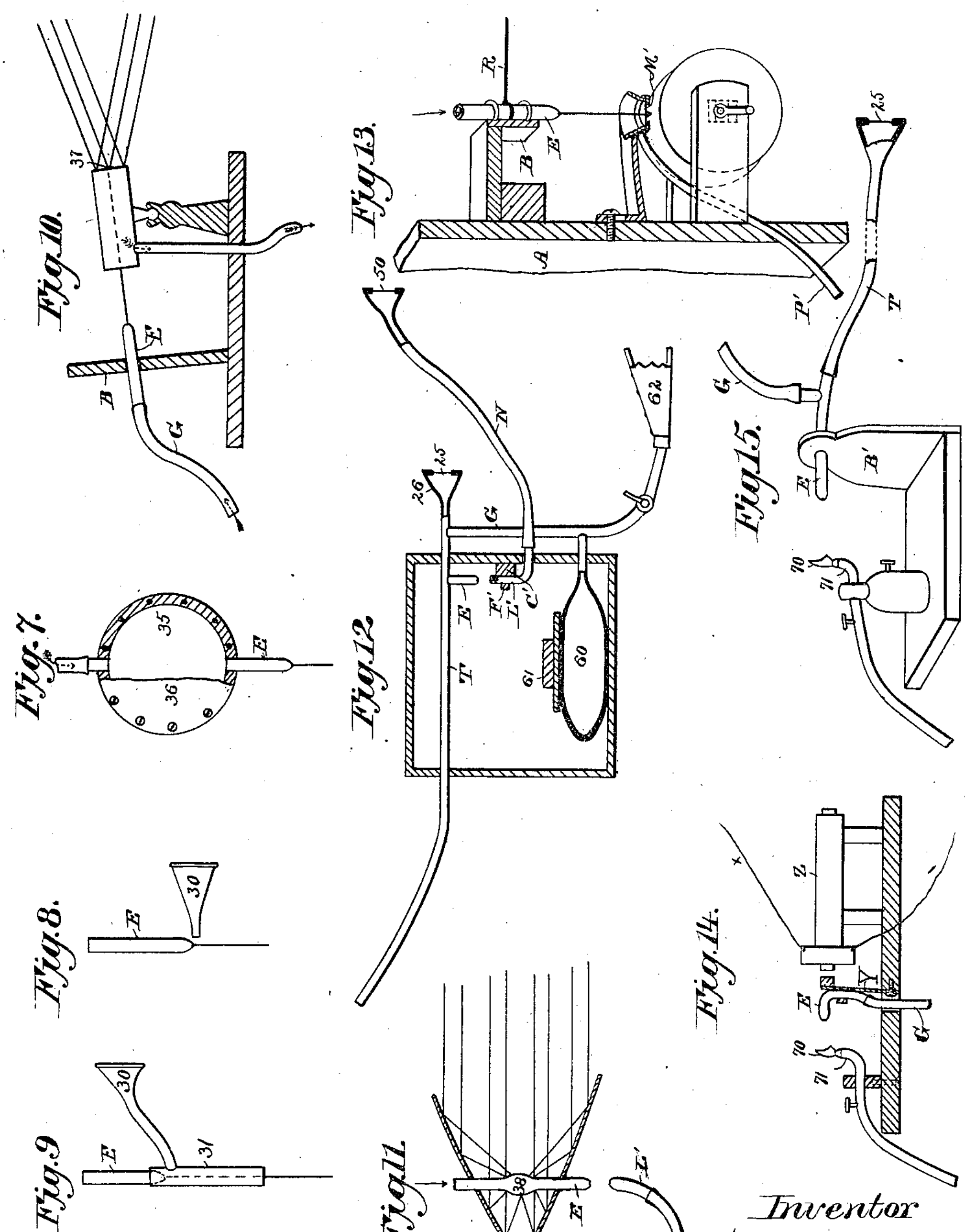

Witnesses

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UNITED STATES PATENT OFFICE.

CHICHESTER A. BELL, OF WASHINGTON, DISTRICT OF COLUMBIA.

METHOD OF AND APPARATUS FOR TRANSMITTING, REPRODUCING, AND RECORDING SPEECH.

SPECIFICATION forming part of Letters Patent No. 336,203, dated February 16, 1886.

Application filed May 1, 1884. Serial No. 129,946. (No model.)

To all whom it may concern:

Be it known that I, CHICHESTER A. BELL, of Washington, in the District of Columbia, have invented a new and useful Improvement in Methods of and Apparatus for Transmitting, Reproducing, and Recording Speech and other Sounds and Signals, which improvement is fully set forth in the following specification.

This invention is based upon the application or discovery and application of certain properties of fluids (gases or liquids) issuing from contracted orifices under pressure—that is to say, of fluids in the form of jets.

It was known prior to my invention that jets were capable of producing noises, and also, under special conditions, of responding to a certain limited number of sounds; but the phenomena were of scientific interest only. The present invention comprises methods and apparatus whereby these previously-known properties of jets, and others discovered first, as I believe, by myself, are or may be applied to useful purposes. It has particular reference to the transmission or reproduction of the undulatory motions which constitute or accompany articulate speech, but is of course able to serve for the transmission or reproduction of more simple vibration, and may therefore be utilized for other purposes.

I have found that by suitable means the jets which I employ can be made not only to transmit such sonorous vibrations without destroying their character, but to amplify them and increase their efficiency, and the employment of the jet for this purpose constitutes one of the most important practical parts of my invention. In order to accomplish these results, the jet must be brought to a suitable condition, and suitable means be adopted to throw it into vibrations and to receive the vibrations. I have invented various contrivances for this purpose.

I will state the general nature of the use which I make of the jet, and then describe some of the particular ways in which it may be employed. When a jet of suitable size and under suitable pressure issues from a properly-constructed orifice, it may be allowed to pass through a certain distance before its character as a jet is destroyed by breaking up into drops. If sonorous vibrations be impressed upon it at or near the point where it issues from the orifice, they will pass through the whole length of the jet substantially without loss of character, and can be during any part of their course taken off or used to impress themselves upon a suitable vibratory medium, which will thus be thrown into sonorous vibrations substantially similar in form. The jet thus serves as a medium or part of a chain for the transmission or translation of sonorous vibrations without destruction of quality. It is found, moreover, that under suitable conditions the vibrations which are thus imparted to the jet near its origin, are at a point more distant from the origin and near where the jet will break up into drops more efficient as a means for impressing sonorous vibrations of the same character or other bodies or vibratory media than they are close to the point of original disturbance. In such a jet therefore we have a means for actually amplifying the sonorous vibrations, and thus can use it, not merely as a part of the chain through which such vibrations can be transmitted but as an efficient member for increasing their practical effect. I make use of this property (which I develop by suitable contrivances, some of which I will hereinafter describe) by placing the jet somewhere in the line of communication between the transmitting and the receiving operator, and causing sonorous vibrations to pass through it. For the same purpose I place it at the transmitting-station, where it will constitute a portion of the transmitting-instrument. Its use is not limited, however, to any one particular position, and it may therefore be placed for the same purpose anywhere between the transmitting-operator and the receiving-operator—as, for example, in connection with an instrument which is at once a receiver and transmitter, and thus forms a sort of relay.

The vibrations to be transmitted can be impressed upon it in many ways. The orifice or vessel containing the fluid issuing in a jet from it, or the jet itself, may be agitated by the sonorous waves produced directly by the voice acting upon it. It may be agitated by intermittent or undulatory currents of electricity. It may be agitated mechanically by a phonograph-record in motion. The sonorous vibrations of the jet may be taken off and caused to impress themselves upon the next piece of mechanism or link in the chain of transmission, also in various other ways. If the jet or a suitable portion of it form part of an electrical circuit, variations in the jet will vary the resistance of that circuit, and thus produce electric undulations, which may be utilized on the spot or at a distance by means of well-known telephonic instruments. The jet may be allowed to fall upon a diaphragm, which it will throw into corresponding sonorous vibrations. It may be allowed to strike upon a suitably-arranged and inclosed mass of air or tube, which it will throw into sonorous vibrations. These sonorous vibrations, whether of diaphragm, tube, or air, may be employed to create the sensation of sound on the spot, or they may be made to impress themselves upon devices for the transmission and reproduction of the same vibrations at a distance.

It might be well to state that when I speak of "sonorous vibrations of a jet," I do not mean to be understood as saying that the jet vibrates from side to side like a vibrating spring. I refer to any kind of sonorous vibrations or tremor which is propagated through the jet, so that being received at one end it makes itself felt at the other. When a jet of circular cross-section strikes an object under the proper conditions, the fluid spreads out in a thin film or sheet, which is for a certain distance continuous like the jet itself. This film or sheet while it is continuous, has, I find, the property of responding to sonorous vibrations, and of transmitting them without destruction of their form. The vibrations are transmitted to the sheet or film from the body of the jet, and they are magnified in the transmission the same as when carried along the nearly-cylindrical portion of the jet. I wish it therefore to be understood that the utilization of such a sheet or film having the properties of a jet is within the invention. In some cases it is desirable to have the vibratory medium affected by such a sheet or film—as, for example, where a current of electricity is to be thrown into a state of vibration by the varying resistance of the jet; but if the jet is to operate mechanically it is desirable that the jet should play full against the vibratory body, so as to utilize the energy or *vis viva* of the moving fluid. In this connection I may observe that it is not intended to include, but, on the contrary, to exclude, as being foreign to the invention, the use of a manometric flame, such as Koenig's, for responding to the undulations of speech or other sounds. When such a flame is used as the transmitter of a photophone, sounds would no doubt be transmitted to a distance, and then be reproduced. The flame, however, operates by the variations in its radiant energy or illuminating power due to the variable supply of illuminating-gas, and not at all on the principle of my jets. I may also observe that it is not intended to include, but to exclude, the use of a column of heated air rising from an ordinary flame to act upon a thermal battery or generator of electricity placed at one side of the same, and to produce electric undulations in a telephonic circuit connected with said battery when said column is undulated by talking into an open funnel or mouth-piece on the opposite side of the column of air. Such a column of air has not the properties of my jets. It acts, or would act, in a manner more analogous to the manometric flame, the approach and recession of the column of air taking the place of a variation in the flame itself.

Jets, like all bodies, have a certain fundamental tone, which is dependent upon the size of the jet-orifice and the pressure upon the fluid behind it, being higher as the orifice is smaller and the pressure greater. For the transmission of articulate speech the jet should be pitched in the higher register which corresponds to the overtones of the voice. Although the jet has a fundamental tone, it is capable of responding with nearly equal readiness, when the pressure is not too great, to all sounds of a certain range, which may be made to include those used in speaking. Practically the adjustment can readily be obtained by controlling the flow through the supply-tube, so as to regulate the pressure of the jet-liquid, the necessary indications being furnished by listening to the effect produced. A circular jet-orifice from one one-hundredth ($\frac{1}{100}$) to three one-hundredths ($\frac{3}{100}$) of an inch in diameter, or even a smaller or larger orifice, may be used. Dimensions and proportions found to be useful will be set forth below.

I have described the sonorous vibrations as traveling lengthwise of the jet. While this propagation is very desirable in most cases, in order to increase the effect by reason of the increase in the vibrational movements which take place as the vibrations travel outward from the jet-orifice, yet I do not limit myself altogether to the propagation of sonorous vibrations by this operation, since in some forms of jet-translating apparatus devised by me the operation is different.

So far the description has related to the reproduction or transmission of articulate speech; but it is evident that the same methods and apparatus are adapted to the reproduction of sounds generally. The same capacities of jets can also be used for the transmission of vibrations which did not originally exist as sound. For example, the scratching of a suitable part of the jet apparatus would throw the jet into vibrations which would produce a sound; but the initial cause was the direct vibration of said part, and not the copying of sound-waves (atmospheric vibrations) as in the reproduction of sound.

Certain of my methods of and apparatus for transmitting or translating vibrations by means of jets are believed to be new in the broadest sense, and are therefore included in the invention, whether the jet does or does not copy or preserve the form of the vibrations transmitted. Thus it is evident that the magnifying capacity of jets may be usefully employed in a system of harmonic telegraphy as well as in an articulating-telephone.

Certain other improvements in the nature of combinations, in which one or more jets enter as elements, are also included as well when the said jets are adapted to transmit the form of sound-waves as when they transmit only the rapidity and extent thereof, or are used to produce effects having no direct relation to sound. In all these uses the jet plays or may play the part of a relay or microphone in magnifying the effect, so that a feeble cause may originate a considerable disturbance. This magnifying action is increased rather than decreased by causing the discontinuous portions of the jet to act, and the action of these portions of the jets may be utilized in many cases where the form of the vibrations is not to be preserved, for when the jet breaks up it loses its undulatory character and becomes intermittent in its action.

It should be noted that the breaking-point of a jet is not fixed, but varies as well with the nature of the sound as with its intensity.

In the accompanying drawings, which form a part of this specification, several forms of apparatus constructed in accordance with the invention are represented.

Figure 1 represents in sectional elevation a telephone-station apparatus using a jet-transmitter. Fig. 2 shows a station apparatus for mechanical-telephone lines using a jet-transmitter; Figs. 3 and 3ª, two forms of station apparatus provided with a jet-receiver; Fig. 3ᵇ, another form of jet-transmitter; Fig. 4, a station apparatus for transmission of messages by means of a liquid and employing a jet-receiver; Figs. 5 and 6, station apparatus for electrical-telephone lines, a jet-transmitter being shown in Fig. 5 and a jet-receiver in Fig. 6. Figs. 7, 8, and 9 represent other modes of imparting vibration to the jet. Fig. 10 represents a jet photophone-transmitter; Fig. 11, a jet photophone-receiver; Fig. 12, a jet-transmitter operating by air for speaking-tubes; Fig. 13, a jet-recording apparatus or phonograph, and Figs. 14 and 15 special forms of jet-translating apparatus.

Referring to Fig. 1, the vibratory plate or sounding-board B, which carries the jet-tube E, is fastened by one edge to the back board or support, A, near the bottom of said support. The plate or board is or may be of wood. Suitable dimensions are three-eighths of an inch thick with a surface of six inches square. As shown, the plate or board is screwed to a block below, which in turn is screwed to the back board. Other fastening means could of course be used. The jet-tube is preferably of glass. It is stuck into a hole in the vibratory plate or sounding-board. The upper end is connected by a flexible pipe or rubber tube, G, with the elevated reservoir H. This reservoir rests on a shelf, 1, supported by brackets, 2, which are fastened to the back board or support by bolts 3, passing through slots 4 (see Fig. 3ª) in the back board, so that by loosening the wing-nuts 5 on the end of said bolts the brackets, shelf, and reservoir can be set at a greater or less elevation, to change the head or pressure of the jet-orifice in the lower end of jet-tube E.

In the pipe or tube G is the cock or valve 6, for cutting off the flow of the jet-liquid. It is controlled by a lever-arm, 7, of brass. The arm is provided at the outer end with a hook or fork to receive the ordinary hand-telephone, X. It is combined with a retractile spring, 9, a back contact, 10, and a front contact, 11. The lever-arm is connected constantly through the spring 9 with the line which extends to the distant station, where there is or may be an apparatus similar to that shown. The back contact, 10, is connected with a branch to ground, which includes the receiving-telephone X, and also the coils 12 of a magneto-telephone, which is acted upon by the jet and serves as a transmitter. The front contact, 11, is connected with a branch to ground, which includes signaling apparatus of any ordinary or suitable construction—as, for example, that in common use on telephone-lines. When the telephone hangs on the hook or fork, it holds down the arm 7, as shown in dotted lines, so that it bears upon the contact 11, and thus puts the line to ground through the signaling-branch. At this time the cock is closed. On removal of the telephone X the spring lifts the arm, opening the cock, and putting the line to ground through the transmitting and receiving telephones.

The transmitting-telephone is or may be of any ordinary or suitable construction. As shown, the coils 12 are mounted on a permanent bar-magnet, 13, which is adjustably supported in the case 14. The case is fastened in a block in the face of the back board. At the top of said case is the ordinary telephone-diaphragm, M, of thin sheet-iron. The jet plays upon the center of the diaphragm. The retaining-ring 16, for holding the diaphragm in place, is provided with one or more holes, 17, to allow the water to run off into the cup 18, whence the tube 19 carries it into the lower reservoir, P.

On speaking in the vicinity of the apparatus the board B will take up the vibrations of the air and communicate them, through the tube E, to the jet. The latter, owing to the vibrations imparted to the jet, will fall with varying energy upon the diaphragm, and impart to it vibrations, which in turn will induce in the coil 12 electrical vibrations or undulations that pass on to the line. If the apparatus be properly constructed and adjusted, the original speech will be reproduced by the receiving-telephone at the distant station.

The advantage of using the jet, instead of talking directly to the transmitting-telephone, is that the jet apparatus is much more sensitive to sounds uttered at a distance from the instrument.

In order to prevent the passage of air-bubbles or particles of solid matter to the jet-tube E, a filter, I, is placed in the supply pipe or tube G.

Water is preferred as the jet-liquid. With this liquid the pressure or head (measured from the lower end of the jet-tube to the surface of the liquid in the reservoir H) should, to get the best effect, be that of a column of about forty-nine (49) inches, the jet-orifice being about twenty-eight thousandths ($\frac{28}{1000}$) of an inch in diameter. The smaller the orifice the less should be the pressure. It is preferred that the jet-orifice should be a circular opening in a thin plate.

The best mode I have devised of making the jet-tube practically is as follows: Take a fusible glass tube three-sixteenths ($\frac{3}{16}$) of an inch in internal diameter, with sides about one-thirty-second ($\frac{1}{32}$) of an inch thick and upwards of four (4) inches in length. Heat it at an intermediate point—say two (2) inches from the end; draw it out; cut it off at a point where the glass is thin—say when the tube is one-sixteenth ($\frac{1}{16}$) of an inch in diameter; grind off the end square; heat until the glass is softened and the sides collapse. Then withdraw, and when cool the tube is ready for use. Glass is preferred for the jet-tube; but metal, hard rubber, amber, steatite, or other material may be used. It is not necessary for the jet-orifice to be in the end of a tube. It may be in the bottom or side of any suitable vessel or receptacle.

To adjust the instrument, see that the continuous portion of the jet strikes upon the diaphragm when a loud sound is produced in its neighborhood. Then place the telephone X to the ear, and raise or lower the reservoir H until a good articulation is secured. If the high tones are not brought out, raise the reservoir; if the low tones, lower it a little. The transmitting-telephone can be adjusted to increase or diminish the loudness. If the articulation is not loud enough, lower the telephone; if indistinct or rattling, raise it. The adjustment of the jet tube would answer the same purpose. The diaphragm of the transmitting-telephone would ordinarily be from three to five inches below the jet-orifice, depending on the size of the jet.

The effect of varying the height of the reservoir, which is simply to vary the pressure on the liquid at the jet-orifice, can be obtained by throttling more or less the flow of the liquid. Thus in Figs. 2 and 3 a cock, K, is shown as provided for this purpose. If the pressure be too great, close it partially; if too little, open it wider.

Referring to Figs. 2 and 3, the vibratory plate or sounding-board is supported at its upper and lower edges by ledges or projections C, so that it is separated by a slight distance from the back board. Preferably pieces D, of rubber, felt, or like material, are placed between the vibratory plate and the ledges or projections C, in order to prevent or lessen the transmission of vibrations to it from the back board. The plate on its face is grooved vertically in the middle, and in the groove is placed the glass jet-tube E, which is somewhat longer than the plate, so as to project beyond it at top and bottom. The tube is held in the groove by buttons F, which are turned over the tube. These buttons allow the ready removal, replacement, and adjustment of the tube.

In the supply-pipe G, leading from the elevated reservoir H, in addition to the spring cock or valve 6 and filter I, is a cock, K, for controlling the flow. Directly under the jet-orifice is placed a small metal tube, L, which fits in a groove in a block, C', (asphalt, brick, metallic lead, or iron, or other material which is a poor conductor of sound-vibrations,) and is held in place, so as to permit its adjustment, by a button, F'. The upper end of the tube is covered with a diaphragm or membrane, M, (preferably thin sheet rubber.) The tubes E L are so adjusted that the jet from the former, E, plays upon the center of the diaphragm, and that the said diaphragm is in the continuous part of the stream not far from the point where, if allowed to fall freely, it would of itself be broken up into drops under the influence of the greatest disturbance to which it is likely to be subjected.

In Fig. 2 the tube L conveys the sound-waves produced in the confined air by the varying impact of the jet upon the membrane M into the space in front of the diaphragm Q. The stretched wire R is attached in any ordinary or suitable way to the center of this diaphragm, opposite the mouth of tube L.

S is a hearing-tube, for enabling the person using the telephone to receive messages transmitted mechanically from the distant station over the line-wire R.

In Fig. 3 the line-wire R is connected with the vibratory plate B, so that the vibrations of the wire are communicated to the jet and through it and the diaphragm M are transmitted to the air in the tube L. The flexible tube N conveys the sounds to the ear of the listener. The vibrations of the plate B, imparted to it by sounds in the neighborhood, or by other means, are transmitted along the wire to the distant station. Thus this apparatus, like that of Fig. 2, is both transmitter and receiver; but, unlike that, it receives through the jet instead of transmitting through it, and transmits instead of receives in the ordinary way.

The apparatus at the distant station or stations may be duplicates of those shown in Figs. 2 and 3; but it is not essential that they should be such.

If it be desired to equip a line with both jet-receivers and jet-transmitters, this can easily be done. The jet-receiver of Fig. 3 may receive vibrations communicated through the stretched wire from the jet-transmitter of Fig. 2

The hearing-tube S, Fig. 2, or N, Fig. 3, is supported on the end of arm 7 when not in use. The weight of this tube S suffices to draw down the arm against the tension of spring 9, and close the cock 6, so as to shut off the flow. When the tube S is removed, the spring opens the cock and allows the jet to resume its action.

It is evident that the sound-conveying tubes of Figs. 2 and 3 can be extended and form a speaking-tube of any convenient length, the stretched wire or stretched wire and diaphragm Q being omitted or not, as desired.

In Fig. 2 there are really two lines—first, the sound-conveying tube L, and, second, the stretched wire R, which latter is thrown into vibration indirectly by the sounds conveyed through the former. The wire may, however, be vibrated directly, as shown in Fig. 3[b], wherein the jet plays directly upon the button in the center of the diaphragm Q, with which the wire R is connected. In this figure the jet-tube E is horizontal instead of vertical and, as in Fig. 1, it is perpendicular instead of parallel to the plane of the vibratory plate B. P′ is a pipe for carrying off the water. The other parts are as before described.

The apparatus of Fig. 3[a] is the same as that of Fig. 3, except that the vibratory plate B is fastened at the upper end only to a block, C″, instead of at both ends, and that the jet-tube is secured thereto by staples; also, that the tube L is fastened by straps instead of by buttons.

In Fig. 4 the stretched wire and telephone-line of previous figures is replaced by a body of liquid confined in a pipe, T, and communicating with the jet-liquid. The vibrations from the distant station impressed upon the liquid by the sound-waves striking against a diaphragm, 25, in the bell-mouth 26, are transmitted through the liquid in the pipe T, and throw the jet at the receiving-station into vibrations. These are rendered audible in the tube N. It is evident that the tube N may also contain a liquid, and also that it may be extended to any suitable distance; also, that the arrangement shown would operate with gases (air, for example) as well as with liquids. (See Fig. 12.)

In transmitting sounds through fluids, and specially through liquids, it is desirable to use pipes of metal or glass, or other hard elastic material, since soft material—such as rubber—very readily absorbs the vibrations.

In Fig. 5 the jet acts to vary the pressure of electrodes in constant contact; or, in other words, the jet plays upon the very light (preferably mica) diaphragm of a contact-telephone or battery-transmitter, W. The electrodes are shown included in a local circuit with the battery and primary of an induction-coil, while the secondary of the induction-coil and the telephone-receiver X are included in the main line. This is the usual arrangement at stations of electric-telephone lines, and is therefore shown. Other known or suitable arrangements could be adopted. In this figure the automatic cock 6 is utilized as a switch for opening and closing the circuit of the local battery, the spring-contact 20 being provided in addition to those shown in Fig. 1.

In Fig. 6 the jet-tube E is attached to the free end of a light spring, Y, of the flat kind. The spring is provided with an armature which bears very lightly upon the pole of permanent magnet Z, provided with a bobbin on its pole-piece. Electric undulations or vibrations in the bobbin throw the jet into corresponding vibrations, and these may be received as sound through the tube N.

It is obvious that the jet could be made to impart vibrations to the operative devices of other telephone-transmitters, and could be thrown into vibration by any of the known forms of telephone-receiver; or, more broadly, that it could be made to vibrate or could be vibrated by any known or suitable means for transforming atmospheric or mechanical into electrical vibrations, or to transform the latter into the former. It is obvious, also, that the jet acted upon by the receiver could operate a transmitter, and thus form part of a telephone-relay.

The instruments shown in Figs. 3, 4, and 6 may be considered as relays, reproducing the vibrations transmitted through one line (the wire R, Fig. 3, the liquid of pipe T, Fig. 4, or the electric circuit in Fig. 6) into another, (the sound-conveying tube N in said figures.) As shown, the reproduced vibrations are transmitted for a short distance, (the length of tube N;) but it is obvious that they could be transmitted farther—*i. e.*, by increasing the length of said tube. It is also obvious the vibrations of the body of confined air in tube N could be further transmitted by any instrument so placed as to be acted upon by vibration—as, for example, any telephone, mechanical or electric, having the diaphragm in the position of that marked Q, Fig. 2. Further, the jet could operate directly upon the transmitter—as, for example, in Figs. 1, 3[b], and 7.

In the instruments hereinbefore described the jet-tube is carried by a vibratory support, B, through which the vibrations are communicated to the jet-tube and jet; but this is not essential, for the vibrations may be communicated directly to the jet-tube or to the jet. In a mechanical telephone the stretched wire could be attached directly to the jet-tube E, as it practically is in Fig. 3[a]. The vibrations could be communicated directly to the jet by sounds uttered or produced in the neighborhood thereof, and these sounds could be directed or concentrated by a funnel or bell-mouth, 30, Fig. 8, as or shortly after it leaves the orifice in the jet-tube. A preferred arrangement is shown in Fig. 9, where the jet is inclosed in a glass tube, 31, and the bell-mouth 30 communicates with said tube. The speaker talks into the bell-mouth. The jet could also be thrown into vibrations by a diaphragm or plate or vibrating body in contact with the liquid behind the jet. This is shown in Fig. 7, wherein the liquid on its way to the jet-tube E passes through a chamber, 35, of which the front wall is formed by a vibratory plate or diaphragm, 36. It is also shown in Fig. 4; but in that case the diaphragm 25 was at some distance.

Fig. 10 shows the jet applied to vibrate a mirror, 37, upon which a beam of light or other radiant beam is allowed to fall. The beam is thus thrown into corresponding vibrations, which may be rendered audible by any suitable photophonic receiver, with or without the introduction of electricity.

In Fig. 11 the radiant beam is concentrated by a reflector, 39, upon the jet-tube E, which is coated with lamp-black at 38, so as to absorb the radiant energy. This receiver may be used with the transmitter shown in Fig. 10, or with other photophonic transmitter. It is preferred to use air or other gas with this instrument. The jet plays upon the end of a metal tube, L', in which a small orifice is provided. The tube is adjusted so that the orifice is in the axis of the jet. The jet communicates its vibrations to the air confined in the tube L' and the sound-conveying tube N, which communicates with the tube L'. To prevent the air blowing into the ear of the listener, the bell-mouth at the end of the tube N is provided with a diaphragm, 50.

The air to be supplied to the jet-tube may be compressed by any suitable means which yield a constant or approximately constant pressure, notwithstanding the constant escape. The means shown in Fig. 12, for example, may be used. The apparatus shown in this figure is to be used at one end of a speaking-tube, T, a similar apparatus being used at the opposite end. Compressed air or gas, under pressure, is supplied to the tube T from the collapsible bag 60 through the tube G. A weight, 61, on top of the bag, creates the pressure. The bag is filled when exhausted or whenever desired by means of the bellows 62, having its nozzle connected with a prolongation of the tube G. The air escapes in a jet from the orifice in tube E, which communicates with the tube T. The jet plays upon the perforated end of the tube L', and the sounds are conveyed to the ear of the listener through the tube N. The tube T is provided at the end with a bell mouth, 26, closed by a diaphragm, 25. On talking to the diaphragm 25 at either end of the tube T the latter impresses its vibrations upon the confined air, which in turn throws the jets at both ends of the line into vibrations corresponding thereto. These vibrations are in turn communicated through the confined air of tubes L' N to diaphragms 50 and the ears of the listeners. It is found that a pressure equal to three-sixteenths ($\frac{3}{16}$) of an inch of water behind the jet-orifice gives good results, the orifice being about four hundred and twenty-three ten thousandths ($\frac{423}{10000}$) of an inch in diameter, and the tube upon which the air-jet plays having an orifice of, say, one twenty-fifth ($\frac{1}{25}$) of an inch in diameter, and being distant from the jet-orifice one inch or thereabout. Of course these figures are variable.

Instead of duplicating the apparatus at the distant station other suitable transmitting and receiving apparatus may be used thereat.

In Fig. 13 the jet plays upon the diaphragm M' of an Edison phonograph. The jet, as shown, is adapted to respond to vibrations passing along the stretched wire R; but it may evidently be vibrated in any suitable way. Speech or other sound may thus be recorded.

It is evident that the jet may be used to reproduce recorded speech; also, that it could be used in rendering sound-vibrations visible by means of a suitable instrument, such as a phonautograph.

In Fig. 13 the apparatus is designed for use with a liquid jet, but it may evidently be modified for use with a gas jet.

In all the foregoing, except the apparatus shown in Figs. 11 and 12, wherein it acts upon confined air, the jet has been allowed to act upon a solid body, and the vibrations of said body have been conveyed through a body of confined air or other line, such as a stretched wire, electric current, radiant beam, and the like; but neither of these conditions is essential. The jet may act upon fluids, and the vibrations may be received through the atmosphere. Sounds (including articulate speech) may be so magnified as to be audible over a room in which the receiving-instrument is placed.

In Figs. 14 and 15 an air jet from the tube E plays upon a gas-flame, 70. Preferably the burner 71 is of the pin-hole kind, and is arranged with the axis of its flame perpendicular to the direction of the air jet. The jet being produced under the conditions stated with reference to Fig. 12, and the burner having a circular orifice about the size of the jet-orifice, the combustible gas (ordinarily illuminating-gas) may issue therefrom under a pressure of one-eighth ($\frac{1}{8}$) of an inch of water, and the jet may bear upon the flame just below the apex of the flue or inner cone.

In the case of gas (air) jets it is found desirable to exclude the outer part of the jet and allow the center only to act upon the device to be acted upon. This is effected in the apparatus shown in Fig. 12 by the shape and size of the end of the tube L'. With the apparatus of Figs. 14 and 15 the separation is of course not effected. In Fig. 14 the jet is vibrated by the varying attraction of an electro-magnet, Z, as in Fig. 6. In Fig. 15 the vibrations are communicated to the jet-fluid by means of a diaphragm, 25, as in Figs. 4 and 12. The jet might also be vibrated by impressing the vibrations upon the supporting-plate B'. The jets can be inclosed in a vacuum or partial vacuum. Thus in the apparatus shown in Fig. 3^b^, where the jet is in an inclosed chamber, the air may be withdrawn therefrom through the pipe P', the pressure of the water to supply the jet being regulated to compensate for the absence of back-pressure. When the jet is to vibrate a body, such as a diaphragm, it is desirable to prevent the accumulation of liquid thereon, as this interferes more or less with the transmission of the vibrations, and the apparatus shown have therefore been so constructed or arranged that the liquid will immediately run off.

It is not considered necessary to show jet-translating apparatus which respond only to tones, or which are capable of utilization only for special purposes, the "articulating jet-translating apparatus," as it may be called, being the best embodiment of the invention.

A large number of fluids may be used to make the jet; but water, free from particles in suspension, among liquids, and air among gases, are suitable for general purposes. When a gas is used, it may be desirable, in order to secure adjustment, to render the jet visible, as by the introduction of smoke.

Having now fully described my said invention and the manner of carrying the same into effect, what I claim is—

1. In the reproduction of speech, the improvement consisting in translating from one vibratory medium to another, through a jet, sonorous vibrations similar in form to the sound-waves of the spoken words, substantially as described.

2. The method of translating from one medium to another vibrations similar in form to sound-waves, by impressing the vibrations of the former upon a jet, and causing the jet to impress the same without destruction of their form upon the second medium, substantially as described.

3. In the reproduction of speech and other sounds, the improvement consisting in translating or transferring the sonorous vibrations of one medium into another through a fluid jet, substantially as described.

4. The method of transmitting speech and other sounds by throwing upon a line sonorous vibrations corresponding in form to the speech or other sound-waves, and causing the sonorous vibrations transmitted to impress themselves through a jet upon a vibratory receiving medium, substantially as described.

5. The improvement in transmitting speech and other sounds consisting in causing a sensitive jet to impress upon the medium constituting the line vibrations similar in form to the sound-waves, substantially as described.

6. The improvement in transmitting speech and other sounds consisting in transferring the sonorous vibrations of one line to another through a vibratory jet, substantially as described.

7. The method of reproducing speech and other sounds by impressing corresponding vibrations upon a jet, and causing the latter to impress upon the atmosphere vibrations similar in form thereto, whereby the vibrations are rendered audible, substantially as described.

8. The method of impressing vibrations similar in form to sound-waves upon a vibratory medium through a jet, by impressing the vibrations upon the jet-fluid near the jet-orifice, and causing the continuous portion of the jet at its outer part to act upon said medium, substantially as described.

9. The method of transferring the vibrations of a jet to a vibratory medium, whereby the same may be made evident by receiving the impact of the continuous portion of the jet upon a vibratory body constituting or connected with said medium, substantially as described.

10. The method of throwing a jet into vibrations corresponding to sound-waves by impressing similar vibrations upon the device or material in which the jet-orifice is formed, substantially as described.

11. The improvement in transmitting intelligence consisting in impressing upon a jet vibrations representing the message or signal to be transmitted, and causing the said jet to act upon a vibratory medium connected with or forming part of the line, substantially as described.

12. The improvement in transmitting intelligence consisting in throwing upon a line vibrations representing the message or signal to be transmitted, and causing the said vibrations to impress themselves upon a jet, which acts upon the receiving medium, substantially as described.

13. The improvement in transmitting intelligence consisting in throwing upon a line vibrations representing the message or signal to be transmitted, causing the said vibrations to impress themselves upon a jet, and causing the said jet to act upon a vibratory medium connected with or forming part of a second line or constituting a continuation of the former, substantially as described.

14. The improvement in transmitting intelligence consisting in acting over one line upon the fluid of a jet and causing the latter to act upon another line or continuation of the former line, substantially as described.

15. The combination, with a line for the transmission of intelligence, of a jet-translating apparatus—that is to say, provided with a jet-orifice, and a passage or chamber for supplying fluid under pressure to said orifice, and further provided with means for varying or responding to variations in said jet—substantially as described.

16. The combination, with a line for the transmission of speech and other sounds, of a jet-translating apparatus, comprising means for translating or transferring from one substance to another through the intermediary of a jet vibrations similar in form to sound-waves, substantially as described.

17. The combination, with the jet-producing means, of a device arranged in the path of said jet and means for transferring to a second device or confined medium the move-

ments of said former device under the varying impact of the jet, substantially as described.

18. The combination, with jet-producing means, of a vibratory plate or sounding board adapted to copy the vibrations of sound-waves and forming a support to the device provided with the jet-orifice, substantially as described.

19. The combination, with jet-producing means and means for impressing vibrations similar in form to sound-waves on the jet, of means for subjecting a receiving medium to the action of the continuous portion of the jet produced, substantially as described.

20. In an apparatus or system for transmitting speech and other sounds, a small stretched membrane of flexible elastic and extensible material—such as soft vulcanized thin sheet-rubber—in combination with means for concentrating the impressing vibrations in the center of such membrane, substantially as described.

21. A jet-translating apparatus provided with a jet-orifice, a passage or chamber for supplying fluid under pressure to said orifice, and means for subjecting a vibratory medium to the action of the jet from said orifice, said apparatus having the parts arranged, as explained, so that the vibratory medium to be impressed will be acted upon by the continuous portion of the jet, substantially as described.

22. The combination, with devices for producing a jet and impressing vibrations thereupon, of isolating means for excluding the influence of foreign vibrations on said jet, substantially as described.

23. In a jet-translating apparatus, the jet-tube in combination with a vibratory support by which the same is carried, substantially as described.

24. The combination, with a vibratory plate or diaphragm, of a jet-tube carried thereby, substantially as described.

25. The combination, with the means for producing a jet and imparting vibrations thereto, of a sound-conveying tube and a membrane or diaphragm at one end of said tube in the path of the jet, substantially as described.

26. The combination, with the means for producing a jet and imparting vibration thereto, of the sound-conveying tube and the membrane or diaphragm at the end of the tube, said membrane or diaphragm being arranged, as explained, so as to be acted upon by the continuous portion of the jet, substantially as described.

27. In a system or apparatus for producing, reproducing, transmitting, recording, or rendering visible sonorous vibrations, the combination of a vibratory plate or diaphragm and the jet-tube carried thereby with the means for receiving and conveying the vibrations of said jet, substantially as described.

28. The combination, with the jet-tube and means for supplying fluid thereto, of an automatic cock in the supply-pipe provided with retracting means, such as a spring, for actuating the same when released, substantially as described.

29. The combination of a vibratory plate, a jet-tube carried thereby, a sound-conveying tube, and a membrane or diaphragm at the end of said tube in the path of the jet, substantially as described.

30. The sound-conveying tube having a thin membrane of elastic material—such as a sheet of rubber—stretched over the end, in combination with means for causing a sensitive jet to play on said membrane, substantially as described.

31. A transmitter of sonorous vibrations containing a fluid jet for amplifying the same without substantial loss of character, as set forth.

32. In an apparatus for transmitting sonorous vibrations by means of a fluid jet, the combination, with the jet-tube of such apparatus and the tube for supplying liquid to said jet-tube, of a filter for removing bubbles or solid particles from the jet-liquid, substantially as described.

33. The automatic cock and switch comprising, in combination, a cock or valve, an operating-arm provided with a hook or fork at the end, a retractile spring, and electrical contacts, substantially as described.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

CHICHESTER A. BELL.

Witnesses:
C. J. HEDRICK,
PHILIP MAURO.