Dec. 25, 1945. A. S. HOWELL 2,391,627

TRANSDUCER

Filed Jan. 19, 1944 2 Sheets-Sheet 1

Fig. 1

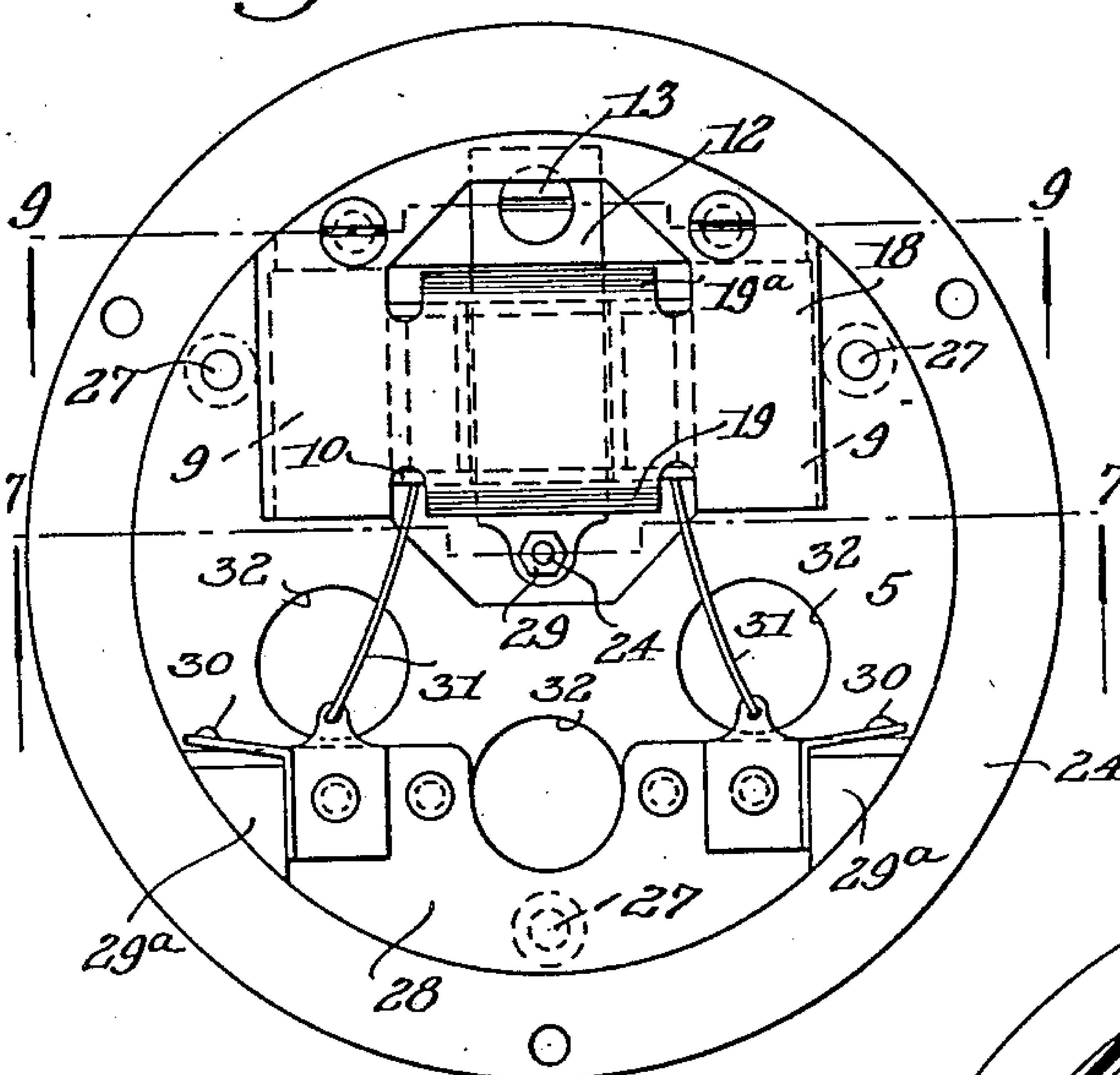

Fig. 6

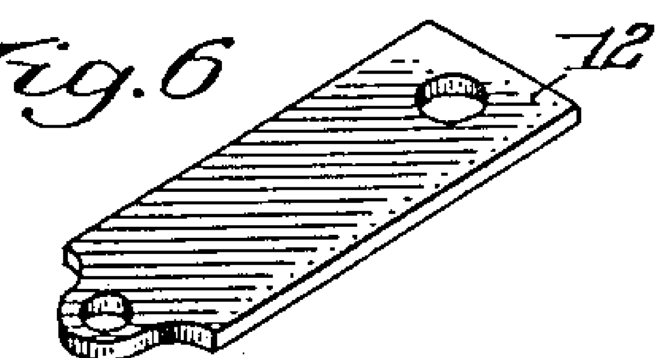

Fig. 5

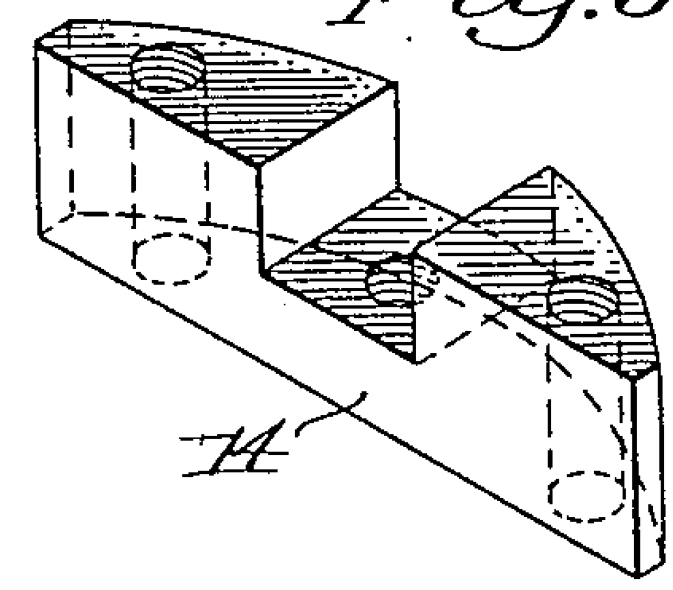

Fig. 2

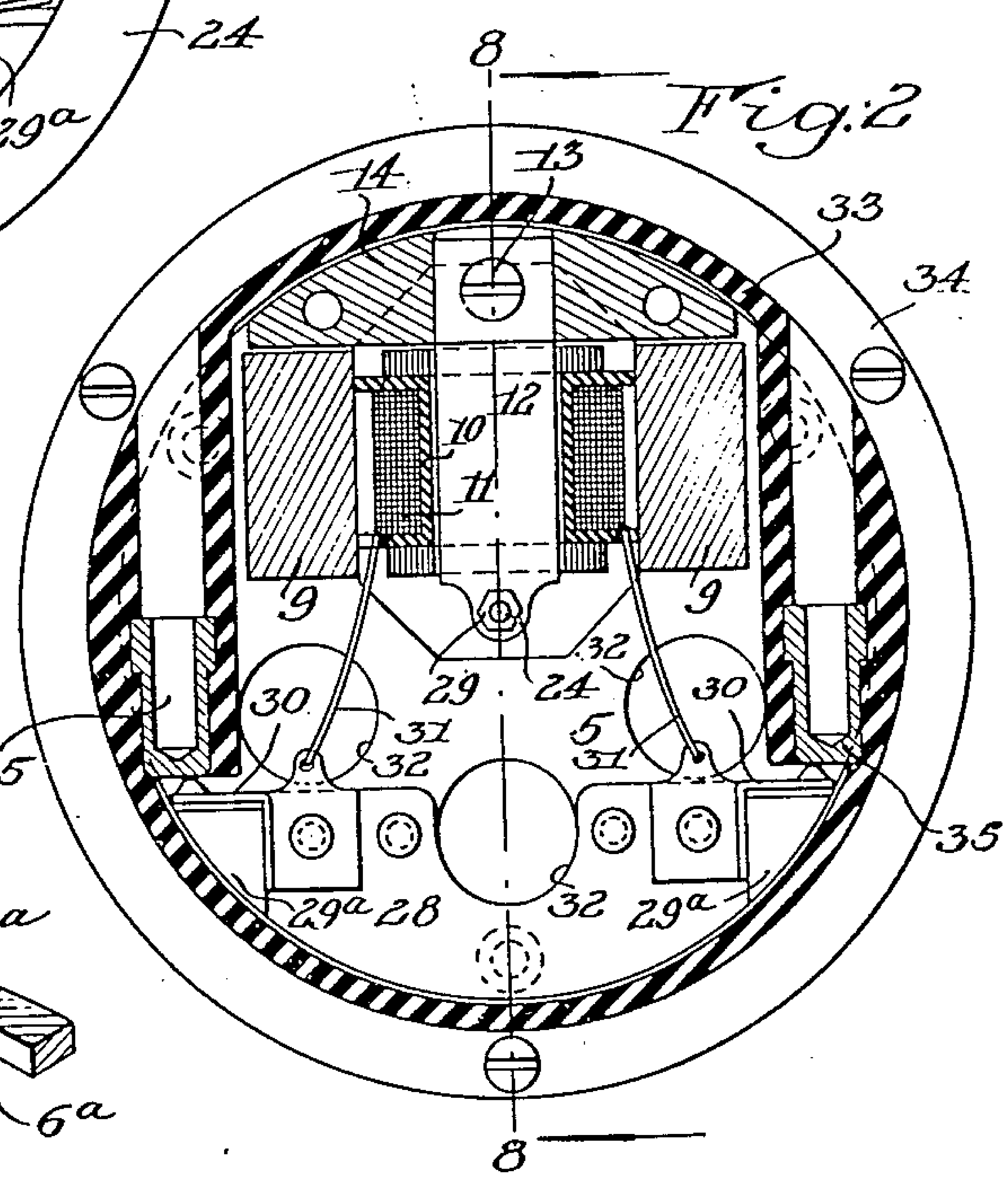

Fig. 3

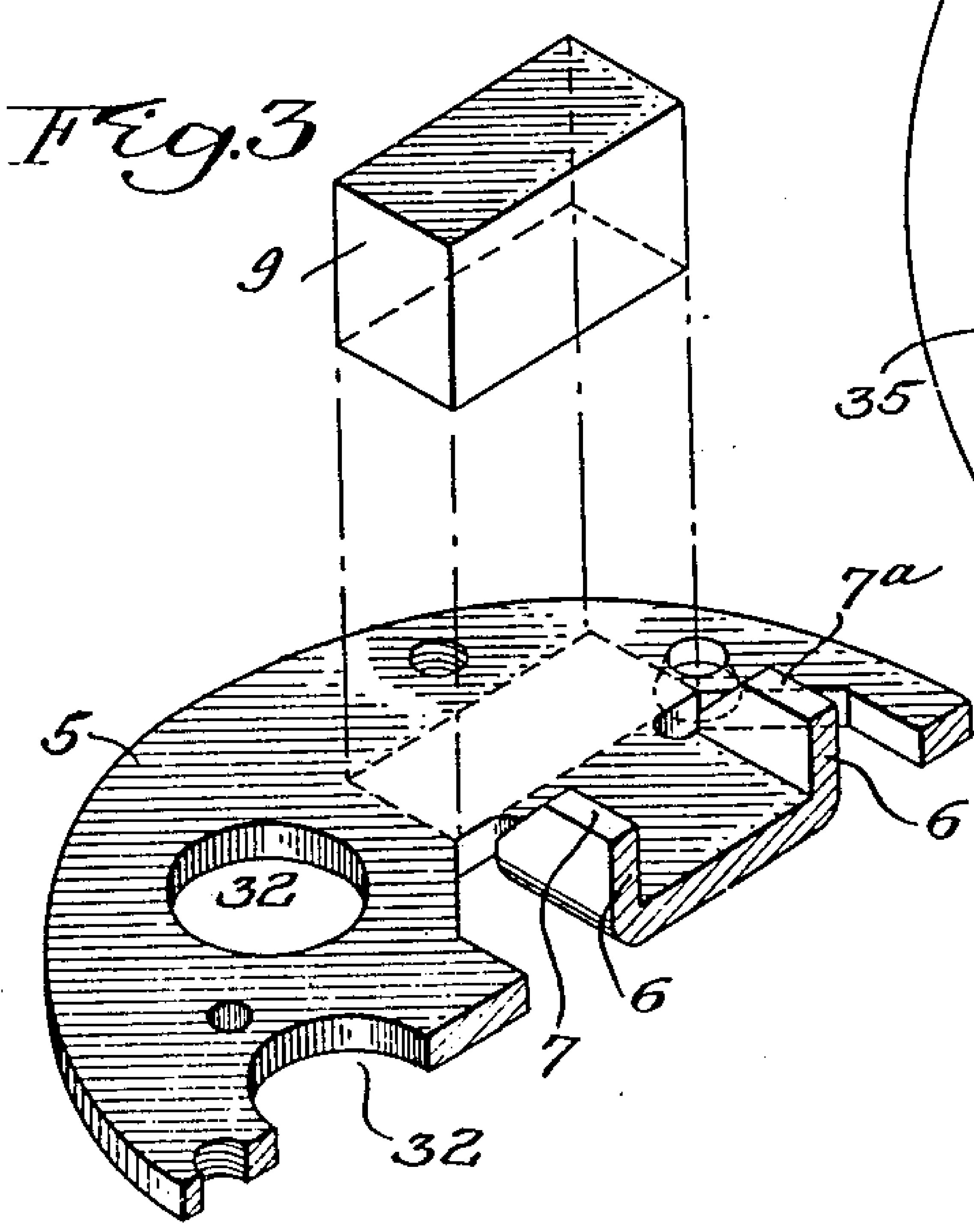

Fig. 4

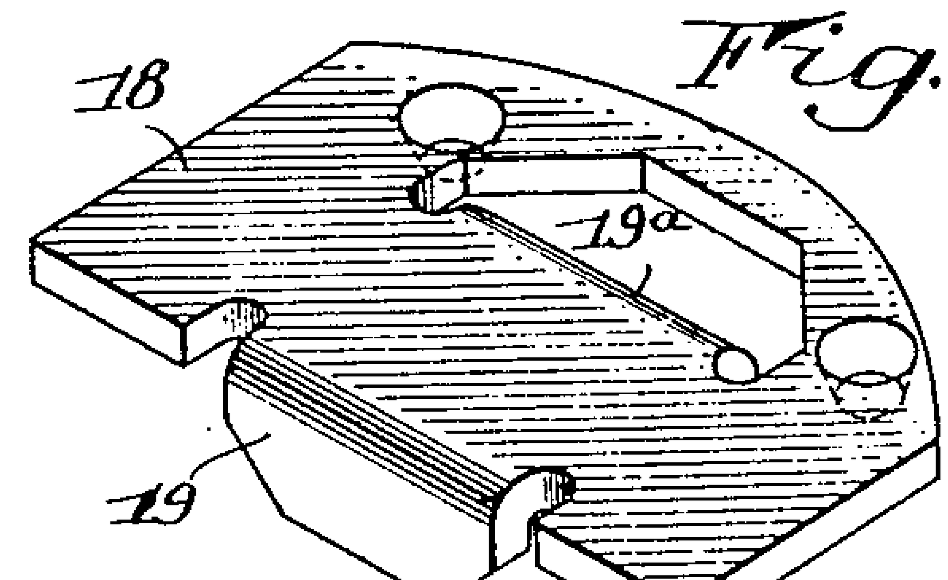

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Fig. 7

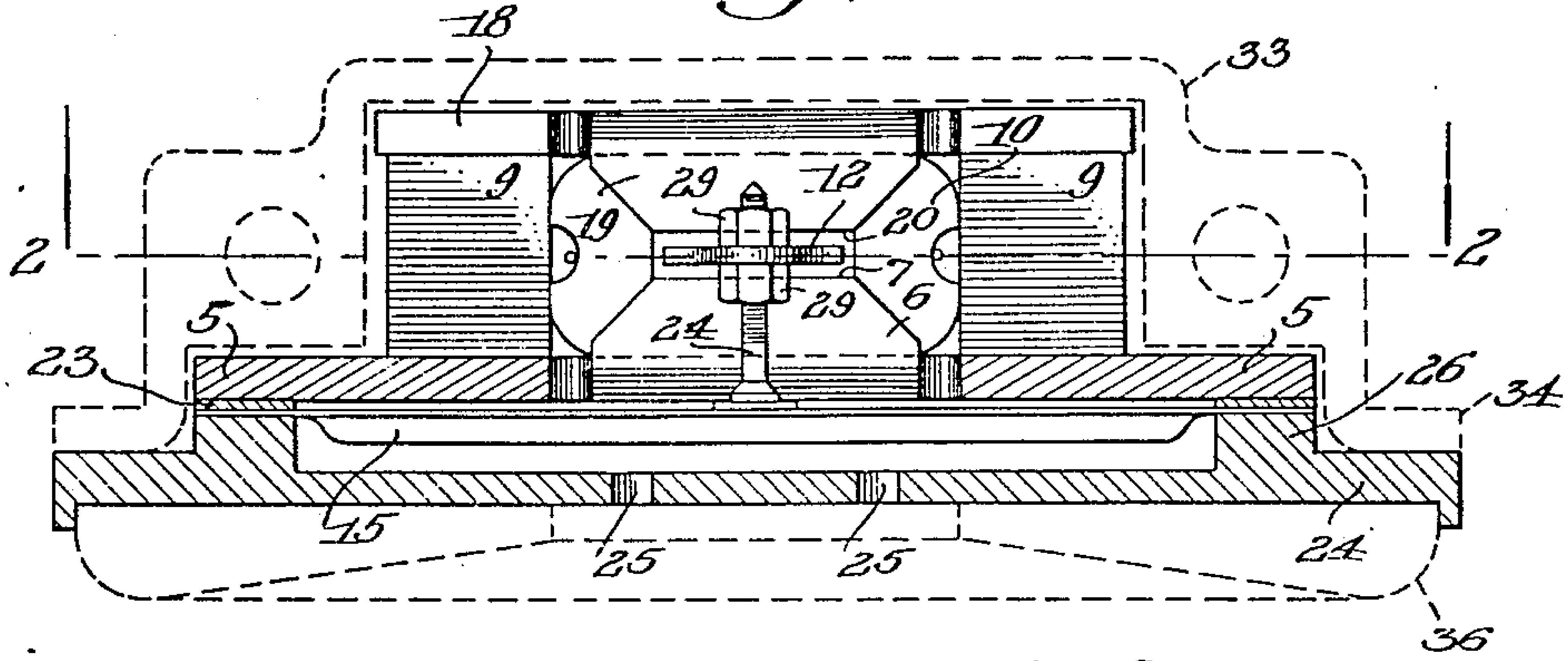


Fig. 8

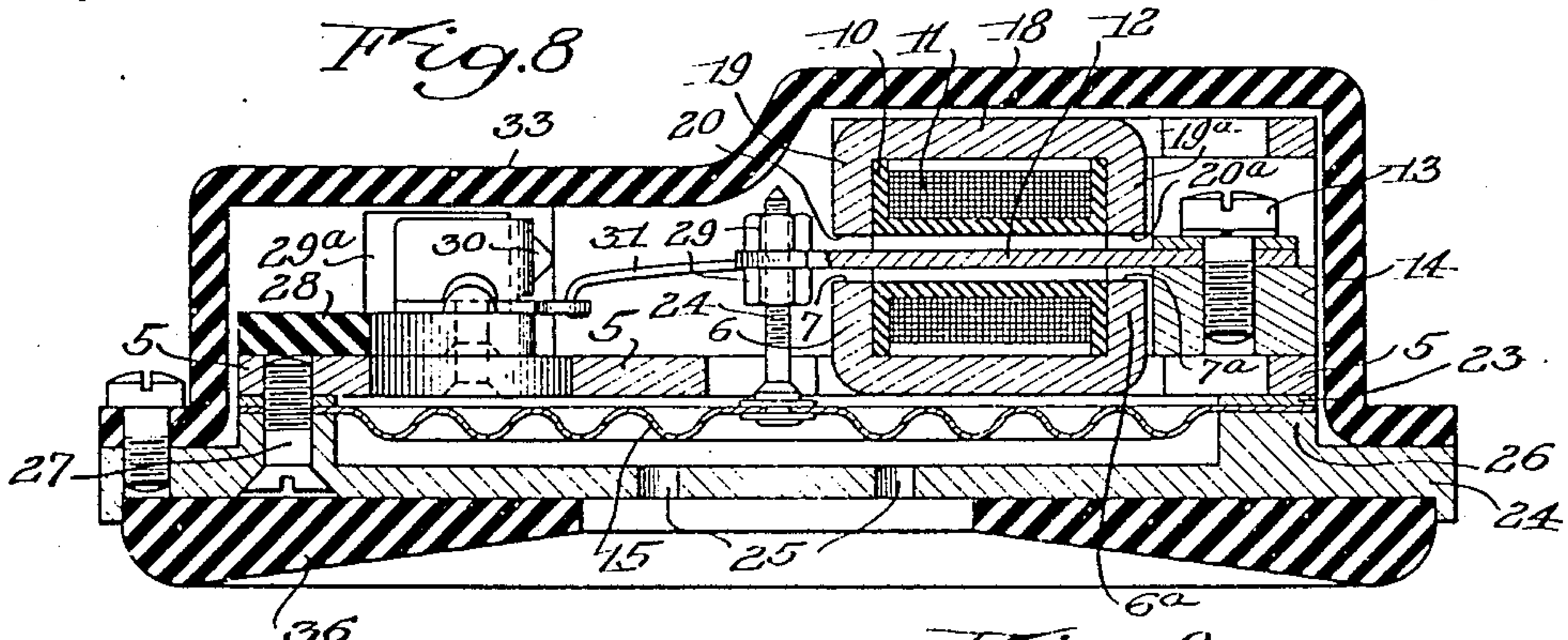


Fig. 9

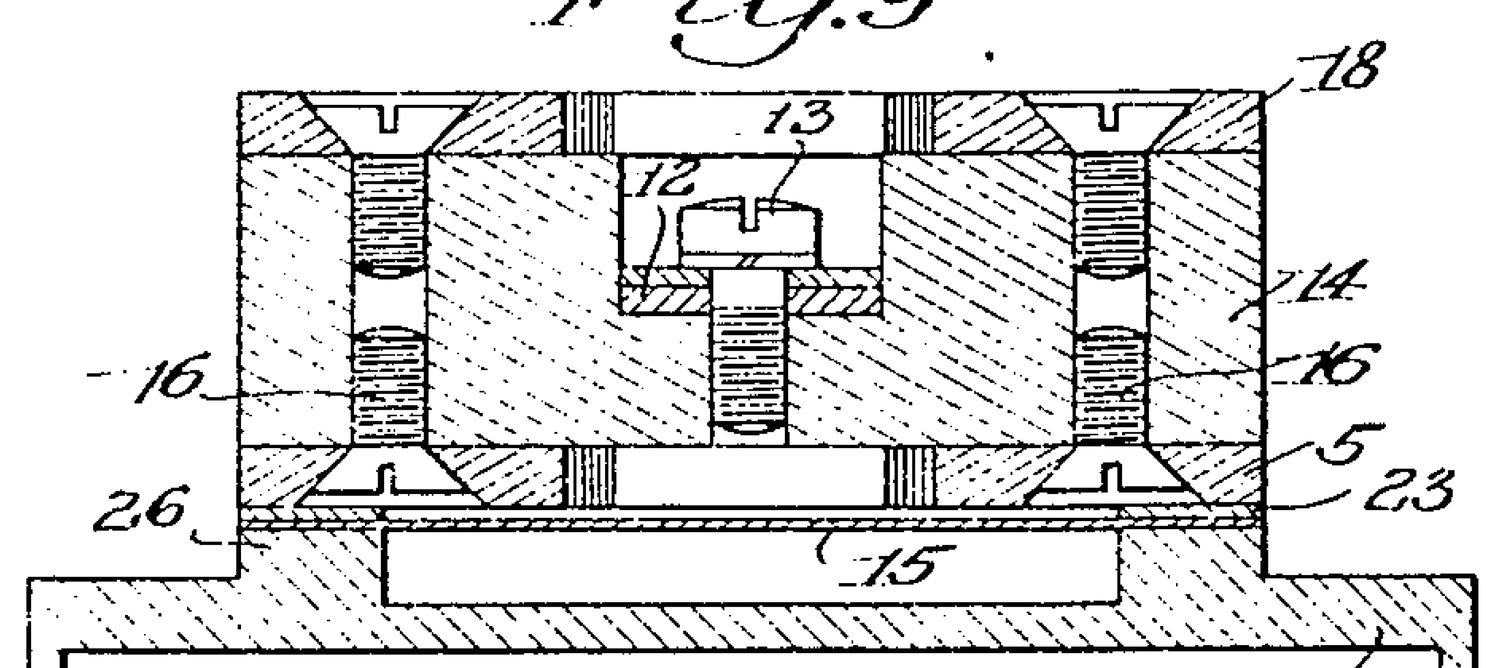


Fig. 10

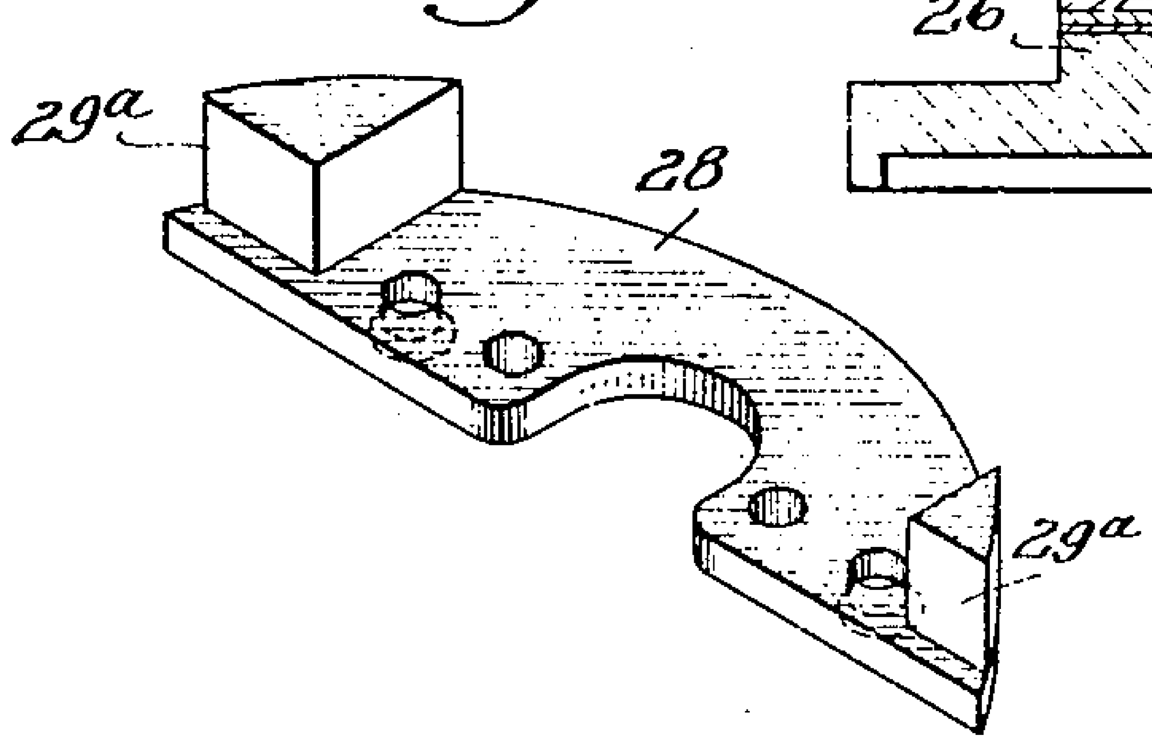
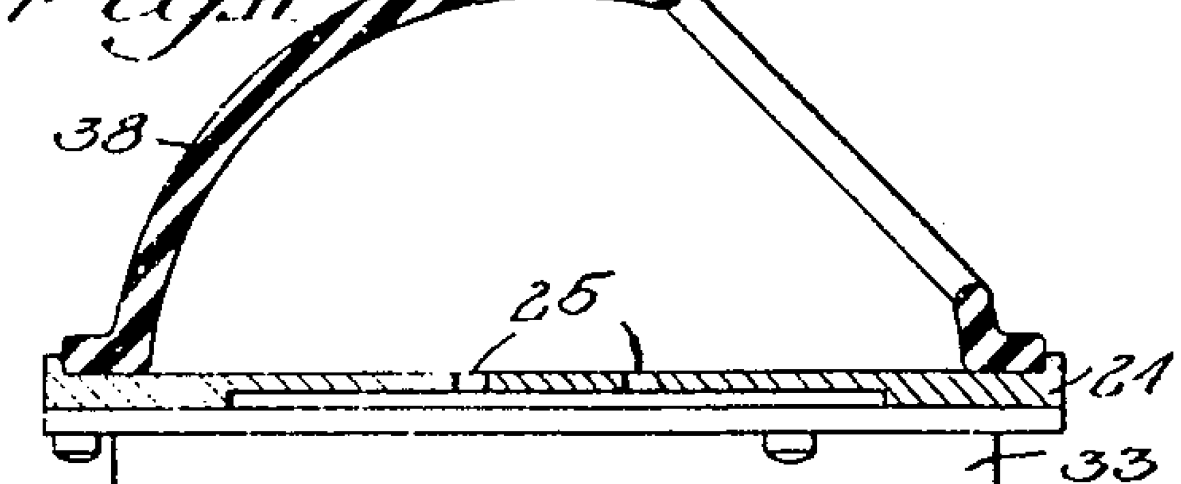


Fig. 11



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Patented Dec. 25, 1945 2,391,627

UNITED STATES PATENT OFFICE

2,391,627

TRANSDUCER

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Application January 19, 1944, Serial No. 519,073

9 Claims. (Cl. 179—119)

This invention relates to an acoustical transducer more commonly referred to as a sound-powered or self-energized telephone.

A telephone of this type is adapted to serve either as a transmitter or receiver thus when two of such telephones have their respective terminals connected by suitable conductors in an electrical circuit, the arrangement comprises a complete telephone system which operates without an external source of current or power other than the sound from the speaker's voice. Such a sound-powered telephone is especially useful for military purposes and therefore it must be small in size so that it can be used in conjunction with a helmet and its construction must be such that it will not be damaged when overloaded by loud blasts.

The main feature of the invention relates to a telephone construction of the mentioned type wherein a minimum number of parts are required and wherein the construction is such that the telephone will be found rugged and reliable for long periods of service, even with a greatly reduced thickness of the transducer.

Other features of the invention will appear from the detailed description and claims when taken with the drawings in which:

Fig. 1 is a plan view of the telephone with the casing thereof removed;

Fig. 2 is a section through the telephone taken substantially on the line 2—2 of Fig. 7;

Fig. 3 is an exploded perspective view of the frame plate and one permanent magnet, a portion of the frame plate being broken away;

Fig. 4 is a perspective view of the upper pole member;

Fig. 5 is a perspective view of the supporting block on which the reed armature is mounted;

Fig. 6 is a perspective view of the reed armature;

Fig. 7 is a section through the telephone taken on line 7—7 of Fig. 1;

Fig. 8 is a section through the telephone taken on the line 8—8 of Fig. 2;

Fig. 9 is a section through the telephone taken substantially on the line 9—9 of Fig. 1;

Fig. 10 is a perspective view of a terminal strip; and

Fig. 11 is a fragmentary showing of a transmitter mouth piece.

In the drawings, the numeral 5 designates a circular frame plate, preferably made of magnetic steel of high permeability. This frame has punched therefrom, a pair of parts 6 and 6*a* which are bent up in spaced parallel relation to form a lower pole piece, each of these parts having its upper corners cut away so that it tapers to the pole faces 7, 7*a* (Fig. 7). The frame has secured to its upper surface (Figs. 3 and 7), at each end of the parts 6, 6*a* of the pole piece, a rectangular permanent magnet 9, constituting a pair of magnets preferably made of Alnico V which serve as flux sources. These magnets are conveniently secured to the frame plate, in the parallel position shown, by means of an adhesive such as a phenolic resin.

The rectangular space (Fig. 2) between the magnets 9, 9 on the one hand and parts 6, 6*a* of the pole piece on the other, is just sufficient to receive the hollow flattened spool 10, of insulating material on which there is wound a coil 11, preferably of double enamel wire #39. It will be noted that the ends of the spool 10, engage the pole parts 6, 6*a* respectively and that the pole faces 7, 7*a* of these parts are substantially flush (Fig. 8) with the lower surface of the central opening through the spool. This opening through the spool is of such dimensions that a flexible reed-type armature 12 of magnetic material, can vibrate freely therein. One end of this armature is clamped as by a screw 13, in the recessed portion of a segment-shaped supporting block 14 while the other end of the armature projects beyond the pole piece for connection to a diaphragm 15 to be described. The block 14, which is made of non-magnetic material, such as brass, is fastened by screws 16, 16 (Fig. 9) to the frame plate 5, with the recess in the block communicating with the opening through the spool. It will thus be seen that the plate 5 serves a triple purpose. It forms one pole piece, it also serves as the frame or base of the device and it further serves as a magnet contact and as a magnetic connector between the magnets and the pole piece region of the frame.

The opposite pole member 18 (Fig. 4) is formed with pole parts 19, 19*a* in the same manner as the frame 5, except that only sufficient material is allowed outside of the pole piece region to provide for its suitable mechanical mounting and to provide a suitable area of contact with the magnets 9. This pole member is fastened by suitable screws, to the upper surface of the supporting block 14 in contact with the upper surface of the magnets 9, 9 and with the pole faces 20 and 20*a* (Fig. 8) of the parts 19, 19*a* in spaced registry with pole faces 7 and 7*a*. It will be noted that the pole faces 20, 20*a* are substantially flush with the upper inside surface of the opening through spool 11. The pole member 18 then fulfills a dual purpose since it provides one pole piece region and it serves as a magnetic contact and magnetic connector between the magnets 9 and this region.

The lower surface of the frame plate 5 (Fig. 8) serves as a support for a circular corrugated diaphragm 15. This diaphragm, which has approximately the same diameter as the frame 5, has its border clamped to the border of the frame with a thin washer 23 of non-magnetic material, such as aluminum, mounted between these clamped parts. The means for clamping the diaphragm to the frame comprises a circular cover plate 24 having central openings 25 for the passage of sound and a concentric annular shoulder 26 projecting from the border of one face thereof. Screws 27 passing through registering openings in the shoulder 26 on the plate 24 and in the diaphragm 15, are threaded into tapped holes in the frame to draw the mentioned parts together. The center of the diaphragm is connected to the free end of the reed armature 12 by a connecting rod 24 which passes through the opening in the frame 5 resulting from the upward forming of the part 6. In the arrangement shown, the lower end of the connecting rod is secured to the diaphragm 15 while the upper threaded portion of the rod passes through a hole in the free end of the armature 12. The nuts 29 (Fig. 8) threaded on the rod, engage each surface of the armature to serve as a convenient fastening means which also functions to permit adjustment of the effective length of the rod.

It is an important requirement of this device that it have the ability to withstand blasting sound pressures, without damage. The corrugations in the thin diaphragm 15 are an aid in strengthening it. However, this is often insufficient and auxiliary means of protection must be provided. By reducing the clearance between the diaphragm 15 and the frame 5, the travel of the diaphragm in one direction is limited by the frame except for such small unsupported areas that result from necessary openings in the frame. The cavity or space between the diaphragm 15, and the frame 5 functions acoustically as if it were not separated by the frame 5, from the large space about the armature and the pole pieces. This condition prevails because these spaces communicate through large openings 32 in the frame. Hence, the diaphragm to frame separation may be reduced to the point where undesirable viscosity effects, due to the frictional flow of air between the ridges of the diaphragm and the underside of the frame, adversely influence the response. On the other hand, the space or cavity between the diaphragm and the cover plate 24, forms the entire effective acoustic compliance in front of the diaphragm. Therefore, in order to obtain the maximum effective reduction in the separation between the surfaces of the frame 5 and the cover plate 24 which define the total diaphragm cavity, the diaphragm to frame separation is reduced either to the point where undesirable viscosity effects start to appear or until the travel of the diaphragm is unduly restricted. The diaphragm to cover plate separation is then reduced until acoustic limitations partly involving the size and proximity of the cover plate holes 25, become productive of a loss in response. By placing the corrugations entirely on the cover plate side of the plane of the border of the diaphragm, the frame to diaphragm clearance may be conveniently established by means of the spacing washer 23 and said clearance will then be equal to the thickness of the spacing washer. If viscosity effects are neglected, the spacing may be reduced to a value only sufficient to insure that the normal travel of the armature will not be unduly restricted by the diaphragm hitting the frame, considering the practical dimensional tolerances of the parts involved.

The response curve (not shown) of the unit described has a first resonance peak at approximately 1350 cycles per second and a second resonance peak at approximately 2000 cycles per second.

The first resonance peak is primarily determined by the constants of the moving diaphragm-armature system and the stiffness of the total cavity behind the surface of the diaphragm adjacent the frame.

The second resonance peak is largely determined by the size and number of the holes 25 in the cover plate 24 together with the cavity between the cover plate and the diaphragm 15. It will be understood, however, that the resonant effects due to conditions at one side of the diaphragm tend to modify the resonant effects due to conditions at the other side thereof.

On the upper surface of the frame 5 (Fig. 8), there is mounted a terminal segment or strip 28 of insulating material, having spaced upstanding lugs 29a. These lugs 29a serve as lateral supports for the metal contactors 30 to which the conductors 31, 31 from the respective ends of the coil 11, are soldered.

The parts mounted on the upper side of the frame (Fig. 2) are enclosed in a cup-like casing 33 of molded insulating material having at its rim, a projecting peripheral flange 34. This flange is fastened to the border of cover plate 24 which projects beyond the edge of the frame 5. This casing has molded therein, metal inserts or jack contacts 35. These contacts which respectively engage the contactors 30, are adapted to receive plug contacts (not shown) in which the conductors of the telephone circuit (likewise not shown) terminate. It will be understood that the conductors can be soldered directly to the jack contacts 35 in which case, the terminal segment 28 and the contactors 30, mounted thereon, will be omitted.

When the device is to be used as a receiver, an annular ear cap 36 is adhesively fastened to the exposed surface of the cover plate as shown in Fig. 8. On the other hand, when the device is to be used as a transmitter the ear cap will be replaced by a conventional mouthpiece 38 (Fig. 11).

What I claim is:

1. In a transducer unit, a frame of ferromagnetic material having spaced upstanding pole pieces struck up therefrom, a pair of permanent magnets of high coercive material contacting said frame in the region of said pole pieces, a top plate of ferromagnetic material, spaced pole pieces on said plate, means for mounting said plate in fixed relation to said frame to contact said magnets, with the free ends of the pole pieces thereon extending toward the free ends of the pole pieces on said frame, a coil mounted between said plate and said frame adjacent said pole pieces, a reed of ferromagnetic material having one end fixedly mounted and having its other end portion extending into the field of influence of said pole pieces as well as of said coil, and means including a diaphragm connected to

the last mentioned end portion of said reed whereby said unit can translate sound into electrical energy and vice versa.

2. In a transducer unit, a frame of ferromagnetic material, spaced upstanding pole pieces on said frame, a pair of permanent magnets of high coercive material contacting said frame in the region of said pole pieces, a top plate of ferromagnetic material having spaced pole pieces struck up therefrom, means for mounting said plate in fixed relation to said frame to contact said magnets, with the free ends of the pole pieces thereon extending toward the free ends of the pole pieces on said frame, a hollow coil mounted between said plate and said frame with the open ends of said coil terminating adjacent said pole pieces, a reed of ferromagnetic material fixedly mounted at one end to extend through said coil and having its other end portion extending into the field of influence of said pole pieces, and means including a diaphragm connected to the last mentioned end portion of said reed, whereby said unit can translate sound into electrical energy and vice versa.

3. In a transducer unit, a frame of ferromagnetic material, spaced upstanding pole pieces on said frame, a pair of permanent magnets of high coercive material contacting said frame in the region of said pole pieces, a top plate of ferromagnetic material, spaced pole pieces on said plate, means for mounting said plate in fixed relation to the front side of said frame to contact said magnets, with the free ends of said pole pieces thereon extending toward the free ends of pole pieces on said frame, a coil mounted between said plate and said frame adjacent said pole pieces, a reed of ferromagnetic material fixedly mounted at one end and having its other end portion extending into the field of influence of said pole pieces as well as of said coil, means including a diaphragm secured at one surface of its margin to the reverse side of said frame and having its central portion connected to the last mentioned end portion of said reed whereby said unit can translate sound into electrical energy and vice versa, and a cover plate secured to the other marginal surface of the diaphragm to provide a cavity, said cover plate having holes therein, said holes and said cavity serving to cause resonant effects in the range of two thousand cycles.

4. In a transducer unit, a frame of ferromagnetic material, spaced upstanding pole pieces on said frame, a pair of permanent magnets of high coercive material contacting said frame in the region of said pole pieces, a top plate of ferromagnetic material, spaced pole pieces on said plate, means for mounting said plate in fixed relation to the front side of said frame to contact said magnets, with the free ends of the pole pieces thereon extending toward the free ends of the pole pieces on said frame, a coil mounted between said plate and said frame in the region of said pole pieces, a reed of ferromagnetic material fixedly mounted at one end and having its other end portion extending into the field of influence of said pole pieces as well as of said coil, means including a concentrically corrugated diaphragm secured at one marginal surface to the reverse side of said frame and having its central portion connected to the last mentioned end portion of said reed whereby said unit can translate sound into electrical energy and vice versa, and a cover plate secured to the other marginal surface of the diaphragm and defining a cavity with said diaphragm, said cover plate having several holes therethrough serving with said cavity to effect a predetermined resonance peak in the frequency response of said unit.

5. In a transducer unit, a frame of ferromagnetic material, spaced upstanding pole pieces on said frame, a pair of permanent magnets of high coercive material contacting said frame in the region of said pole pieces, a top plate of ferromagnetic material, spaced pole pieces on said plate, means for mounting said plate in fixed relation to said frame to contact said magnets, with the free ends of pole pieces thereon extending toward the free ends of the pole pieces on said frame, a coil mounted between said plate and said frame, a reed of ferromagnetic material fixedly mounted at one end and having its other end portion extending into the field of influence of said pole pieces as well as of said coil, and means including a concentrically corrugated diaphragm secured at its margin to the reverse side of said frame and having its central portion connected to the last mentioned end portion of said reed whereby said unit can translate sound into electrical energy and vice versa, all of the corrugations in said diaphragm being positioned with respect to said frame beyond a plane defined by the margin of said diaphragm whereby limited spacing is possible between the frame and the diaphragm.

6. In a transducer unit, a frame of ferromagnetic material having spaced pole pieces struck up therefrom, a top plate of ferromagnetic material secured in spaced relation to the front side of said frame and having spaced pole pieces struck therefrom to project in the direction of the free ends of said first mentioned pole pieces, the spacing between the pole pieces on said plate being substantially equal to the spacing between the pole pieces on said frame, a pair of permanent magnets of high coercive material, secured to said frame and in contact with said plate in a position where each magnet substantially spans the space between the pole pieces thereon, a hollow coil positioned between said pole pieces with the open ends of the coil positioned adjacent said pole pieces, a reed of ferromagnetic material fixedly mounted at one end and having its other end portion projecting through said coil into the field of influence of said pole pieces, and a diaphragm having its central portion connected to the projecting end of said reed.

7. In a transducer unit, a frame of ferromagnetic material having spaced pole pieces struck up therefrom, a top plate of ferromagnetic material secured in spaced relation to the front side of said frame and having spaced pole pieces struck therefrom to project in the direction of the free ends of said first mentioned pole pieces, the spacing between the pole pieces on said plate being substantially equal to the spacing between the pole pieces on said frame, a pair of permanent magnets of high coercive material, secured to said frame and in contact with said plate in a position where each magnet substantially spans the space between the pole pieces thereon, a hollow coil positioned between said pole pieces with the open ends of the coil positioned adjacent said pole pieces, a reed of ferromagnetic material fixedly mounted at one end and having its other end portion projecting through said coil into the field of influence of said pole pieces and a diaphragm fixedly mounted by its margin at the reverse side of said frame and having its central

portion connected to the projecting end of said reed.

8. In a transducer unit, a frame of ferromagnetic material having spaced pole pieces struck up therefrom, a top plate of ferromagnetic material secured in spaced relation to the front side of said frame and having spaced pole pieces struck therefrom to project in the direction of the free ends of said first mentioned pole pieces, the spacing between the pole pieces on said plate being substantially equal to the spacing between the pole pieces on said frame, a pair of permanent magnets of high coercive material, secured to said frame and in contact with said plate in a position where each magnet substantially spans the space between the pole pieces thereon, a hollow coil positioned between said pole pieces with the open ends of the coil positioned adjacent said pole pieces, a reed of ferromagnetic material fixedly mounted at one end and having its other end portion projecting through said coil into the field of influence of said pole pieces and a corrugated diaphragm mounted by its margin in parallel spaced relation to the reverse side of said frame, said corrugations being located with respect to said frame beyond a plane defined by the margin of said diaphragm, means connecting the central portion of said diaphragm and the projecting end of said reed and a perforated cover enclosing the side of said diaphragm remote from said frame thereby providing a cavity having an effective acoustic compliance.

9. In a transducer unit, a frame of ferromagnetic material, spaced upstanding pole pieces on said frame, a pair of permanent magnets of high coercive material contacting said frame in the region of said pole pieces, a top plate of ferromagnetic material, spaced pole pieces on said plate, means for mounting said plate in fixed relation to said frame to contact said magnets, with the free ends of the pole pieces thereon extending toward the free ends of the pole pieces on said frame, a coil mounted between said plate and said frame, a reed of ferromagnetic material fixedly mounted at one end and having its other end portion extending into the field of influence of said pole pieces as well as of said coil, and means including a concentrically corrugated diaphragm secured at its margin to the reverse side of said frame and having its central portion connected to the last mentioned end portion of said reed whereby said unit can translate sound into electrical energy and vice versa, all of the corrugations in said diaphragm being positioned at one side of a plane defined by the margin of said diaphragm.

ARTHUR S. HOWELL.