V. TARDIEU.

LONG DISTANCE TELEPHONIC APPARATUS.

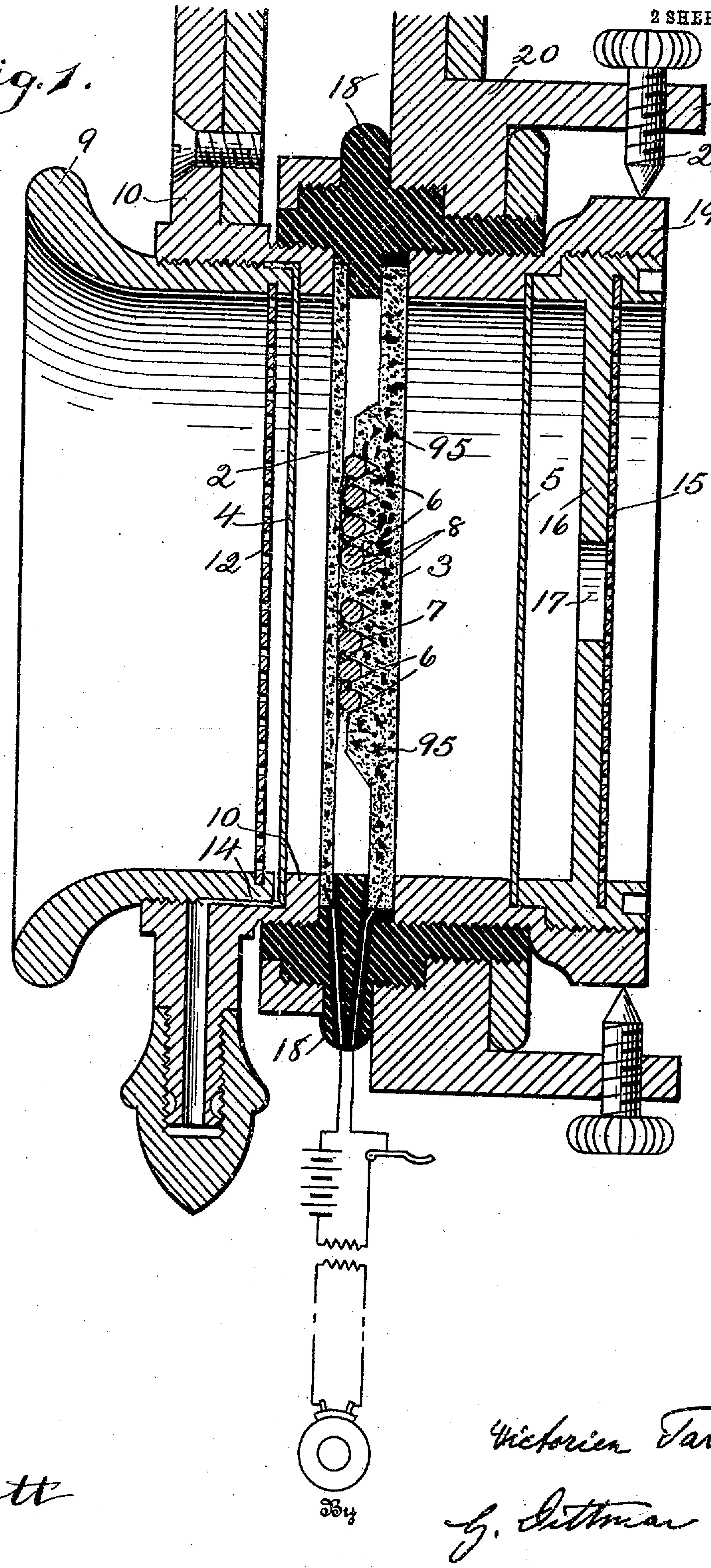
APPLICATION FILED NOV. 5, 1904.

956,228.

Patented Apr. 26, 1910.

2 SHEETS—SHEET 1.

Fig. 1.



Witnesses

T. P. Britt

Hugo Glass

Inventor

Victorien Tardieu

By

G. Dittmar

Attorney

V. TARDIEU.

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Fig. 2.

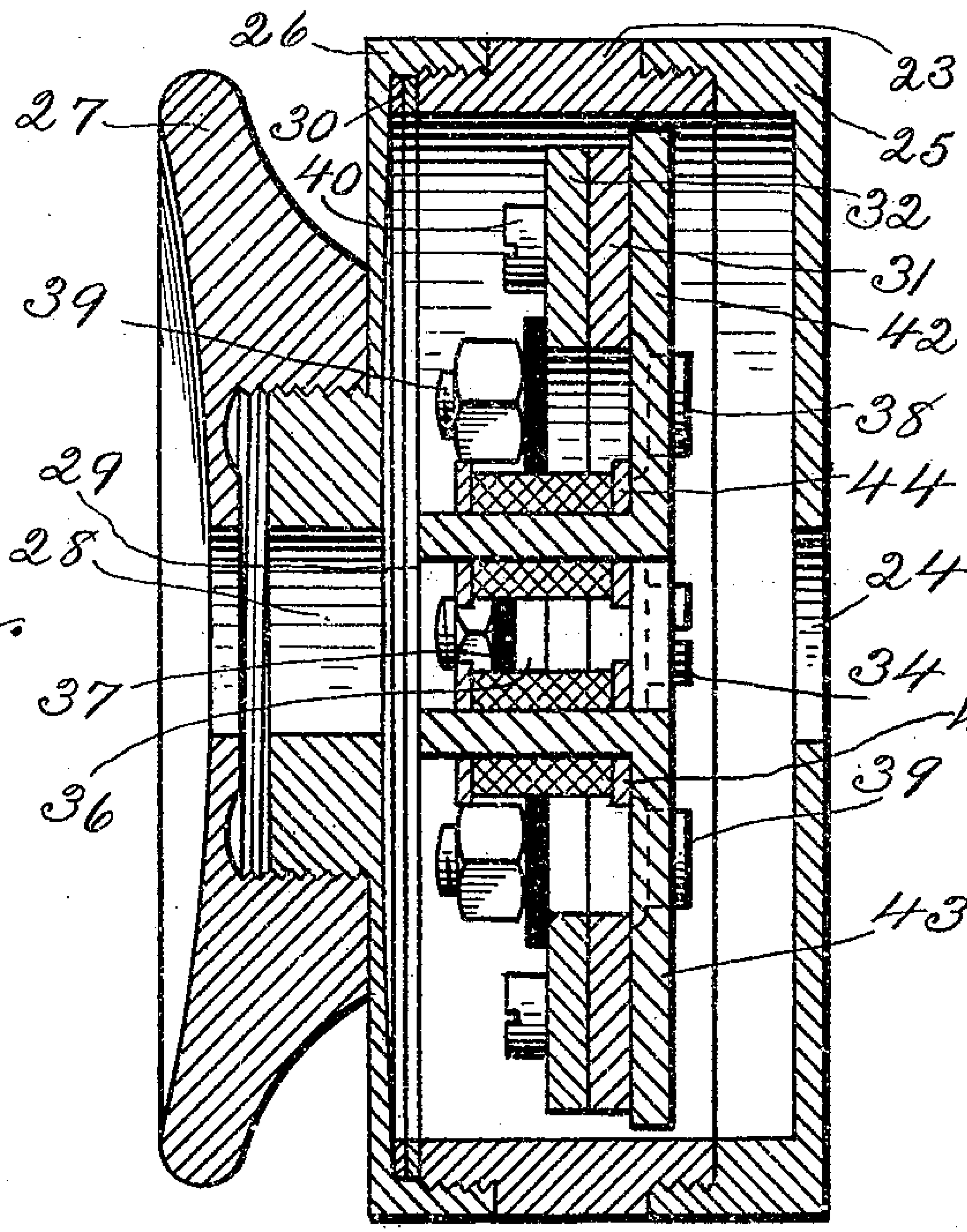
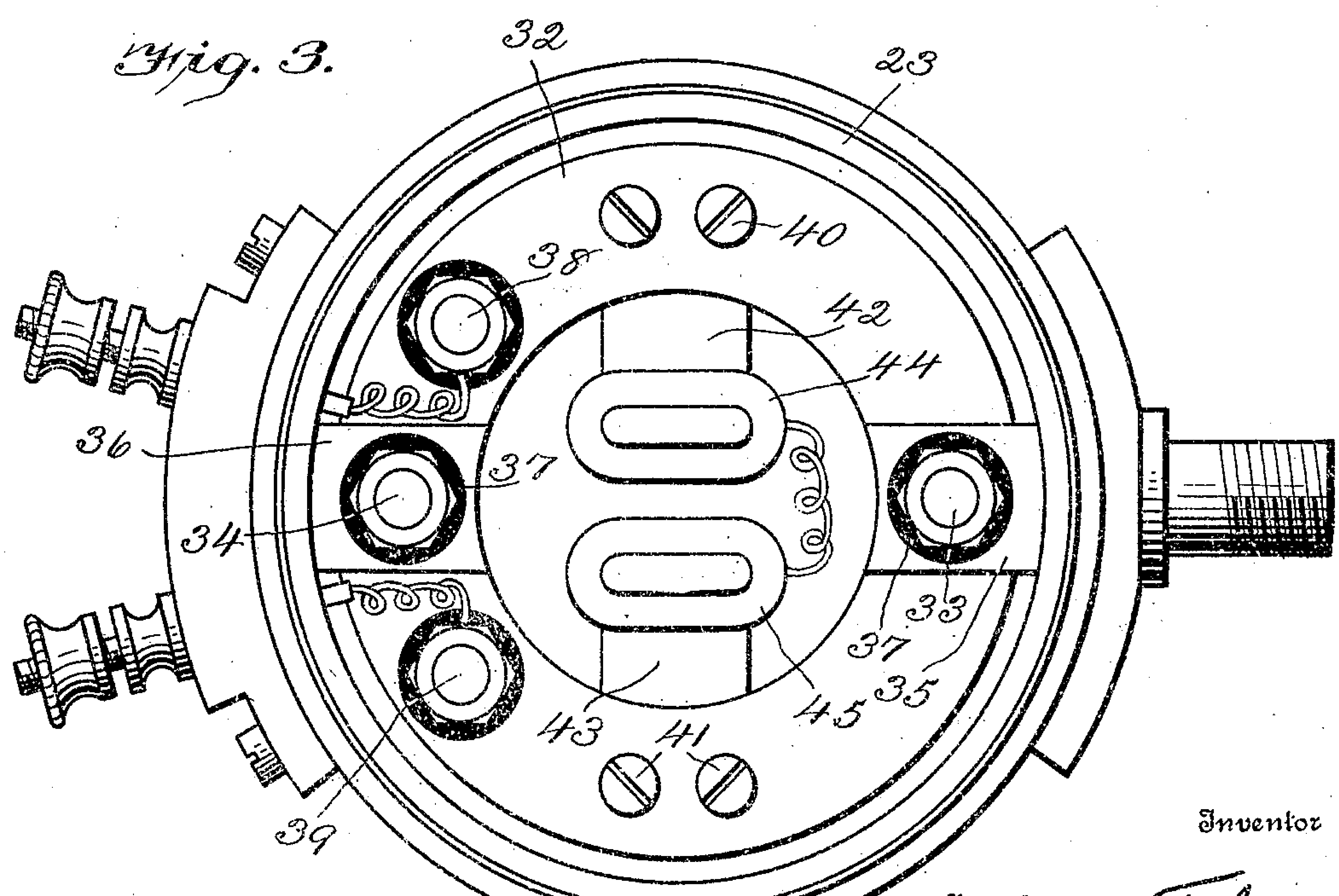


Fig. 3.



Witnesses

T. P. Britt

Hugo Sloss

Inventor

Victorien Tardieu

By G. Dittmar

Attorney

ANDREW B. GRAHAM CO. PHOTO-LITHOGRAPHERS, WASHINGTON, D.C.

UNITED STATES PATENT OFFICE.

VICTORIEN TARDIEU, OF ARLES, FRANCE.

LONG-DISTANCE-TELEPHONIC APPARATUS.

956,228. Specification of Letters Patent. Patented Apr. 26, 1910.

Application filed November 5, 1904. Serial No. 231,601.

To all whom it may concern:

Be it known that I, VICTORIEN TARDIEU, doctor of medicine, a citizen of the Republic of France, residing at Arles, Rhône, in the Republic of France, have invented certain new and useful Improvements in Long-Distance-Telephonic Apparatus, of which the following is a full, clear, and exact description.

This invention relates to apparatus for the distinct transmission of sounds more particularly over long distances and for reproducing musical or the like productions in short in all cases, in which a very clear transmission of sounds is required.

In my apparatus the distinct transmission of sounds is obtained by the use of partly closed pipes or tubes closed at both ends or of hollow bodies, especially in the form of low cylinders, though their form is not essential. In such pipes or tubes, etc., sound waves entering them or beating against them are converted as described later on into sound waves having a higher rate of vibration per second. These latter produce electrical impulses in a microphone, which pass to the telephone receiver, where they are reconverted into sound waves, the receiver also consisting of pipes or hollow bodies, etc.

The conversion of sound waves of a low rate of vibration per second into such of a higher rate is regulated by physical laws, that were first observed by Helmholz and then minutely examined by Rudolf König in Paris and described by him in his work: "*Quelques Expériences d'Acoustique*" Paris 1882, pages 113 ff. and 125 ff.

In closed hollow bodies—for instance low cylinders employed in the transmitter according to my invention—interferences are formed in consequence of the air waves being reflected inside the hollow bodies and then crossing each other. The sounds thus produced by the interferences were called by Helmholz additional and differential sounds and have a far higher rate of vibration per second than the original sounds, in fact they may reach the eighth octave of the latter. König however doubts the existence of additional and differential sounds and calls the sounds caused by the interferences "*sons des battements*." It is quite certain however that the hollow bodies produce besides higher harmonic sounds slight shocks or knocks that are audible at a moderate distance, if the necessary attention is given. These knocks or shocks are evidently the cause, that sound is clearly reproduced by my apparatus even at the greatest distances, though the individual shocks are no more discernible at such distances. The sound then seems to be an uninterrupted even sound without shocks. If several of the above hollow bodies or cylinders of equal diameter are placed together, only clear harmonic upper tones are produced by them, provided that the heights of the several cylinders show harmonic proportions. The best effect, viz. the greatest reinforcement of sound is obtained, if the proportion is 3:2, the quinte or treble (according to König). The application of these principles to telephonic apparatus gives great and unexpected results but requires also a particular construction of my apparatus. Experiments have shown, that the effect of such telephonic apparatus is materially increased, if it is regulated or tuned for the sound or note, which may be regarded as the basis of the human voice, being the note, which occurs most frequently. This tone or note is a "g" of 384 to 424 vibrations per second. All parts of the telephonic apparatus must be proportioned to suit this "g." If another note or tone, for instance an "a" or "h" should prove under certain circumstances a better base the proportions would have to be selected according to it.

I am aware that apparatus are known, the construction of which allow of the supposition, that sounds of a low rate of vibration are converted into sounds of a higher rate in consequence of suitable bodies with a high rate of vibration being introduced therein. There is for instance a microphone transmitter, in which vertical tubes of varying length arranged close together receive the sound waves, which pass through them to the diaphragm and cause their vibration. Then microphone transmitters and telephone receivers are known, in which the vibrating agents consist of several springs, the effect of which is increased by arranging their length in such manner that each of them vibrates to one sound of the diatonic scale. All these apparatus however do not show hollow bodies of harmonic proportions filled with air, in consequence of which no interferences or shocks are produced, on which the superior action of my apparatus depends.

The accompanying drawings represent an embodiment of a telephonic apparatus according to my invention, which I have selected for illustration, but to the details of which I do not confine myself. In this example the arrangements peculiar to my invention their effects and their advantages are shown. The apparatus consists of the microphone transmitter and the telephonic receiver.

Figure 1 represents a vertical axial section through the microphone transmitter. Fig. 2 is a vertical axial section through the receiver and Fig. 3 is a front view of the receiver without the cover and ear piece.

The microphone transmitter, Fig. 1, contains the space or cylinder for receiving and transmitting the sound between the two carbon plates 2 and 3. In front of the carbon plate 2 there is a metal plate 4 and behind the carbon plate 3 a metal plate 5, by which two hollow bodies between the plates 2 and 4, and 3 and 5 are formed. Plate 4 is firmly fastened between the mouth piece 9 and ring 10, plate 2 between rings 10 and 18, plate 3 betwen rings 18 and 19, and plate 5 between ring 19 and the back 16. The plates or disks especially the metal plates should have no play, because a more intense tone is produced, if they are firmly screwed.

The front side of the middle part of the carbon plate 3 has a truncated conical excresence 8 with a projecting rim 95 and four rows of circular grooves 6. The section of these grooves 6 is of a V-shape, so that they can be filled with balls 7. When plate 3 is in a vertical position the balls in any same groove 6 just touch each other, a small space remaining between the two uppermost balls of each row. In this vertical position of plate 3 the balls 7 have some play for moving forward and backward and are kept by the carbon plate 2 from falling out of their grooves. The four grooves 6 contain 6, 14, 20 and 25 or together 65 carbon balls. In the rear side 16 of the microphone, an opening 17 is formed for enabling the metal plate 5 to vibrate freely. A wire gauze disk 15 is fitted over the back 16 and another wire gauze disk 12 is let into a groove of the mouth piece 9 in order to protect the interior of the microphone from damage. The wire gauze 12 retains the moisture of the breath and leads the same to a small tube 13, for which purpose a small groove 14 is formed in the ring 10. The two carbon plates 2 and 3 bear upon an ebonite ring 18 against which they are held by the screwed rings 10 and 19. A ring 20 in which the microphone can be rotated has two arms 21 through each of which passes a screw 22 for properly adjusting the microphone. In consequence of this arrangement the microphone can be washed and maintained free of germs. Thus in the event of an epidemic everyone can have his own mouthpiece and front metal disk 4, as these parts can readily be replaced by others without in any way interfering with the microphone's action.

The receiver shown at Figs. 2 and 3 consists of a box or casing—of the same internal diameter as that of the microphone—which contains the electro-magnet, the membrane and the other necessary parts. The casing consists of a metal ring 23, into one end of which is screwed a cap 25, having an opening 24, while into the other end is screwed a cover 26. An ear piece 27 is screwed on to this cover, which also has an opening 28, the diameter of this being somewhat smaller than that of 24. The cover 26 is formed arched outward toward the ear piece 27 in order to strengthen the sound waves in the ear piece. The vibrating metal plate or membrane 29 is firmly held between two rings 30, fixed between the metal ring 23 and the cover 26. In the casing the magnet is freely suspended in its neutral points, the two superposed rings 31 and 32 being fixed by screws 33 and 34 to two lappets 35, 36, the screws being insulated from the electromagnet by means of disk 37 of insulating material and of insulating linings to the screw holes. Two bolts 38 and 39 effect the conducting connection of the wire line with the wire coils 44, 45 of the magnet. On the rear side of the rings 31 and 32 and connected thereto by screws 40, 41 are two angular soft iron pole pieces 42, 43 arranged at right angles to the points of suspension, which pole pieces carry the wire coils 44, 45, which are of exactly the same height and have the same number of windings. Also the pole pieces 42, 43 must be of exactly the same height. When not in use the magnet attracts the membrane 29 to its pole arms 42, 43 in consequence of which the membrane is curved and can only vibrate to one side. Of course the apparatus described can be applied to all kinds of telephones, whether they be table apparatus or a wall or a box apparatus for the operators of exchange. The size of the several parts of the transmitter and receiver are to a great extent not selected at will but also calculated according to laws and rules of phonology in order to obtain the greatest possible effect in my telephonic apparatus. Experience has proved the following proportions to be especially favorable to the obtention of remarkable good effects.

Very essential for a clear transmission are the proportions of the heights of the cylindrical hollow bodies, which may be calculated in the following manner, practice having shown, that these principles are correct. It is well known that the tone produced by a tuning fork is reinforced by a sounding box, if the fork is placed thereon, the reinforcement consisting in harmonic subsidiary and upper tones produced by the vibration of the box. If two or more tuning forks producing a different number of vibrations are however placed on a sounding box, then the original tones are reinforced and interferences appear besides that are audible and make the impression of shocks. Even if the sounding box contains a partition the tones are reinforced in the same manner (according to Tyndal page 297), and the same shocks can be heard. With several tuning forks and several sounding boxes the effect is increased correspondingly. The transmitter and receiver in my telephonic apparatus consist of a system of such sounding boxes. In the transmitter 3 sounding waves in form of hollow bodies (cylinders) of the same diameter are arranged one behind the other, while the tuning forks are represented by the sound waves produced by speaking, etc. The proportion of the sum of the heights of the two front hollow bodies to the height of the third hollow body is 2:3, in order to produce the effect of the quinte, which gives according to König the greatest effect. The sum of the heights of the two front hollow bodies between the metal plate 4 and the front side of the carbon plate 3 is 8 mm., the carbon plate 2 is included in these 8 mm., while the thickness of the metal plate 4 (0.05 mm.) may be neglected being too insignificant. The height of the middle space between the back of the carbon plate 2 and the front of the carbon plate 3 may vary slightly, according to the number of vibrations of the tone, for which the microphone is designed. For instance for a "g" with 400 vibrations per second the height would be 4.00 mm., for a tone with 424 vibrations per second 4.24 mm.

The carbon plate 2 being 1 mm. thick, the height of the first hollow body between the metal plate 4 and the carbon plate 2 is also variable as the total sum of 8 mm. must not be exceeded. If the middle cylinder be 3.84, 4.00, 4.24 mm. high, then the corresponding height of the first cylinder is 3.16, 3.00, 2.76 mm., thus always giving a sum of 8 mm., including the thickness of the carbon plate 2 which must be taken into account as a partition. The space between the carbon plate 3 and the metal plate 5 is 10 mm. high, thus giving for the third hollow body including the carbon plate 3—which is 2 mm. thick—a depth of 12 mm. The proportion to the two front spaces is therefore also 8:12 or 2:3. The two metal plates 4 and 5 may be painted advantageously with oil color. The diameter of the hollow bodies and in consequence the diameter of the transmitter is also regulated by the wave-length of the tone, that has been selected as fundamental tone and by the octave, viz. the number of vibrations into which the fundamental tone is to be converted. The diameter of the transmitter is however of less importance than the proportions of the other part. The smaller the diameter the higher are the numbers of vibrations and in consequence the tones. Very high tones are however not well reproduced in the receiver, and experience has shown, that the tone should not exceed the fourth octave of the fundamental tone "g" with 424 vibrations. The "g" of the fourth octave has 6784 vibrations. The sound progressing within the hollow bodies with a speed of 341.3 m. per second, this quantity must be divided through the number of vibrations of the highest additional tone, which it is intended to reach. For the "g" of the fourth octave the diameter of the transmitter is therefore 341 300:6784= 50.3 mm.

The receiving and transmitting space proper is the middle cylinder, in which the carbon balls 7 are arranged in such manner, that they are free to oscillate to and fro in consequence of the vibrations of the carbon plates 2 and 3. The conical part 8 of the carbon plate 3 has four circular grooves 6, the section of which is an equilateral triangle 1.92 mm. base and 1.82 mm. height. Each ball has a diameter of about 1.75 mm. The distance between the ball and the carbon plate 2 being 0.12 mm. to 0.30 mm., the space between ball and the apex (viz. the lowest part of the groove) is 1.00 mm., if the ball enters the groove as far as possible. After the ball has rolled out of the groove till it touches plate 2, the space between ball and apex is 1.12 to 1.30 mm. The oscillation of the balls may therefore reach the amount of 0.12–0.30 mm. In consequence of their oscillation the air behind the balls is alternately compressed and rarefied. For this reason a space must be left between the two uppermost balls in which groove—a space equal to 1 ball in the innermost and to two or more balls in the outer one—as otherwise the balls would not have free play, but would interfere with each other and be jammed.

The balls 7 will rest against plate 2 when plate 3 is in a vertical position. The great number of balls enables the transmitter to transform any number of vibrations of the air into electrical impulses in the most advantageous manner, the current passing from plate 2 to plate 3 being interrupted or at least considerably weakened by the resistance of the layer of air between plate 2 and the balls. The distance between the conical part 8 and plate 2 must always be well regulated. Only some hundredth of millimeters being in question it suffices to turn ring 19 a little in the one direction or the other. The ebonite ring 18 is then compressed more or less and the plate 3 moved a little. The telephone receiver consists also of two cylindrical resounding boxes, though their construction differs somewhat from those of the transmitter. They have each an outward opening and are divided by the membrane 29. The vibrating part of this membrane, the casing (sounding boxes) and the transmitter have the same diameter. The diameter of transmitter and receiver must be the same in order to reproduce the sinoides of the carbon plates of the transmitter on the membrane of the receiver. The ratio of the heights of the hollow bodies of the receiver is 8:17, the height of the front hollow body being counted from the outer edge of the opening in the ear piece to the membrane including this, which is 0.25 mm thick, while the back hollow space is counted from the back of the membrane 29 to the outer edge of the opening 24 in the back wall 25.

Any harmonic proportion may prevail between the heights of the two resounding boxes of the receiver, for instance 12:8 or 16:8. If the proportion 12:8—representing a pure quinte—were selected, the sound produced would be an octave below the most piercing tone produced in the two hollow bodies by the vibrations of the membrane. At small distances the tone, which is audible at the back of the transmitter would not be weakened enough. The proportion 17:8 is especially favorable being the tierce of the double octave, by which tones are produced, which are two octaves lower.

In the receiver as in the transmitter not only is the sound reinforced by the hollow bodies, but the same interferences in the sound waves, viz. the shocks above described are produced. The two hollow bodies produce tones, the difference of which is slightly above an octave. In this case shocks are produced according to König, which cause the tone to appear sharp and clear and which reinforce the tone produced in the ear piece, the difference of form of the two hollow bodies of the receiver and the cause of the sound audible in front being far louder than that audible through the opening in the back of the receiver. This is of great importance for small distances, where the sound received by the microphone is reproduced in such strength in the telephone receiver that it would affect the ear painfully, if the front opening were used. It is therefore advisable to use the back opening for small distances reserving the use of the ear piece for speaking at long distances. Of the sound waves produced by membrane 29 a part is reflected by the arched cover 26 till they are able to quit the receiver by the opening 28.

It is of an importance, that the formation of sound is disturbed in no way inside the casing. For this purpose the magnet must be able to oscillate freely, which end is attained by suspending it in the neutral line. The steel membrane 29 is continually attracted by the magnet and rests against the poles. The system oscillates together and is only separated from time to time, the magnet acting both in consequence of its own magnetism and of the electromagnetism produced by the wire coils 44 and 45.

In consequence of the constant attraction of the magnet the membrane 29 is slightly curved, the height of the curve being 0.12 to 0.30 mm., meaning that without the attraction of the magnet the distance between the membrane 29 and the pole pieces 42, 43 would reach this amount. The size of the curvature is equal to the play of the balls 7 of the transmitter. The rings 31 and 32 of which the magnet is composed and the two lappets 35, 36 are each 2 mm. thick, while the pole pieces 42, 43 are slightly thicker 2.25 mm. Their wire coils must be equally high and contain the same number of windings of the same thickness of wire. The external diameter of the magnet is 48.48 mm., and the internal 28 mm. The difference between the upper surfaces of the ring 32 and of the pole pieces 42, 43 is 6.78 mm. The screws 33, 34 by which the magnet is suspended are of a different kind of steel in order to avoid a deflection magnetic lines of force.

My telephonic apparatus acts in the following manner: The sound waves entering the mouthpiece 9 of the microphone transmitter cause the metal plate 4 to vibrate. These vibrations pass on in succession to the air of the first hollow body, the carbon plate 2, the air of the middle hollow body, the carbon plate 3, the air of the last hollow body and the plate 5. The sound waves being reflected within each of these spaces, interferences appear, causing additional and differential tones according to Helmholz or tone shocks (*sons des battements*) according to König. My experiments have shown that additional and differential tones and tone shocks are formed. At all events only harmonic upper tones are produced viz: tones with a great number of vibrations per second, which cause the plates 2 and 3 to oscillate violently and the balls 7 to play. The microphone produces therefore an extremely great number of electric impulses, which pass through the line in the usual manner to the telephone receiver. The magnetism of the electromagnet is changed constantly by the electric impulses—including currents—passing through the coils 44, 45. The membrane 29 begins to vibrate and with it the system of magnet and membrane. Perhaps the membrane may also be separated at times from the magnet and then again united with it. The sound produced is very clear, in consequence of the inducing currents being very weak and of the possible oscillation of the plate being very small. It is doubtful, whether the oscillations of the membrane are distinct oscillations or whether they must be regarded as merely molecular oscillations. There can be however no doubt of the good result. The sound waves are then reinforced by the resounding boxes, which cause also interferences and shocks.

The advantages of my telephonic apparatus are very great, the most essential consisting in the great distance, to which it allows to speak, distances, which up to the present were quite out of question. Experiments have shown the possibility of such transmission up to distances of at least 2000 km. The adoption of harmonic proportion excludes the possibility of disharmonic subsidiary or upper tones. This is another great advantage as these tones are the chief reasons, that telephonic apparatus fail at great distances.

The construction of the microphone transmitter and the telephone receiver is very simple and each part easily accessible. My apparatus may be therefore employed for every kind of telephones, whether they be table apparatus or a wall or a box apparatus for the operators of exchange.

The arrangements and sizes mentioned above may vary according to circumstances. It is for instance not absolutely necessary, that the microphone should have three hollow bodies, two of them being also sufficient, though the effect is then smaller. The proportion between the heights of the two front hollow bodies differs according to the fundamental tone. If, for instance other nations or other races have another fundamental tone, then the apparatus would have to be arranged to suit this tone. If a tone with more vibrations is to be produced in the transmitter, its diameter and consequently the diameter of the receiver would have to be altered.

Instead of the quint another harmonic proportion may be selected for the heights of the hollow bodies, for instance a tierce. If music is to be reproduced, for instance an opera or a concert, the sound may be received by several microphone transmitters that are regulated for different fundamental tones. Of course a corresponding number of telephone receivers would be required for the reproduction.

What I claim as my invention and desire to secure by Letters-Patent is:

1. A telephone system having the transmitter and receiver provided with hollow bodies or chambers arranged close to each other and harmonically proportioned one to the other.

2. A telephone system having a transmitter and receiver provided with hollow bodies or chambers arranged close to each other with the heights of the hollow bodies in the transmitter and receiver respectively showing such dimensions as to present harmonic proportions among each other.

3. A telephone system having a transmitter and receiver with hollow bodies or chambers arranged close to each other with the heights of the hollow bodies in the transmitter and receiver respectively showing such dimensions as to represent harmonic proportions among each other, the hollow bodies of the transmitter having the same diameter and the hollow bodies of the receiver having at the diaphragm the same diameter as those of the transmitter.

4. A telephone system having a transmitter and receiver with hollow bodies or chambers arranged close to each other with the heights of the hollow bodies in the transmitter and receiver respectively showing such dimensions as to represent harmonic proportions among each other, the hollow bodies of the transmitter having the same diameter and the hollow bodies of the receiver having at the diaphragm the same diameter as those of the transmitter, said diameter being related to the fundamental tone for which the apparatus is designed.

5. A telephone transmitter composed of two carbon plates, and metal plates, one in front of and the other behind the carbon plates and spaced therefrom, the said carbon and metal plates being spaced apart to form closed chambers the heights of which are harmonically proportioned one to the other.

6. A telephone transmitter comprising diaphragms or plates arranged to form three cylindrical chambers the central one of which constitutes the microphonic element of the transmitter, and the several chambers having their heights harmonically related one to the other.

7. A telephone transmitter comprising diaphragms or plates arranged to form three low cylindrical chambers, the central one of which constitutes the microphonic element of the transmitter, the sum of the heights of the central chamber and one of the other chambers bearing the proportion to the height of the other outer chamber of two to three.

8. A telephone transmitter having a thin flat carbon diaphragm, another carbon diaphragm with a thickened central portion in which is formed a plurality of concentric grooves varying in number according to the tone upon which the instrument is based and series of carbon balls, one series in each groove and engaging the first named carbon diaphragm.

9. A telephone transmitter having hollow bodies, a case provided with apertures, at the front and back, of different areas, two

metallic diaphragms in the case respectively adjacent to the apertured front and back, two spaced carbon diaphragms between the metal diaphragms and of substantially the same diameter as the metallic diaphragms, and balls loosely confined between the carbon diaphragms the heights of the hollow bodies being harmonically related one to the other.

10. A telephone transmitter having hollow bodies, a case provided with front and back apertures of different areas, two metallic diaphragms in the case respectively adjacent to the apertured front and back, two spaced carbon diaphragms between the metal diaphragms and of substantially the same diameter as the metallic diaphragms, balls loosely confined between the carbon diaphragms, the heights of the hollow bodies being harmonically related one to the other and a wire gauze screen between each metal diaphragm and the respective mouth aperture.

11. A telephone system comprising a transmitter provided with means for converting sound waves into interference shocks or blows and directing them against the microphonic side of said transmitter, and a receiver having means for reproducing the original sounds from the transmitted shocks or blows.

12. A telephone system comprising a transmitter provided with means for converting sound waves into interference shocks or blows and directing them against the microphonic side of said transmitter, and a receiver having means for reproducing the original sounds from the transmitted shocks or blows, the transmitter and receiver being harmonically proportioned one to the other.

In witness whereof, I subscribe my signature, in presence of two witnesses.

VICTORIEN TARDIEU.

Witnesses:

Charles Shumpe,

Victor H. Morgan.