Feb. 16, 1926. 1,573,739

J. H. O'NEILL

TELEPHONIC DEVICE

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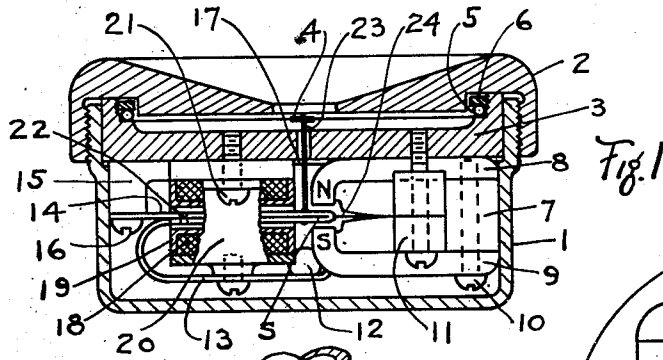


Fig. 1

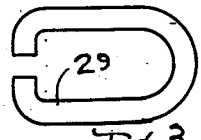


Fig. 3

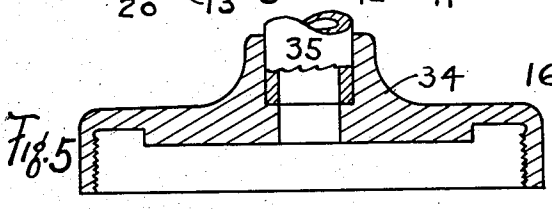


Fig. 5

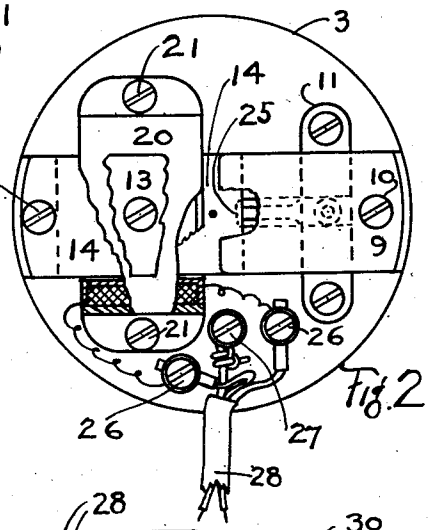


Fig. 2

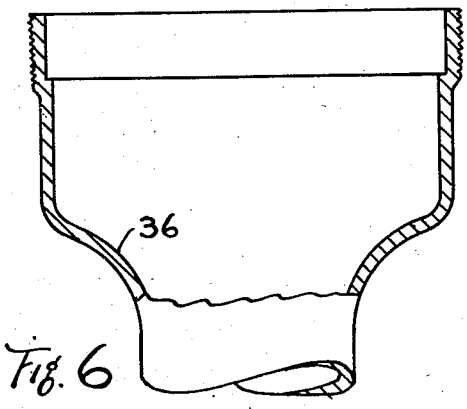


Fig. 6

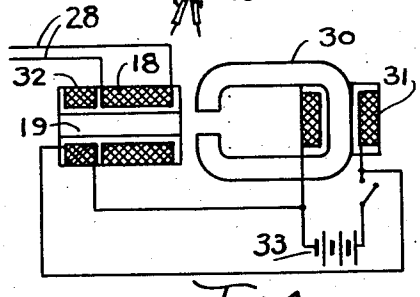
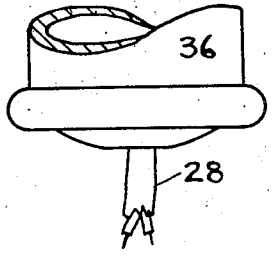


Fig. 4



INVENTOR.

John Hugh O'Neill

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J. H. O'NEILL

TELEPHONIC DEVICE

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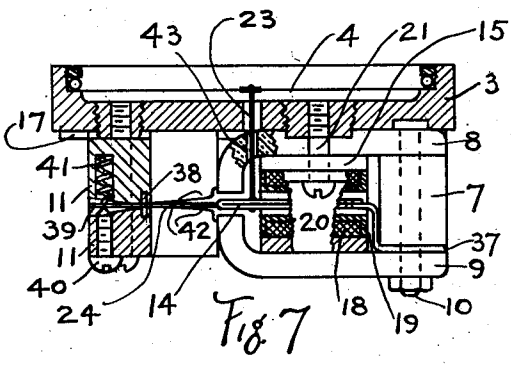


Fig. 7

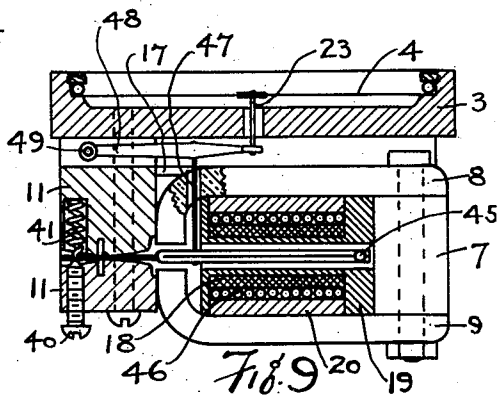


Fig. 9

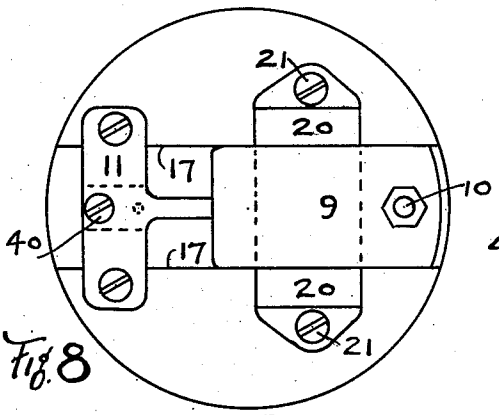


Fig. 8

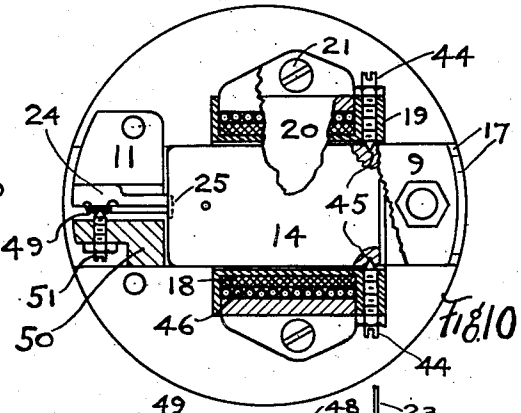


Fig. 10

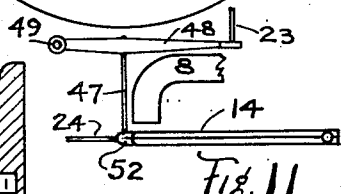


Fig. 11

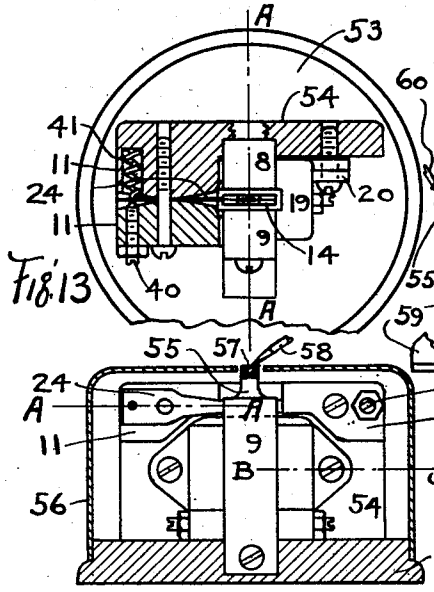


Fig. 13

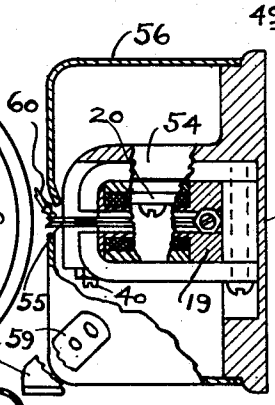


Fig. 14

Fig. 12

INVENTOR.

John Hugh O'Neill

Feb. 16, 1926. 1,573,739

J. H. O'NEILL

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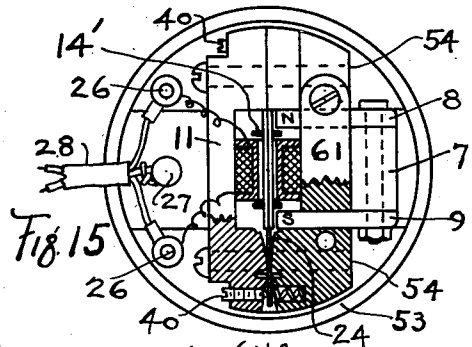


Fig. 15

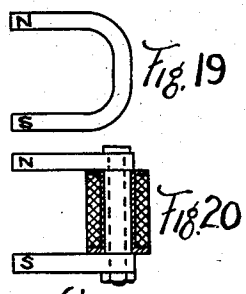


Fig. 19

Fig. 20

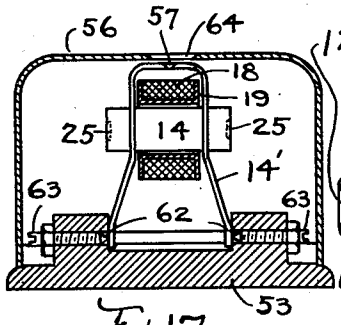


Fig. 17

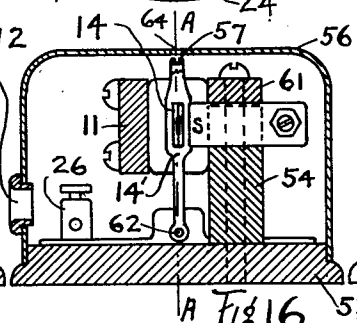


Fig. 16

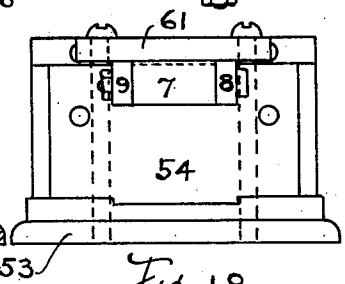


Fig. 18

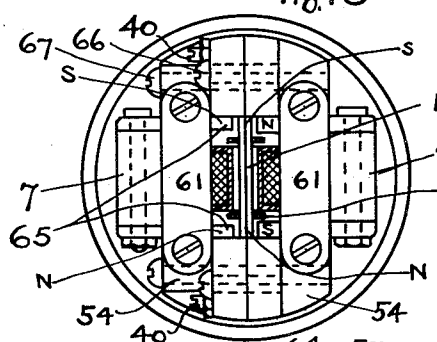


Fig. 21

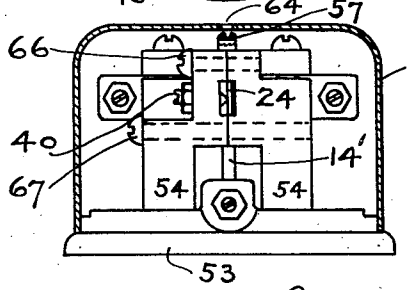


Fig. 22

INVENTOR.

John Hugh O'Neill

Feb. 16, 1926. 1,573,739

J. H. O'NEILL

TELEPHONIC DEVICE

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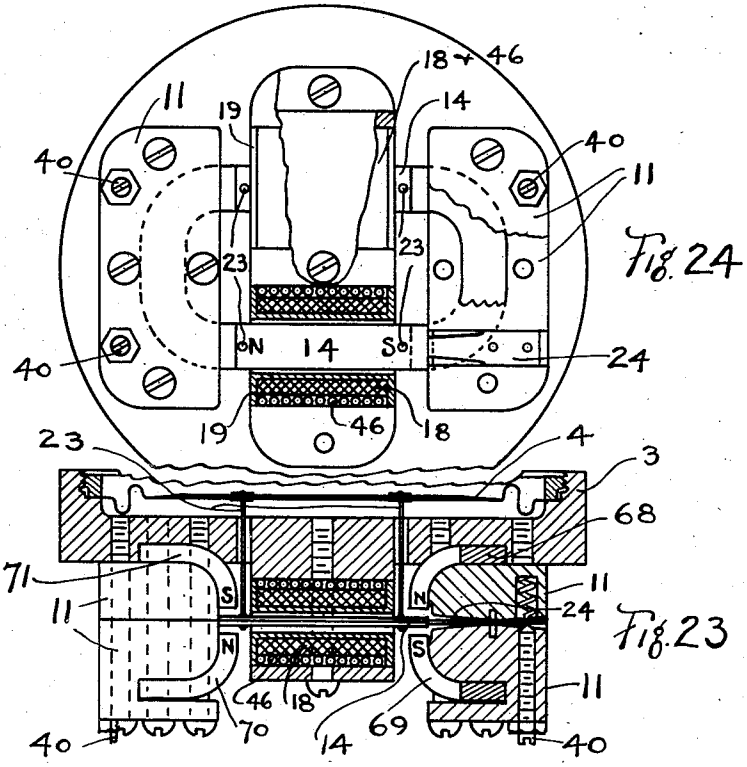


Fig. 24

Fig. 23

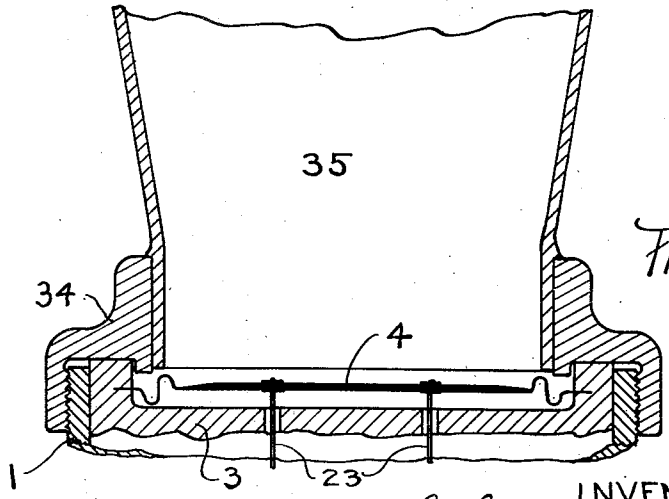


Fig. 25

INVENTOR.

John Hugh O'Neill

Feb. 16, 1926. 1,573,739

J. H. O'NEILL

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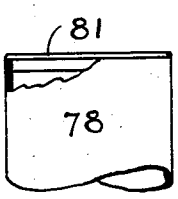


Fig. 31

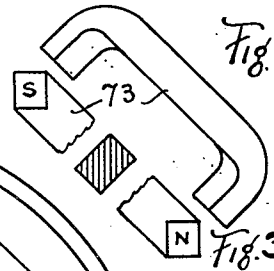


Fig. 29

Fig. 30

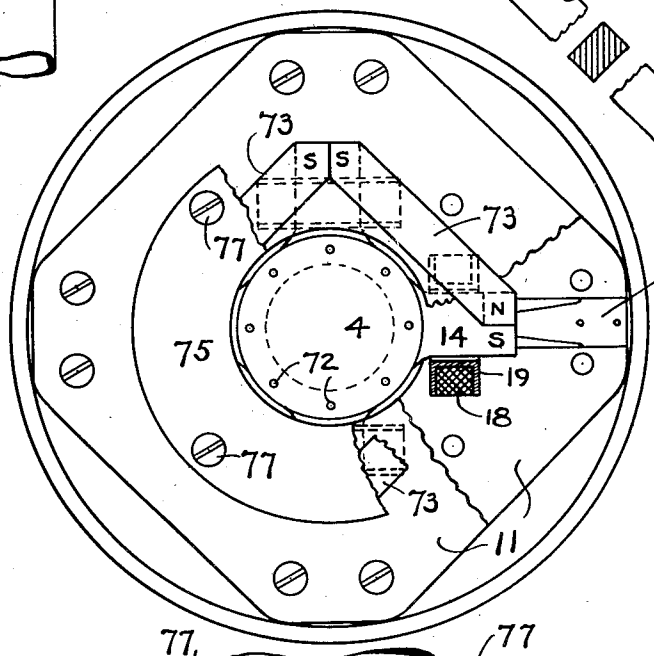


Fig. 26

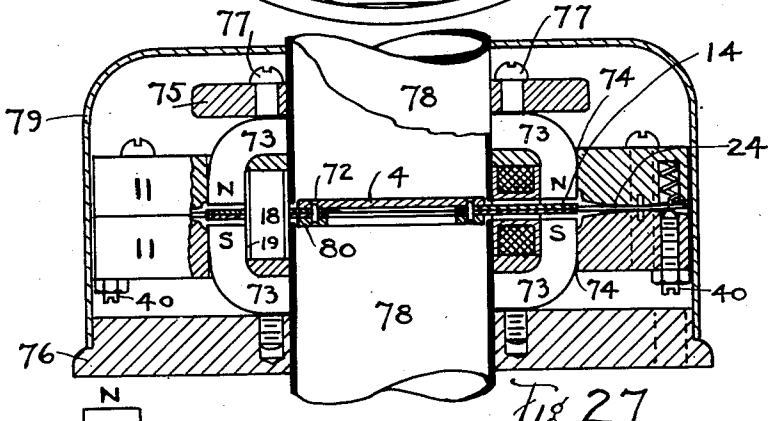


Fig. 27

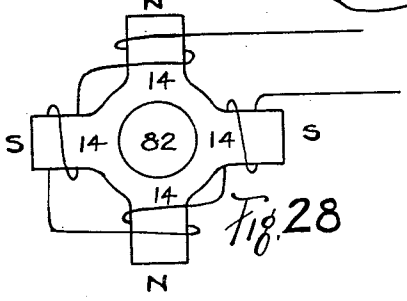


Fig. 28

INVENTOR.

John Hugh O'Neill

Feb. 16, 1926. 1,573,739

J. H. O'NEILL

TELEPHONIC DEVICE

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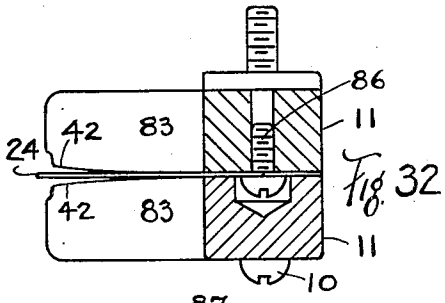


Fig. 32

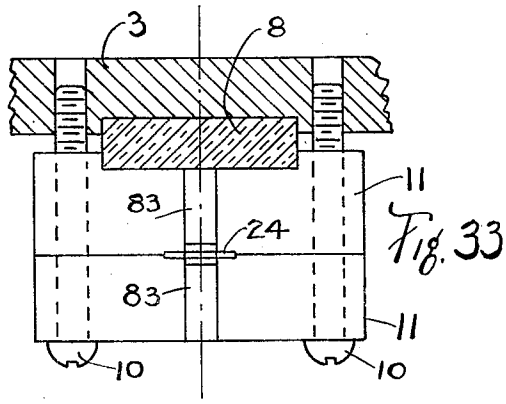


Fig. 33

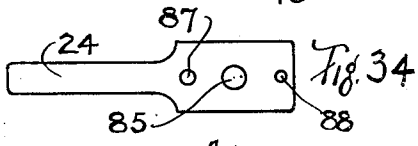


Fig. 34

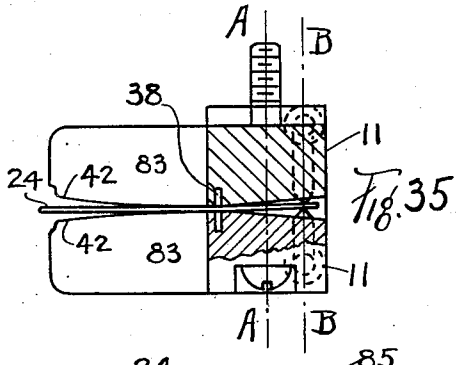


Fig. 35

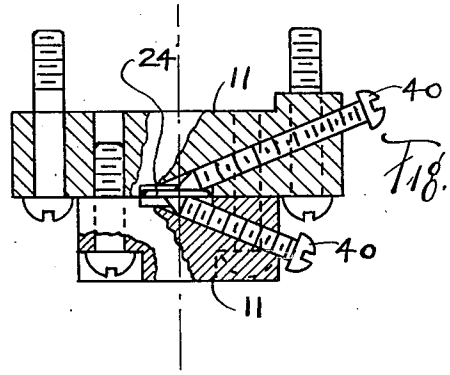


Fig. 36

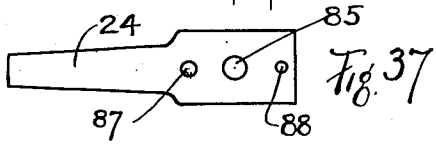


Fig. 37

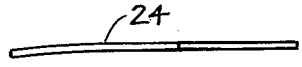


Fig. 38

INVENTOR.

John Hugh O'Neill

Patented Feb. 16, 1926. 1,573,739

UNITED STATES PATENT OFFICE.

JOHN HUGH O'NEILL, OF SPRINGFIELD, MISSOURI.

TELEPHONIC DEVICE.

Application filed October 2, 1922. Serial No. 591,895.

To all whom it may concern:

Be it known that I, JOHN HUGH O'NEILL, a citizen of the United States, and residing at Springfield, Missouri, have invented new Improvements in Telephonic Devices, of which the following is a specification.

This invention relates to telephonic apparatus, and more especially to the production and use of alternating currents or of undulations or pulsations in direct current by means of electro-magnetic apparatus. In this apparatus the vibrating armature is an electro-magnet core, one end or the whole of which is free to move laterally with one or both its poles between magnet poles which are of opposite polarity, said electro-magnet core being attached at its moving end or ends to a non-magnetic diaphragm which is vibrated or actuated by sound or which produces sound.

In a transmitter, the electro-magnet core moving between the magnet poles of opposed polarity has its own polarity reversibly established according to whether it is nearer one magnet pole or the other. Where constant polarity in the electro-magnet core is maintained, the density of its magnetic flux is altered as the core is nearer one magnet pole or the other. These changes in polarity or magnetic flux in the electro-magnet core produce an alternating current in the electro-magnet coil, or where a battery or other direct current is flowing through the electro-magnet coil, undulations are produced in this current. By either of these effects the sound-actuated vibrations of the diaphragm are translated into electrical current of characteristics which, when it is flowing through my receiving apparatus of similar construction will cause identical vibrations of an electro-magnet core and attached diaphragm with the very clear and powerful reproduction of the original sound.

The transmitters built on this principle are especially useful for clear telephonic transmission of sound and more particularly for use in radio broadcasting where great clearness and sharpness of the current characteristics are very important and where any desired amplification of the current is readily available with retention of clearness.

The receiving instruments are very sensitive and give a very clear, undistorted and loud production of sound as compared with other receivers operating on the same current strength.

My receivers may be operated with other types of transmitters as may my transmitters with other types of receivers.

By concentrating the moving electromagnetic functions in the vibrating electro-magnetic core, which is the moving armature, the armature may be constructed with consideration only to the electrical and magnetic functions and the diaphragm be constructed with consideration only to its sensitiveness to sound, and very much better results be obtained than where the diaphragm must cover both uses.

The object of this invention is to produce a highly efficient electro-magnetic system and apparatus for the telephonic transmission and reproduction of sound (including radio-telephonic transmission and reproduction).

It is known that a very sensitive arrangement by which small current changes effect large changes in flux density in an electro-magnet core with correspondingly strong pull to one or the other magnet pole is obtained by the use of an electro-magnet core of which one or both ends are free to move laterally and the one or both ends are located laterally equidistant between equal and opposite magnet poles, which electro-magnet core is adapted to move to and from the respective magnet poles as the polarity in the core is altered by a current in its surrounding coil. This known electro-magnetic principle is the basis of my invention. My invention consists in mechanical improvements in the application of this principle.

In order that the magneto-electric effects be at a maximum of efficiency it is necessary to provide against the formation of stray currents and against magnetic losses, for which purpose it is useful to laminate the electro-magnet core which vibrates and which will be referred to hereafter as the armature. It is also useful as far as is possible to support the magnetic elements and coils on dielectric material.

In order that temperature changes may effect the adjustments as little as possible the magnets and coils should be supported at their sides or short diameters, so that as short lengths as possible of materials of different expansive index be parallel.

Where a diaphragm is its own spring it is never possible to have correct tension, correct amplitude of motion and correct per-

meability to magnetic flux at the same time. So my invention provides for diaphragms of neutral tension or small tension and large amplitude of motion and of non-magnetic character, preferably with a stiff or rigid central portion, or the rim portion may be omitted entirely and the diaphragm be as a piston vibrating back and forth in a tube or as a reed in a slot formed in a passage through which air under pressure flows. In this way the effective area for sound production is at a maximum and the mechanical resistance to the amplitude of motion, which gives loudness, is at a minimum.

In order that the vibrating member or armature have the least leakage of flux density it is useful to have the end of the armature come directly between the magnet poles which are to pull and repulse it. In this way the path of the lines of magnetic force are most direct and effective in producing magneto-motive force and mechanical motion. In a telephonic device the armature vibration is not according to the natural period of the spring but according to the current changes in a receiver. In the past the springs have been long and of constant increments of pressure per unit of flexure, which has made it necessary to have very rigid spring systems where such close clearances are in use as in telephone construction. This has confined the amplitude of vibration to very narrow limits and with most loud speakers necessitated the interposition of a lever between the vibrating element and the diaphragm in order to obtain amplitude of vibration by mechanical means. In my improved construction the springs are short, preferably of non-magnetic material and connected directly to the armature leaving the diaphragm neutral. The springs are of varying effective length and so of varying increments of pressure per unit of distance in the motion of the armature. This varying strength of spring is to provide the longest spring for a very sensitive, easily moved armature in the middle position between magnet pole pieces so that weak impulses of small current changes would produce vibration with as little mechanical resistance to amplitude as possible. A further object attained by a varying spring pressure is that, as the armature is drawn nearer to one pole or the other, the strength of the magnetic pull increases and the strength of the spring also increases approximately to correspond instead of having the same strength at all positions, as in the old practice. Springs of constant increments of pressure made the telephone less sensitive to small current changes than is my improved device. This varying spring strength is provided by means of curved surfaces of suitable material against which the spring bears more and more as it is bent. These curved surfaces are so proportioned that, as the armature approaches very close to a pole of the magnet the spring becomes very short and stiff so that the spring becomes in effect an elastic but positive stop preventing the armature from striking the pole piece. The same effect may be produced by other means such as the use of a curved spring with a straight surface. With such reliable means of preventing the armature from striking the pole piece it is possible to provide for elastic springs, and large amplitude of vibration without danger of noise production. These springs are adjustable for the varying uses to which a transmitter or receiver may be put, such as when the armature is neutral when idle and occupies the middle position without stress as may be used in alternating current work; or the springs may be adjusted to bring the armature to the central position against the pull of a continuous polarity on the armature when idle as when an undulating current is used, or as is sometimes used with an alternating current. The use of a constant polarity is desirable because the most sensitive action is obtained when a constant polarity of about 10 kilogausses per square centimeter of section is maintained in an armature of laminated sheet iron or steel.

Because these springs are adjustable all other parts can be made non-adjustable and interchangeable, thus attaining moderate cost in manufacture and ruggedness in use.

All interior parts are assembled on a plate or disc lying in the plane parallel to the diaphragm. This plate or disc may be of any shape and supported in any position in any type of case or covering. The connection to the diaphragm may be by any suitable means such as a rigid wire or wires and lever. The diaphragm may be directly on the armature or the connection be by resting one end of a lever on the armature and the other end connected directly to the diaphragm such as is the case where a phonograph reproducer needle is rested in a depression in the end of a vertical armature for lateral cut reproducers, or on the end of a horizontal armature which vibrates up and down for hill and dale reproducers.

Other objects and features of the invention will be apparent from the following description.

This invention is illustrated in several embodiments in the accompanying drawings which are larger than actual size for the sake of clearness, wherein:

Fig. 1 is a sectional view of one arrangement of my invention in a head phone casing.

Fig. 2 is a view from below of the interior parts of Fig. 1.

Fig. 3 is a permanent magnet.

Fig. 4 shows an electro-magnet and elec-

tro-magnet coils for the armature and a wiring diagram.

Fig. 5 is a casing cap suitable for loud speaker use.

Fig. 6 shows an ordinary telephone receiver case.

Fig. 7 shows a constant polarity armature arrangement.

Fig. 8 is a bottom view of same.

Fig. 9 shows a constant polarity armature by electro-magnetism.

Fig. 10 is a bottom view of same.

Fig. 11 is a modification of the lever arrangement of Fig. 9.

Fig. 12 is a sectional elevation of my invention for use with a phonograph diaphragm.

Fig. 13 is a partial section in plan of Fig. 12 along lines A—A and B—B.

Fig. 14 is a sectional side view of Fig. 13 along line A—A.

Fig. 15 is a partial sectional plan view of my receiver with the whole armature adapted to vibrate.

Fig. 16 is a sectional elevation of same.

Fig. 17 is a partial section of Fig. 16 on line A—A.

Fig. 18 is an elevation of the right side of Fig. 16.

Fig. 19 is a permanent magnet.

Fig. 20 is an electro-magnet.

Fig. 21 is a partially sectional plan view of a receiver similar to Fig. 15 but with two magnets placed with opposed poles.

Fig. 22 is a partially sectioned elevation of same.

Fig. 23 is a sectional elevation of an assembly disc and parts with a different arrangement.

Fig. 24 is a partial sectional bottom view of Fig. 23.

Fig. 25 is a sectional view of a loud speaker cap and horn used with the arrangement shown in Fig. 23.

Fig. 26 is a partial plan view of a receiver having a four pole armature.

Fig. 27 is a sectional elevation of same.

Fig. 28 is a wiring diagram for armature coils of Figs. 26 and 27.

Figs. 29 and 30 are details of a permanent magnet.

Fig. 31 is a detail of a sound tube.

Fig. 32 is a side view of a spring and clamp.

Fig. 33 is a view of the free end of the spring in Fig. 32.

Fig. 34 is a plan view of the spring shown in Fig. 32.

Fig. 35 is a sectional view of a spring clamp.

Fig. 36 is a sectional view of Fig. 35 on lines A—A and B—B.

Figs. 37 and 38 are spring details.

In Fig. 1, 1 is a watch-case type of receiver casing. 2 is an ear-piece cover cap. 3 is a disc of suitable dielectric material which does not warp and is not affected by moisture such as bakelite or hard rubber and is adapted to be clamped in a casing such as 1 or 36 (Fig. 6) by a cover cap such as 2 or 34 (Fig. 5). On this disc or modification thereof is mounted all the interior parts of my telephonic devices, both as transmitters and as receivers. 4 is a diaphragm, preferably of non-magnetic material such as mica, bakelite, aluminium, etc. 5 is a rubber or other gasket. 6 is an annular nut for securing gasket 5 and diaphragm 4 in disc 3. 7 is a permanent magnet bar to which soft iron pole pieces 8 and 9 are secured by bolt 10. 11 is a spring holder which also forms a clamp for securing the magnet pole piece 8 against disc 3; this clamp and spring holder is shown more fully in Figs. 32 to 38. 12 is an aperture for electrical leads. 13 is a bar of soft iron for carrying a constant polarity to the vibrating armature 14. This polarizing bar may be omitted which will leave the vibrating armature 14 neutral on the center position. 15 is a support block to which the easily flexible fixed end of armature 14 is secured by the screw 16. Support block 15 also fits in the locating groove 17 in disc 3 which groove also locates pole piece 8 in line with the armature 14. Support block 15 also forms the distance piece which locates telephonic current coil 18 and hollow spool 19 centrally in line with the air gap between the pole pieces 8 and 9 of magnet 7. 20 is a clamp member which holds the coil 18 and spool 19 firmly against support block 15 by means of screws 21 which also go through holes in support block 15. This secures and locates block 15 accurately in the groove 17. Armature 14 is laminated, of two or more sheets of suitable soft iron or steel such as silicon iron. The laminations may be held together by cement or by rivets or any suitable means, as at 22. The armature is rigidly connected to the diaphragm 4 by the wire 23. Spring 24 controls the amplitude of motion of the armature and holds the free end of it in central position between magnet poles 8 and 9 when no telephonic current is passing in coil 18. Spring 24 is bent as shown in Fig. 38 when polarizing bar 13 is used so that the pull caused on the armature by the constant polarity will just cause the spring to come to the straight position with the armature central between poles 8 and 9. When bar 13 is not used, spring 24 is straight and holds the armature 14 in central position where the armature is neutral when idle. The operation is as follows: When an alternating current flows through coil 18 the polarity of armature 14 is either alternately reversed in accord with the direction of the current and the armature end in consequence attracted to the magnet pole of opposite polarity and repulsed by the pole

of the same polarity or the magnetic flux of a constant polarity is reduced or increased which causes the magnetic tension between the armature and pole pieces to alter and as the spring 24 is already under tension in holding the armature central such change of magnetic flux causes increase or decrease in the resistance to the spring and the consequent movement of the spring and of the armature and therefore of the diaphragm, in accord with the current. An undulating current has the same effect of changing the flux density of the armature with a constant polarity impressed upon it, and consequently the force of attraction and repulsion between the armature end and the pole pieces fluctuates thus producing motion as above in accord with the current.

In Fig. 2 is shown how the end of spring 24 fits in a slot 25 shown in dotted line in the end of armature 14. The spring 24 may also be rigidly attached to armature 14 by any suitable means such as riveting, welding, brazing or hard soldering. Springs 24 are preferably of non-magnetic material. 26 and 26 are binding posts for the telephonic current leads and 27 a post to which is tied the lead cord 28.

In Fig. 3, 29 is a one piece permanent magnet which may be used in place of permanent magnet 7 and pole pieces 8 and 9.

In Fig. 4 is shown an electro-magnet 30 which may be used in place of permanent magnets 7 or 29. 31 is the energizing coil for maintaining a constant polarity on the magnet 30. A polarizing coil 32 may be wound on spool 19 where desired for producing a constant polarity on armature 14 and bar 13 be omitted. Coils 31 and 32 may be energized from any suitable source of current as the battery 33.

In Fig. 5, 34 is a cap fitting case 1 which may be used where loud speaker effects are desired and any loud speaker horn be attached as by tube 35.

In Fig. 6 is shown a case 36 which is substituted for case 1 where my invention is to be used for ordinary telephone receiver use with a hook switch. The leads 28 are brought in through a hole in the end to binding posts 26 and 27 the same as when case 1 is used.

In Fig. 7 is shown a different arrangement of the same elements which is suitable where louder sound reproduction is desired than is available with arrangement shown in Fig. 1. The telephonic current coil 18 and armature 14 are shown between the pole pieces of magnet 7 in order to make room for a larger magnet. Constant polarity for armature 14 is provided by carrying its flexible end to one pole of the magnet 7 as at 37. The spring clamp 11 is made to allow adjustments in the tension of spring 24. The spring 24 is located endwise by pin 38 so that when the end 39 of spring 24 is moved up or down by the screw 40 the end of the spring engaging the armature 14 is moved in the opposite direction. Spring 41 holds end 39 firmly against adjusting screw 40. Curving surfaces 42 extending from clamps 11 are so shaped that the spring 24 as it is bent from central position progressively comes in contact with a surface nearer and nearer its free end thus shortening the effective length of the spring and correspondingly increasing the spring stiffness until, before the armature strikes a pole piece, the spring is stronger than the magnetic pull thus enabling the spring to be very sensitive and easily moved a central position and at the same time possessing stiffness and strength when needed near the limit of motion. Where there is a magnetic pull in one direction only as in Figs. 15 and 16 the springs 24 may be bent as in Fig. 38 and the surface 42 be straight. The curve of the spring is sufficient to hold the armature 24 at the proper distance from the ends of poles 8 and 9 against the pull of the permanent magnet 7 when no telephonic current is flowing. The wire 23 connecting the armature 14 and the diaphragm 4 passes through a hole 43 in pole piece 8.

Fig. 8 illustrates a bottom view of Fig. 7 in which the locating groove 17 is more clearly shown.

In Fig. 9 is shown a very compact arrangement suitable where very loud sound reproduction is desired as for loud speaker purposes. The coil spool 19 has one head thickened so as to provide support for cone bearing screws 44 shown in Fig. 10 which engage cone sockets 45 in the non-vibrating end of the armature and support it as a pivot. The telephonic current coil 18 may have a polarizing coil 46 wound over it so as to maintain constant polarity on the armature 14. The connecting wire 47 connects the armature 14 with lever 48 secured by cone bearings 49 at the fixed end. Lever 48 is provided with connecting wire 23 to the diaphragm 4. Slot 17 is of two depths to act as guides for the magnet pole 8 and spring clamp 11 and also to form room for the lever 48.

Fig. 10 illustrates a bottom view of Fig. 9 in which one of the lugs 50 is shown which extends into slot 17 from clamp 11. These lugs support cone bearing screws 51 and 51 which hold lever 48 in a pivot bearing.

In Fig. 11 is shown how the connecting wire 47 may be attached to a lug 52 extending from armature 14 and a greater mechanical amplification of motion be given to the diaphragm than is shown in Figs. 9 and 10 with the other parts remaining substantially the same. Lug 52 may preferably be of non-magnetic material.

In Figs. 12, 13 and 14 is shown an adapta-

tion of the magnet, coils and armature of Figs. 9 and 10 but placed vertically from the base 53 against a projection 54 which supports the parts as does disc 3 in previous figures. The projection 54 has integral with it one half of the spring clamps 11. Springs 24 and clamps 11 are in this case placed on both sides of the armature 14. Springs 24 are attached at the sides of the armature 14 between the pole pieces 8 and 9 of the magnet 7 so as to leave the end of the magnet unobstructed. Lug 55 projects from the vibrating end of armature 14 so as to come approximately flush with the casing 56. 57 is a small slot or depression provided in the end of lug 55 adapted to receive the point of a phonograph needle 58 which is held in the slot securely by gravity, the regular weight of the phonograph reproducer and phone arm being used. In this way my invention is particularly useful in the receiving of radio-telephonic currents and in translating such into sound with great clearness and loudness as the phonograph reproducer is used together with the tone arm and amplifying horn, making in combination with my invention an especially pleasing loud speaker. In Figs. 12 and 13 the device is shown as adapted to use with lateral cut phonograph reproducers with the base 53 standing in any convenient place on the phonograph board or on the turn table. In Fig. 14 is shown an adaptation by which the casing 56 in Fig. 12 is provided with legs 59 which steady the device when turned over 90°, in which position the vibrations of the armature can be transmitted to a hill and dale reproducer as illustrated by the Pathé needle 60 shown resting against the side of lug 55. A depression not shown aids in holding the needle 60 in place. Spring adjusting screws 40 need a different adjustment for use with each type of phonograph reproducer.

Figs. 15 to 20 show a different application of my invention by which the magnetic flux in both ends of the armature is used to produce vibration. In this case the whole magnetic armature vibrates. In these figures my invention is shown as adapted to produce sound by using the diaphragm of a phonograph as in Figs. 12, 13 and 14. In Fig. 15 the supporting projection 54 holds the magnet 7 in a horizontal position with the poles equidistant from the base 53. Clamp 61 holds magnet 7 in place in projection 54 which, in this case, may be a separate piece from the base 53. Armature 14 is also held horizontal with its ends opposite the magnet poles 8 and 9 by yoke 14′ which is pivoted at its base by the cone bearings 62 formed by cone bearing screws 63. Armature 14 is surrounded loosely by telephonic current coil 18 wound on spool 19 which is secured in place against projection 54 by combined coil clamp and spring clamp 11. The springs in this case are attached to each end of the armature as at 25 and the yoke 14′ carries at its upper extremity a hole or slot 57 adapted to receive a phonograph needle which is inserted through aperture 64 in the casing 56. Armature 14 is held against the magnetic pull caused by the constant polarity and magnetic flux induced by permanent magnet 7 by the springs 24 at each end. In this case springs 24 may be curved when the armature 14 is in idle position and only one surface, and that a straight one, be used to progressively alter the spring stiffness. Telephonic current flowing through coil 18 changes the magnetic flux in armature 14 which causes the armature to vibrate in accord with the current. Fig. 19 is another form of permanent magnet and Fig. 20 is an electro-magnet which may be used in place of magnet 7. In Figs. 21 and 22 is shown support member 54 and magnet 7 on both sides of the armature 14. The two magnets 7 are placed with poles of opposite polarity opposite. The magnets are thus placed so that the armature may be neutral between them when idle and also so that changes in polarity or flux density in the armature may produce a double magneto-motive force by the armature being simultaneously attracted by one magnet and repulsed by the other. One magnet may be weaker than the other as indicated by the smaller cross section of the pole pieces at 65 as compared with that of the pole pieces of the opposite magnet. This difference allows a constant polarity to be maintained in the armature which when of the right flux density aids in the sensitiveness of sound transmitting. or receiving. Tension springs 24 are held between the supports 54 and adjusted by screws 40 as in other forms of my invention. Yoke 14′ carries the armature 14 as in Fig. 17. Projections 54 are held together clamping the springs 24 and coil 18 by bolts 66 and 67.

In Figs. 23, 24 and 25 is shown the assembly of the items of my invention into an apparatus for the very sensitive transmitting and receiving of sound, in which the four ends of the two armatures vibrate between opposing poles of four magnets, the four armature ends being rigidly attached at equally spaced positions to a diaphragm with stiff central portion and a very flexible rim. In this way a large but very sensitive surface is available for receiving vibration from sound waves and translating them into electric current; or, vice versa, of translating alternating or undulating telephonic current into sound waves with great sensitiveness, clearness and loudness. Figs. 23 and 24 show the spring clamp members 11 which are also clamps for magnets 68, 69, 70, and 71. These magnets are arranged so that their poles are opposite across each end of

the armatures 14 and also of opposite poles across the length of the armatures 14. The two coils 18 for the telephonic current are so connected in parallel or series that both armatures are attracted toward or repelled from the diaphragm 4 by the magnets in unison. Where it is desired to use a still larger diaphragm surface a greater number of magnet pairs with their respective armatures may be used and the diaphragm be attached at many points to the vibrating armatures. Polarizing coils 46 may be wound over the telephonic current carrying coils 18 and connected so as to produce a constant polarity in the armatures 14 which will pull both in the same direction. The ends of armatures 14 are adjusted in the air gaps between the magnet pole pieces by the adjusting screws 40 bearing on the tension springs 24 as in previous figures. In Fig. 25 is shown a suitable opening of large diameter from the diaphragm 4 into the amplifier horn 35.

In Figs. 26 to 31 is shown a modification of my invention in which a plate of any suitable non-magnetic material such as wood, bakelite, aluminium, magnesium, or other light stiff material is fastened directly to the armature, the purpose being to avoid the lens effect which is produced when a flexible diaphragm is used in which the ampitude of motion or vibration is greatest in the center and grows less from the center to the rim with the result that the effective area which moves with sufficient amplitude to give the desired loudness is but a small proportion of the area of the diaphragm. In this modification the whole area of the diaphragm is substantially effective area and has the advantage that the sound is not distorted by bending of the diaphragm surface. The result is great sensitiveness and accuracy in operation of the apparatus both for transmitting and receiving sound by means of telephonic current. In Figs. 26 and 27, 4 is the diaphragm fastened by the rivets 72 to armature 14 which in this case may have the form of a cross of equal arms surrounded loosely by telephonic current coils 18 and spools 19. Springs 24 are arranged at the end of each arm of the armature and are of the same construction and function as previously described. Permanent magnets 73 are arranged in two groups with like poles together, one group on each side of the armature, and the groups arranged so that the magnet poles are opposite across the armature ends. The poles of magnet 73 are inserted through holes 74 in spring clamp members 11 which also clamp the telephonic current coils 18 and spools 19. Magnets 73 are held in place by clamp ring 75, base 76 and screws 77. Sound tubes 78 are also held by clamps 11 and by base 76 and casing 79. Diaphragm 4 and washer ring 80 fit with small clearance in tubes 78 and vibrate respectively into each tube as the armatures 14 vibrate, actuated by telephonic current when receiving, or when transmitting the diaphragm 4 is vibrated by sound waves entering one tube 78 and moves the armature 14 which induces current in coils 18. When it is desired to transmit sound a cap 81 in Fig. 31 may be used to close one tube and the other tube be left open with or without the use of an amplifying horn, or where it is desired to screen out a general noise and only transmit a special series of sounds one tube, 78, is pointed towards the source of the sound ond the other tube 78 left uncapped, under which condition the diaphragm is balanced against the general noise and will transmit only the special sound. When acting as a receiver, both tubes 78 may be left open with or without amplifying horns, or one may be closed with a cap 81, or both the tubes 78 may be brought together into one horn. Fig. 28 shows in diagram how the telephonic current coils are connected so that like poles are opposite across the armature. Armature 14 is built up of thin plates, preferably with a hole 82 in the center so as to make the structure as light in weight as possible. Air under constant pressure may be supplied to the space enclosed by casing 79 and base 76, said air flowing through the clearance spaces between the tubes 78 and the diaphragm 4 and washer 80, said air being pulsated by the diaphragm which causes an increase in the loudness of sound reproduction over that when no current of air flows.

In Figs. 32 to 38 are shown details of the tension springs 24 and their clamps 11 and adjusting screws 40. Figs. 32 and 33 show a non-adjustable spring and clamp suitable to some uses as in the assembly shown in Figs. 1 and 2. 83 are projections from the body of the clamp pieces 11 which have curved surfaces 42 adapted to shorten the effective length of the tension spring 24. Fig. 34 shows detail of a spring suitable to use with the clamp shown in Figs. 32 and 33. Hole 85 in spring 24 is for screw 86. Figs. 35 and 36 show a form of clamp 11 provided with screws 40 for adjusting the tension on spring 24. Pin 38 fits in hole 87 in spring 24 and locates it in clamp 11. This form of clamp is also useful in such assemblies as shown in Figs. 1 and 2. In Fig. 37 is shown a tapered spring which may be used in place of the type shown in Fig. 34, and hole 88 may be used as a bearing for holding spring 41 as is shown in other assemblies. Fig. 38 shows how spring 24 may be bent so that when its tension is adjusted as is needed to hold against a constant polarity the spring 24 is straight when the end of the armature 14 is central in the air gap between the pole

pieces of opposed polarity. The spring is then central between curved surfaces 42. Curved spring 24 in Fig. 38 may be used with a backing on its convex side of a straight surface, and the result of progressively shortening the effective length of the spring be attained as the spring is bent closer to the straight surface. Any other method of spring construction may be used which gives increasing increments of pressure per distance traveled away from the central or idle position.

Many combinations of the improved constructions shown may be made and all come within the scope of my invention.

I claim:

1. In an electro-magnetic telephonic device, a magnet with poles closely approaching and opposite each other forming an air gap, a laminated electro-magnet core with the first end flexibly supported in central position in said air gap by a spring, the second end elastically secured leaving the first end free to vibrate between said opposed magnet poles, a spool loosely surrounding said core, and an electro-magnet coil wound on said spool, connections for periodically variable electrical current to said coil, and a diaphragm rigidly connected to the vibrating end of said core by a connecting member.

2. In an electro-magnetic telephonic device, a disc of dielectric material enclosed in a casing and clamped therein by a cap, a diaphragm carried in a depression in the first side of said disc, a connecting member extending from said diaphragm through a hole in said disc to a vibrating armature on the second side of said disc, an electro-magnetic structure secured to the second side of said disc including a magnet with poles closely approaching and opposite each other forming an air gap, an inflexible armature the first end of which is flexibly supported centrally in said air gap by a spring, the second end of which is secured against vibration but the first end is allowed to vibrate freely between said opposed poles, an electro-magnet coil loosely surrounding said armature, and connections for periodically variable electrical current to said coil.

3. In an electro-magnetic telephonic device, a disc of dielectric material enclosed in a casing and clamped therein by a cap, a diaphragm carried in a depression in the first side of said disc, a connecting member extending from said diaphragm through a hole in said disc to a vibrating armature on the second side of said disc, an electro-magnetic structure secured to the said second side of the disc including a magnet with poles closely approaching and opposite each other forming an air gap, a laminated armature the first end of which is flexibly supported centrally in said air gap by a spring, means of adjusting the tension of said spring, curved surfaces gradually reducing the effective length of said spring as the spring bends each way from center, the second end of said armature secured against vibration but allowing the first end to vibrate freely between said opposed poles, an electro-magnet coil loosely surrounding said armature, means for maintaining a constant polarity on said armature, and means for producing a periodically variable magnetic flux in said armature.

4. In an electro-magnetic telephonic device, an inflexible electro-magnet core armature with one end free to vibrate, the vibrating end supported by a flat spring, said spring straight in central position, and curved surfaces cooperating to progressively shorten the effective spring length as the spring is bent from the central position.

JOHN HUGH O'NEILL.