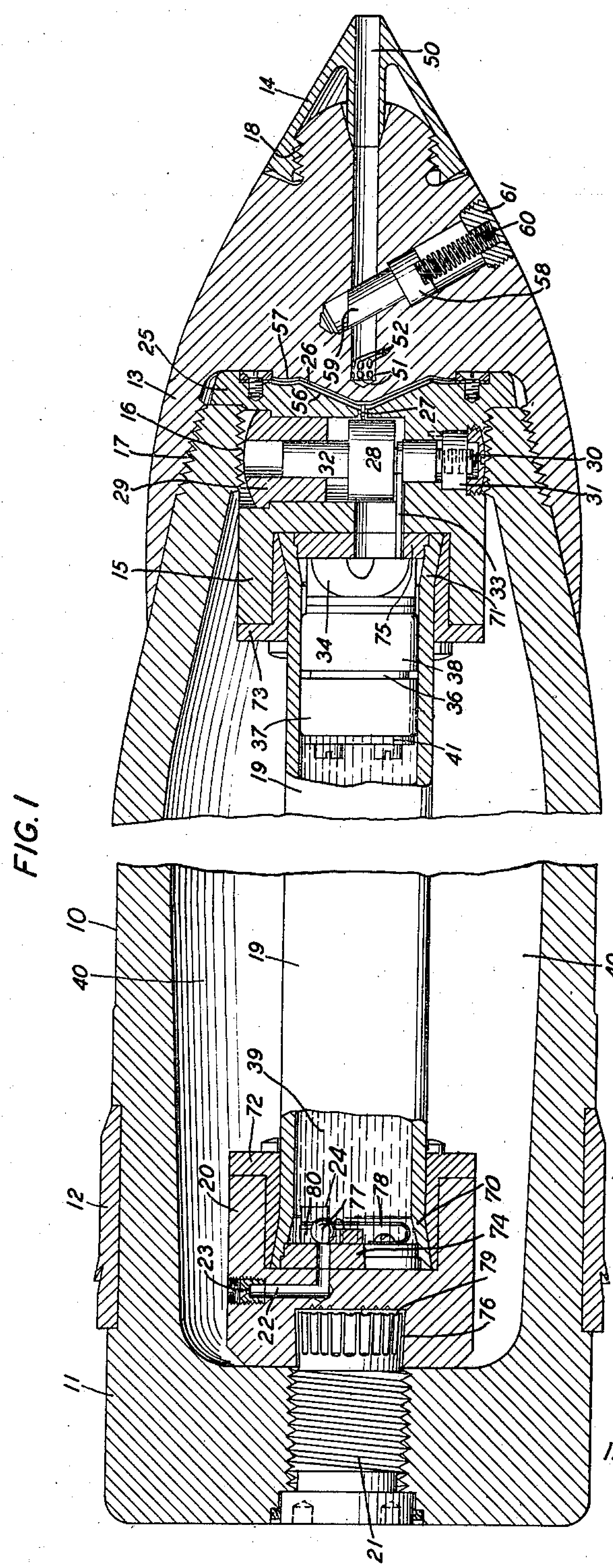
Sept. 3, 1946. L. A. ELMER ET AL 2,406,816

SOUND RECORDING PROJECTILE

Filed Dec. 19, 1941 3 Sheets-Sheet 1



INVENTORS: L.A.ELMER
C.A.LOVELL
BY
C.A. Sprague
ATTORNEY

SOUND RECORDING PROJECTILE

Filed Dec. 19, 1941 3 Sheets-Sheet 2

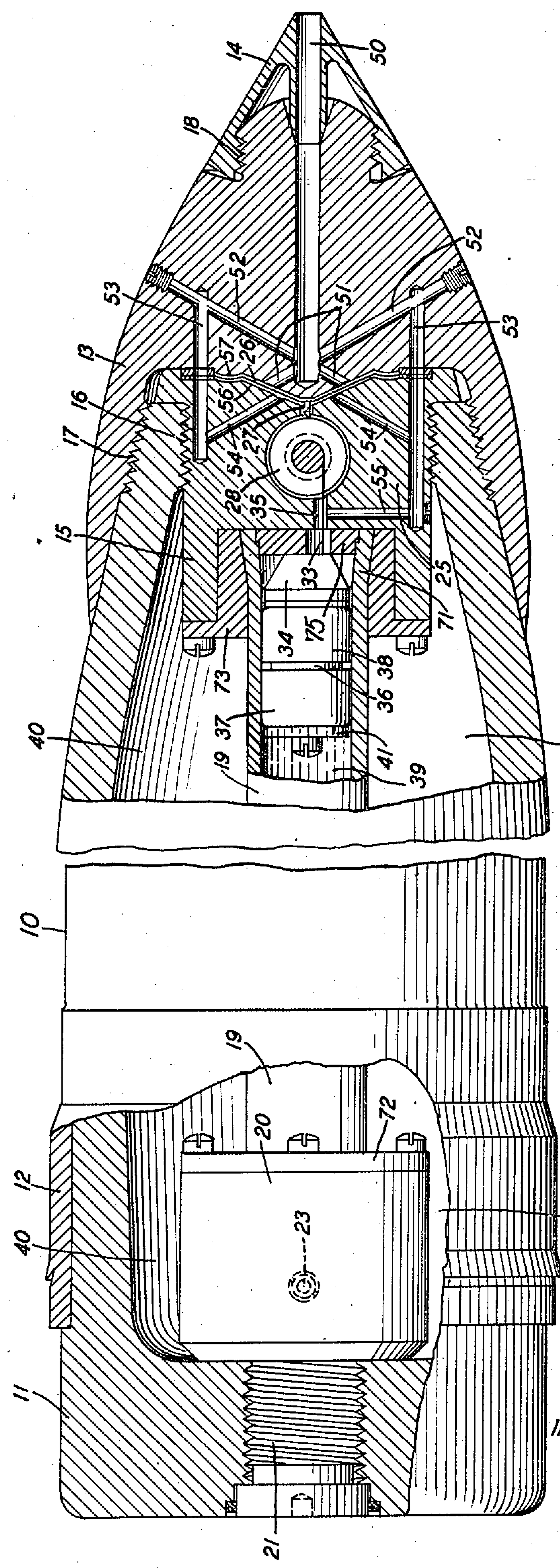


FIG. 2

INVENTORS: L. A. ELMER
C. A. LOVELL
BY
C. A. Sprague
ATTORNEY

SOUND RECORDING PROJECTILE

Filed Dec. 19, 1941 3 Sheets-Sheet 3

FIG. 4

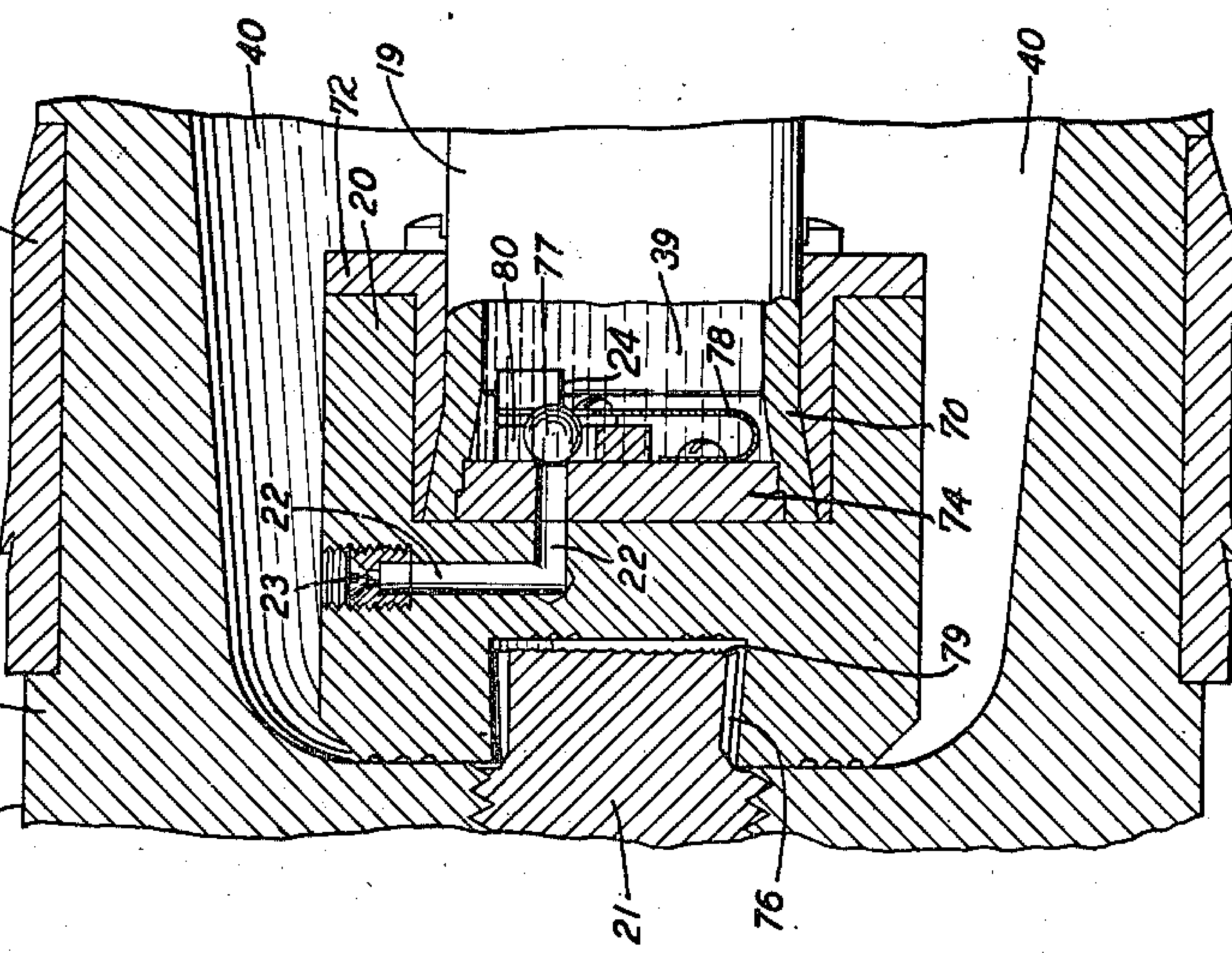


FIG. 5

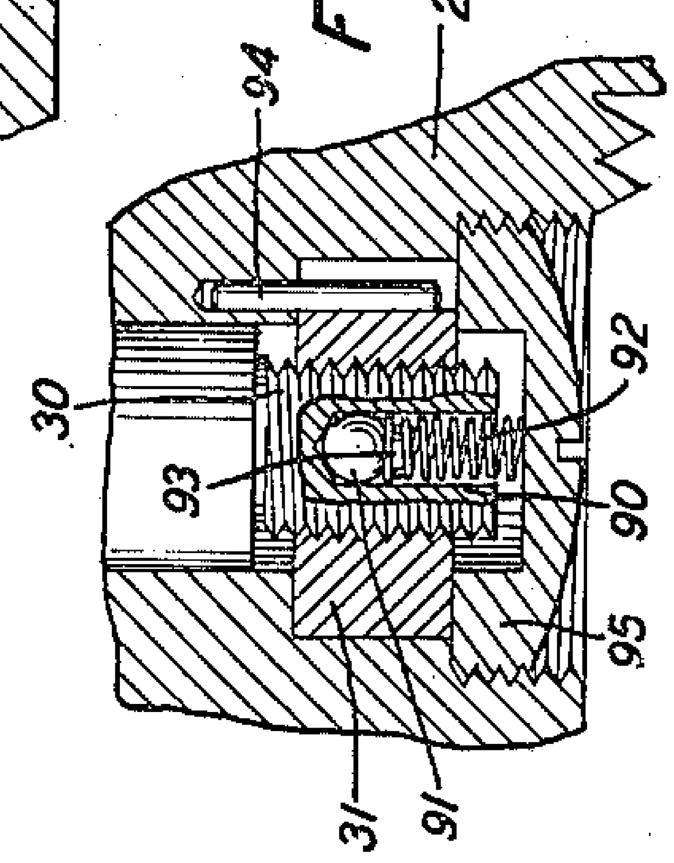
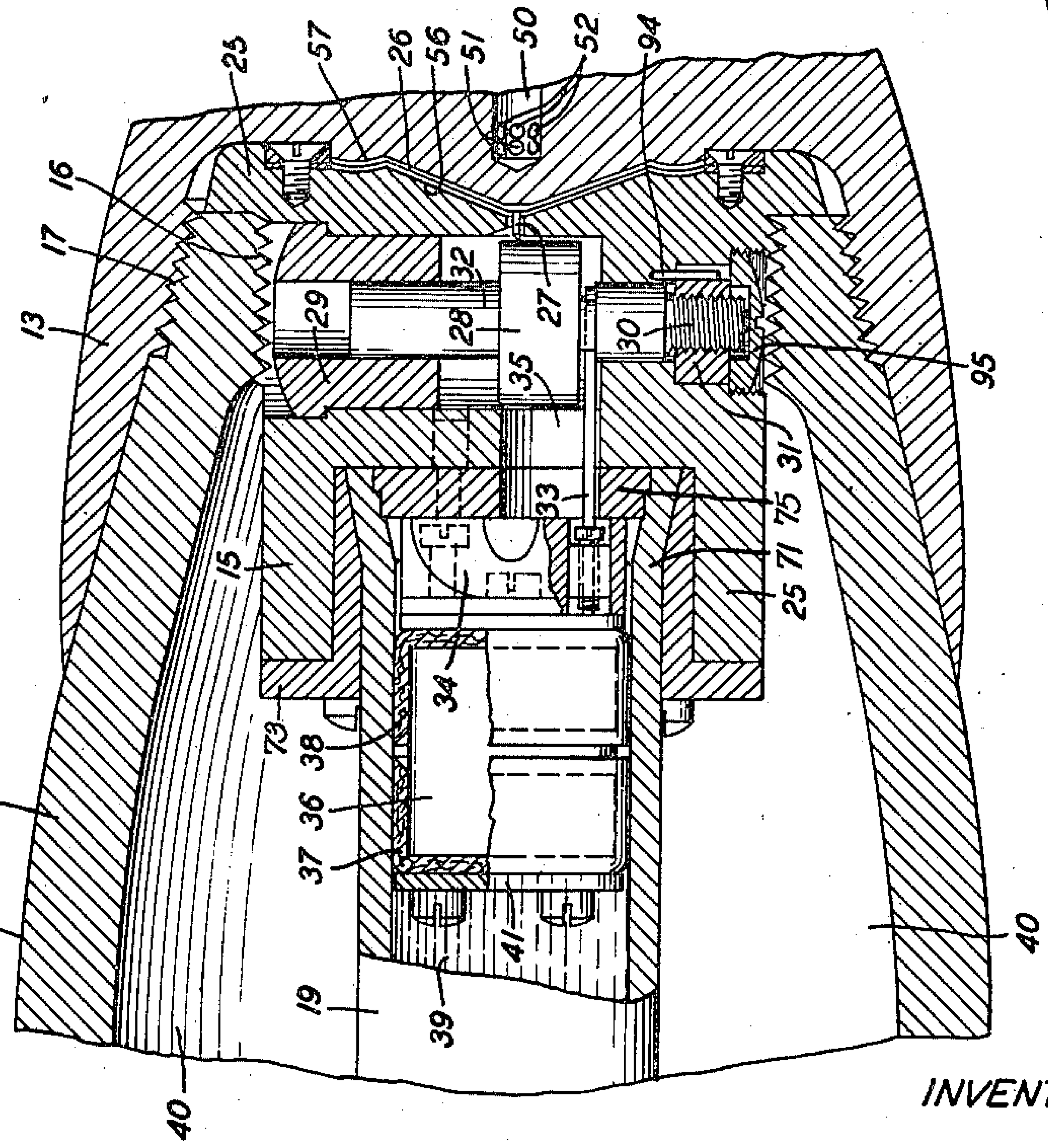


FIG. 3



INVENTORS: L. A. ELMER
C. A. LOVELL
BY C. A. Sprague
ATTORNEY

Patented Sept. 3, 1946

2,406,816

UNITED STATES PATENT OFFICE

2,406,816

SOUND RECORDING PROJECTILE

Lloyd A. Elmer, Summit, and Clarence A. Lovell, Maplewood, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 19, 1941, Serial No. 423,668

14 Claims. (Cl. 274—1)

1

This invention relates to casing or shell structures each comprising a casing or shell adapted to be moved through a fluid medium and having mechanism therein to be operated while the shell or casing is in motion. More specifically the invention relates to casing or shell structures comprising apparatus for recording the intensity of sound fields within a medium through which the shell is caused to move.

In a copending application of Harvey Fletcher, John F. Muller and Carl D. Swartzel, Jr., Serial No. 423,568, filed December 19, 1941, there is described an aerial recorder comprising a shell or projectile adapted to be fired from a gun and propelled to the sound field in the vicinity of an airplane or to another sound field the intensity of which it is desired to measure by a recording mechanism contained within the shell. The present invention primarily relates to improvements in this general type of recorder although the invention in certain of its aspects is capable of other uses.

In the aerial recorder described in the above-mentioned copending application, the sounds to be recorded are conducted to the general vicinity of the diaphragm in the interior of the shell through a central passageway in its nose, which passageway connects with and permits the sound to reach the diaphragm through a group of smaller passageways connected to the central passageway. To assist in equalizing the air pressure on the diaphragm, another group of smaller passageways connects the central passageway with a space in the rear of the diaphragm. A stylus attached to the diaphragm is adapted to engage a rotating drum which is coated with a suitable material which can be cut or engraved by the stylus to form a record. The drum is mounted with its axis transverse to the longitudinal axis of the shell and it is preferably adapted to move along its axis as it rotates, screw mechanism being provided to control this axial movement. Driving means for the drum consists of a motor mechanism comprising a piston adapted to move within a cylinder which preferably has an elliptical cross section to prevent its turning within its mounting. The piston is connected by means of a metal tape to the drum to rotate the latter as the piston is driven downward (that is, away from the nose of the shell) within its cylindrical casing, the tape being maintained taut by the friction on the threads of the moving drum shaft. The liquid in the cylinder is drawn out through a carefully adjusted orifice (to regulate its rate of flow) into a

2

compartment which encloses the cylinder. As the orifice opening is displaced from the axis of the cylinder, there is a centrifugal force (due to the rotation) acting on the liquid to pull it through the orifice and thus reduce the pressure on the underside of the piston, permitting it to be driven downward by the pressure on the top side of the piston. A valve is adapted to cut off the central passageway until the force due to linear acceleration holding the valve closed is overcome by the centrifugal force opening the valve. Before the shell is fired, the interior of the shell casing is pumped up to an internal pressure slightly greater than that anticipated at the nose at the beginning of the flight, which pressure may approach 6 to 10 atmospheres. Some trouble has been experienced in models constructed in accordance with the Fletcher et al. invention due to leakage of the compressed air from the casing. While the device is operative even though it is not pumped up to such a pressure, a considerable period of time is required after the valve cutting off the central passageway is opened before the air pressures on the upper and lower sides of the diaphragm are equalized due to the relatively large volume of air space within the casing (particularly in the compartment surrounding the cylinder) which must be pressure equalized. This is due to the fact that the relatively large space in the interior of the shell is connected to the central passageway only through the smaller passageways and it thus takes a relatively long time for this large space to reach the same pressure as that applied to the front of the diaphragm. It is obvious that until this equalization of air pressures is reached, no recording truly representative of the pressure on the diaphragm from the sound waves is attained.

It is an object of this invention to provide a casing or shell of the general type of the one described in the preceding paragraph in which the above-mentioned disadvantages are in large measure alleviated.

Other objects will be apparent from the following description and claims.

In accordance with the present invention, it is not necessary to pump up the interior of the casing to a pressure above atmospheric pressure nor does it take such a relatively long time to equalize the air pressures on both sides of the diaphragm after the valve in the nose of the shell opens and air at high pressure is suddenly applied to the diaphragm. This result is accomplished by completely sealing off the interior of the shell casing, that is, by sealing off the chamber or compartment surrounding the motor cylinder from the diaphragm chamber. Thus, two closed compartments are formed, one, the motor cylinder, and the other, the chamber surrounding the cylinder, which compartments are connected by a constricted passageway containing the carefully adjusted orifice. The first compartment, of course, has a capacity which varies as the piston is forced downward. In the present invention, the only parts of the shell which are subjected to the increased air pressure caused by the passage of the shell through the air or other fluid medium are the front and the back of the diaphragm, the chamber containing the recording mechanism and the upper side of the piston. The chamber surrounding the cylinder preferably contains air (or other gas if desired) at normal atmospheric pressure.

The sealing of the inner portion of the shell from the regions of increased air pressure, in addition to having the above-mentioned advantages, makes possible another very desirable feature. In the Fletcher et al. shell, the movement of the piston within the cylinder is caused, as pointed out above, by the lessening of the pressure on the underside of the piston. The chamber into which the liquid flows has (in this Fletcher et al. shell) practically the same pressure as the upper side of the piston (because this chamber is connected by passageways to the diaphragm cavity which in turn is connected to the space above the piston). In the present arrangement the interior of the casing remains substantially at normal atmospheric pressure while the upper portions of the piston is subjected to an increased pressure due to the flight of the shell through space (which may be as great as from five to ten times normal atmospheric pressure). This great difference in pressure makes it possible to have a greater driving force available for turning the recording drum.

Various other improvements over the Fletcher et al. recording device have been incorporated in the shell or casing member provided in accordance with the present invention which improvements will be apparent from the description which follows and the claims appended hereto.

The invention will be more readily understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which:

Fig. 1 is a sectional view, with parts broken away, taken along a plane through the longitudinal axis of a shell in accordance with this invention;

Fig. 2 is a longitudinal view, with parts broken away, partially in cross section along a plane through the longitudinal axis and at right angles to that of the section shown in Fig. 1;

Fig. 3 is an enlarged cross sectional view of a portion of the apparatus shown in Fig. 1 taken in the same plane as in Fig. 1;

Fig. 4 is an enlarged longitudinal cross sectional view of another portion of the shell shown in Fig. 1; and

Fig. 5 is an enlarged fragmentary view, with parts broken away, of a portion of the apparatus shown in Fig. 3.

Referring more specifically to the drawings, which show an illustrative embodiment of the present invention, the outer portions of the shell or projectile 10 are of any suitable material, such as steel. They comprise a body member 11, a ring 12 around a portion of the body member 11 for contacting the rifling in the interior of the gun to cause the shell to have rotation about its central or longitudinal axis, a cap 13, and a nose piece 14.

Mounted within the body or casing member 11 is an assembly 15 which will be designated the "recording block." The recording block 15 is mounted within the body or casing member 11 by means of screw threads 16, external screw threads 17 being provided on the body or casing member 11 to engage complementary internal screw threads on the cap 13. By means of this arrangement, that is, because of the fact that the casing member 11 is held fast between the recording block assembly 15 and the cap 13, there is no tendency for the casing member 11 to split open when the shell 10 strikes a target (usually a sand bank so that the shell may be easily recovered and its record removed). It will, of course, be understood that it is important and necessary to recover the shell after its flight in order to remove the record. Screw threads 18 are provided for a cut-in portion of the cap 13 to mesh with complementary internal screw threads on the nose piece 14.

Between the recording block mechanism 15 and the base of the shell casing is mounted a cylinder 19, preferably made of a light strong metal such as duralumin. This cylinder 19 may be of circular cross section but it is preferably elliptical as shown in the drawings in order to prevent turning movement between the cylindrical casing 19 and the shell casing 11 and between the piston and the cylinder. The cylinder contains a suitable fluid 39, preferably one which will not ignite or explode when the shell strikes the target. Suitable fluids are, for example, water and carbon tetrachloride. At the base end of the shell, the cylinder 19 is firmly held within a supporting member 20 which in turn is secured to the base by a screw plug 21. The fluid in the cylinder 19 passes out through an elbow member 22, having an orifice 23 of predetermined size at the extremity thereof at the periphery of the supporting member 20, into a sealed compartment or chamber 40 surrounding the cylinder 19. A small valve 24 to be described more fully below is placed in the elbow member 22.

The recording block mechanism comprises a metal housing 25, a diaphragm 26 supported at its periphery from the housing 25, a stylus 27 fastened to the diaphragm 26 in such a position that it makes contact with a drum 28 which is mounted on a shaft 32 which is free to turn in two bearings, one in the removable bushing 29 and the other in the main steel housing 25. A screw threaded portion 3 on one end of the shaft 32 of the drum 28 is screwed into a nut 31 which cannot rotate because it is loosely pinned by the pin 94 (see Fig. 5) to the main housing. Therefore, when the drum 28 rotates, it moves laterally at the same time and the stylus 27 cuts a helix in the surface coating on the drum. Preferably this surface coating is cellulose acetate or nitrate, although it may be of any other suitable material. One end of a metal tape 33 (preferably of strong thin steel) is connected to the shaft 32 and the other end of the tape is fastened to the top portion 34 of the piston 41. The recording block 15 has a passageway 35 therein through which the metal tape 33 passes and also through which air is allowed to pass to the top portion 34 of the piston 41 to drive it downward (to the left in Figs. 1, 2 and 3). The top portion 34 of the piston 41 is connected to the body portion 36 of the piston by any suitable means. Two leather washers 37 and 38 are placed around the lower and upper portions of the body member 36 of the piston and are shaped and proportioned so as to make a fluid-tight seal at the top of the cylinder 19 to prevent leakage of air to the fluid 39 with which the cylinder 19 is filled and to prevent leakage of the fluid 39 through the opening or passageway 35 leading to the chamber enclosing the recording drum 28.

The sound waves to be recorded reach the front of the diaphragm 26 by means of a passageway 50 in the nose of the shell and various smaller passageways 51 and 52 connecting to the central passageway. The sound waves are also conducted to the rear of the diaphragm 26 by means of passageways 52, 53 and 54. The central passageway 50 preferably surrounds the longitudinal axis of the shell. There are, for example, six passageways 51 leading from the central passageway 50 to the front of the diaphragm 26 in order to distribute the sound waves and the air pressure over a larger surface area of the diaphragm. Similarly, there are, for example, six passageways 52, the axes of which are inclined to the longitudinal axis of the shell and which connect with an equal number of passageways 53 leading in turn to the passageways 54 which lead to the back of the diaphragm. One of the passageways 53 connects with a passageway 55 leading to the chamber containing the drum 28, which chamber is connected by the passageway 35 to the space at the top portion 34 of the piston. By means of the arrangement described above, the air pressures on the front and back of the diaphragm are equalized, but, due to the fact that the paths from the central passageway 50 to the back of the diaphragm 26 are much longer than those to the front surface thereof and to the fact that the transmission characteristics differ, the sound waves on the front of the diaphragm at any particular instant have not the same strength or phase as those on the back of the diaphragm and consequently the sound pressures are not equalized. This permits the diaphragm 26 to be moved up and down (to the left and right in Figs. 1, 2 and 3), causing the stylus 27 to vary its depth of cut on the drum 28 and thus record signals representative of the sound waves which enter the shell from outside. These sounds may be caused by the motion of the shell itself (for instance, a whistle) and also by sound caused by other elements such as by an airplane, if the shell is adapted to be moved through air, or possibly by a ship if the shell or similar casing member is adapted to be propelled through water. It will be clear to those skilled in the art that the aerial recorder described above may be readily adapted for use in heavy mediums. By means of the various passageways, the pressure on each of the two sides of the diaphragm 27 is made equal to that in the passageway 35 leading to the top of the piston but, because the interior chamber 40 is sealed off from these passageways, the pressure in the chamber 40 remains substantially the same as at the start of the flight, for example, at normal atmospheric pressure.

For protective purposes, the face 56 of the housing 25 clears the diaphragm 26 by only a very small amount, for example, by about .012 inch. Similarly the rear surface 57 of the cap 13 clears the diaphragm surface by a similar amount. As the diaphragm cavity formed between the faces 56 and 57 is of similar shape to the diaphragm itself, that is, the diaphragm is lower at the center thereof than at the edges, the cavity affords maximum protection to the diaphragm. The steel housing 25 also protects the drum 28 and its associated equipment.

The passageway 50 in the nose of the shell is interrupted by an automatic valve mechanism 58 which comprises a sliding plug member 59 held in place across the passageway 50 by a spring 60 which is backed by a screw plug 61. When the component of force urging the plug toward the longitudinal axis of the shell due to the linear acceleration thereof vanishes as this linear acceleration ceases, the centrifugal force (tending to move the plug 59 away from the longitudinal axis) operates this valve and opens the passageway 50. When the valve 58 is opened, a force is applied to drive the piston 41 within the cylinder 19, which force is due to the air pressure on the top side of the piston (which pressure is now relatively high) minus that on the lower side of the piston. The force on the lower side of the piston is the difference between that caused by the pressure of the atmosphere in the chamber 40 (usually normal atmospheric pressure) and the centrifugal force acting on the liquid 39 passing through the orifice 23.

The nose 14 is made of soft metallic material, such as copper, so as to close the central passageway 50 to the diaphragm 26 as soon as the shell strikes an earth or sand upright target or the ground. This construction is to reduce to a negligible value the amount of earth or sand which might be driven into the diaphragm cavity when the shell strikes the target or ground, as these materials would be likely to damage the record if the sand or earth reaches it.

The cylinder 19 is designed to be fixed in position at both ends and to be securely held against damage in firing or striking. As pointed out above, it is preferably of elliptical cross section and the end portions 70 and 71 are inclined outwardly so that an axial pull will cause the cylinder 20 to be wedged more tightly in the collars 72 and 73 surrounding them. Outward expansion of the collars is prevented by the metal housing 25 and the block 20 in which the collars 72 and 73 are mounted. Inward collapse of the tube at the ends is prevented by the plug members 74 and 75.

The recording block assembly 15, the cylinder 19 and the block 20 are assembled as a unit and this subassembly is then inserted into the shell body. The length of the cylinder 19 is made such that the recording block 15 may be screwed tightly into the shell casing and the base block 20 seats firmly on the base of the shell. This supports the cylinder 19 against linear acceleration. The screw member 21 has a dovetail end which is inserted in a similarly-shaped socket 76 in the block 20 and the intervening space between the two is filled with a suitable cement. This construction is to prevent the collapse of the tube when the shell strikes the ground or target. Splines are cut on the surfaces of the screw end and bracket to prevent rotation of the base block 20.

The valve mechanism 24 is preferably one of the ball type. The ball 77 is held on its seat by a spring 78 exerting a force of about five times the weight of the ball. A guide member prevents the ball from being swept off its seat due to angular acceleration in case the fluid leaks past the ball before firing. After the shell leaves the muzzle of the gun the deceleration of the shell reduces the pressure of the ball 77 on its seat enough to permit the centrifugal force on the ball to move it away from under the spring 78 and away from the ball seat in the elbow member 22. The movement of the ball 24 is in an upward direction in the plane of the drawings of Figs. 1 and 4. In addition the deceleration of the recorder deflects the spring 78 far enough to release the ball. Angular acceleration produces a tangential force of very small amount which is negligible.

The orifice 23 is made the proper size so as to give a recording drum surface feed of, for example, about 12 inches per second. The orifice size is selected so as to give the desired rate of flow for the calculated pressure expected at the orifice. This provides a very accurate timing mechanism for the recording drum 28.

Due to the rotation of the drum 28 about the longitudinal axis of the shell, there is a centrifugal force set up which bears down on the screw threads of the members 30 and 31, thus exerting a friction between these screw-threaded members and in turn setting up a tension in the metallic tape 33 which drives the drum 28 about an axis transverse to the longitudinal axis of the shell. In accordance with this invention, the friction between the screw-threaded members 30 and 31 is decreased by means of a ball 91 and a compressed spring 92 placed in a slot 90 surrounding a portion of the axis of the shaft 32 upon which the drum 28 is mounted. (See Fig. 5 which is a fragmentary enlarged view, with parts broken away, of a portion of the structure of Fig. 3.) A cap 93 is tightly fitted within the end of spring 92 which is nearer the center of the shell. The top of this cap makes contact with the ball 91 in such a way that the rotary movement of the ball (as the shaft 32 turns) is not conveyed to the spring 92. The outer end of the spring 92 is backed by the screw-threaded plug 95 in the steel housing 25. The spring 92 forces the ball against the shaft 32 in a direction opposite to the centrifugal force. (The direction of the centrifugal force is downward in the showing of Figs. 2, 3 and 5.) This greatly reduces the tension on the tape 33. During the time of travel of the shell 10 the drum 28 is moved along its axis (upward in Figs. 1 and 3) but the spring 92 continues to force the ball 91 in an upward direction against the shaft 32 but with a decreasing force comparable to the decreasing centrifugal force.

The method of operation of the aerial recorder described above is as follows:

The shell is placed in a gun in the same manner as a standard anti-aircraft shell containing an explosive charge. When the shell is fired, the action of the mechanism is as follows: While the shell is being accelerated in the barrel of the gun, the centrifugal forces exerted on the automatic valve 58 in the nose and the valve 24 in the block 20 containing the orifice 23 tend to open these valves. However, their design is such that the linear acceleration forces produce a pressure in a direction to cause the valves to stay closed. This relieves the diaphragm 26 of the nose pressure when the shell is pushing air out of the barrel of the gun and during this period the fluid motor piston 41 remains essentially at rest. As soon as the shell is a few feet from the barrel of the gun, however, the linear acceleration has changed from this high positive value to a small negative one and the valves 58 and 24 open. When the valve 24 opens (caused by the ball 77 moving away from its seat) fluid from the cylinder 19 begins to be discharged through the calibrated orifice 23 by the centrifugal action of the spinning shell and the piston 41 is forced down in the cylinder 19 by the air pressure on the top side of the piston 34. The air reaches the top side 34 of the piston 41 by means of the nose passageway 50, small passageways 52, 53 and 54 to the space in the rear of the diaphragm 26, and thence through the passageway surrounding the stylus 27 to the cavity containing the drum 28 and thence through the passageway 35 to the top side 34 of the piston 41. The movement of the piston downward in the cylinder 19 pulls the tape 33 with it and turns the drum 28. The drum 28 is caused to move along its axis by the movement of the screw 30 in the nut 31 loosely pinned to the housing 25 by the pin 94. The pressure on the screw threads of the members 30 and 31 (which pressure, as explained above, is due to centrifugal force and causes a friction which places a tension on the tape 33) is reduced or compensated by the spring 92 forcing the ball 91 against the shaft 32 at the axis thereof within the slot 90. As the drum 28 moves along its axis (upward in Figs. 1 and 3) the ball 91 continues to be pressed against the shaft 32 by the action of the spring. Because the ball 91 makes contact with only the center of the cap 93, even though the ball turns with the shaft 32 the spring does not turn with it. By this arrangement the torque caused by the friction is greatly reduced due to the reduction in the radius of friction action (the radius of friction action is much smaller on the ball 91 than on the screw threads of the members 30 and 31). Inasmuch as the stylus 27 rests upon the drum 28 and is moved to the left or the right in Figs. 1, 2 and 3, a helical record of the sounds reaching the diaphragm 26 after the valve 58 is opened is cut on the surface coating of the drum 28. This record continues until the piston reaches the end of its travel. Generally about four seconds is a good average record time but the time of travel, of course, depends upon the calibration or adjustment design of the orifice 23 as well as upon other factors such as the linear and rotational velocities of the shell, etc. The moment the valve 58 in the nose of the shell opens, air will flow in, and due to the arrangement of passageways 51, 52, 53 and 54, equalization of the pressures at the front and rear of the diaphragm 26 takes place in a relatively short time. At the same time the air flowing through the passageway 53 connected to the passageway 55 and the passageway 55 quickly places the space around the drum 28 and the space at the top 34 of the piston 41 at the same pressure as at the diaphragm 26. Inasmuch as this space 40 is completely sealed off from the space subjected to increased air pressure (due to the linear speed of the shell), there is a relatively large force acting upon the piston. The force driving the piston down (that is, away from the nose) in the cylinder 19 is the difference between the pressure on the top side 34 of the piston, that is, the increased air pressure due to the linear speed of the shell, minus the back pressure or force on the liquid. This back pressure is the difference between the force due to the pressure of the atmosphere in the chamber 40 minus the centrifugal force tending to eject the liquid through the orifice 23. While in a preferred embodiment of this invention it is planned to utilize the centrifugal force to reduce the pressure required on the top part of the piston, it is clear to those skilled in the art that a shell may be constructed having the orifice along the longitudinal axis of the shell and make use only of the difference between the pressure due to the accelerated speed of the shell and that of the chamber 40 at the start of the flight as the driving force on the piston 41. During the relatively short time required to equalize the pressure on the two sides of the diaphragm 26, a large static pressure acts upon the diaphragm in a direction tending to force the diaphragm against the face 56 of the assembly block 15, but, due to the narrowness of the cavity containing the diaphragm 26, the movement is restricted to a distance of the order of about 12 mils. The diaphragm 26 will thus not be harmed. As soon as the pressures on the diaphragm are equalized, the stylus 27 resumes a normal position and makes a normal depth of cut in the record, and will then make a hill and dale recording of the sound pressures acting on the diaphragm 26. These sound pressures, as in the case of the air pressures, are conducted from the exterior of the shell through the passageway 50 and the smaller passageways connected thereto. Due to the fact that the distance to the back of the diaphragm 26 is greater than the distance to the front and because of a difference in transmission characteristics, the sound pressure on the front of the diaphragm at any particular instant is not in phase with that in the back so these pressures are not equalized (as in the case of the air pressures). Thus the depth of cut of the surface on the drum 28 is representative of the sound pressure encountered by the nose of the shell as it moves through the fluid medium. The recording drum 28 is enclosed as much as possible by the steel housing 25 to give it maximum protection when the shell lands. Preferably the shell should be aimed so that it lands in a soft target such as a sandbank so that it may be recovered and its record removed. This record furnishes data which may be used, for example, in the design of sound actuated fuses for discharging explosive charges contained in anti-aircraft shells. A particular advantage of the shell of this invention is that it is not necessary to pump up the interior of the shell, it being preferable that the chamber 40 be at ordinary atmospheric pressure. Moreover, a large driving pressure is available for moving the piston.

While the invention in the form described in detail above was evolved primarily as a solution of the problem of measuring sound to which a sound sensitive aerial projectile is subjected, it is to be understood that the invention has several broader and different aspects than this. It is applicable to the recording of sound for any purpose in any fluid medium. Moreover, in certain aspects the invention is obviously of use for other purposes than sound recording, an example being sound control of an explosive within a moving shell or casing. Furthermore, the invention in certain of its aspects has still wider application since it relates broadly to the control of any desired mechanism within a casing or shell moving through a fluid medium.

What is claimed is:

1. In combination with a casing or shell adapted to be moved through a fluid medium, of mechanism in said shell operative when said shell is in motion, two closed compartments within said shell having a constricted passageway therebetween, one of said compartments being of variable capacity and having a fluid filling, and means for utilizing pressure generated in said medium by the movement of said shell therethrough to cause inward movement of one wall of said last-mentioned compartment to operate said mechanism under control of the resulting passage of fluid through said passageway.

2. The combination with a generally cylindrical casing or shell adapted to be projected through a fluid medium so as to be given a rotary motion during its travel, of two closed compartments within said shell having a constricted passageway therebetween, one of said compartments having a liquid filling therein, said compartments being so positioned within the shell that said liquid is caused to flow through said passageway by centrifugal force generated by rotary motion of the shell, and mechanism in said shell under control of the flow of fluid through said passageway.

3. A device for recording sound waves in a sound field while moving in said field comprising a casing or shell adapted to be moved in said field, a sound responsive member mounted within said casing, a sound recording medium in cooperative relation thereto, two closed compartments within said casing having a constricted passageway therebetween, one of said compartments being of variable capacity and having a fluid filling, means for utilizing pressure generated in said medium by the movement of said shell therethrough to reduce the size of said last-mentioned compartment, and driving means coupled to said last-mentioned compartment to produce relative movement between said recording medium and said sound-responsive element.

4. A device for recording sound waves in a sound field in a field medium while moving in said field, comprising a casing or shell adapted to be propelled into or through said field, of a sound responsive diaphragm mounted in said casing, a motor member comprising a piston chamber and a piston, a recording drum, a stylus attached to said diaphragm to record movement thereof on said drum, means including a passageway within said casing open to said fluid medium through which said casing travels and extending to the vicinity of said diaphragm and to one side of said piston, and means for causing the movement of said piston to rotate said drum, said piston chamber underneath said piston being closed except for a constricted opening into a compartment in said shell from which the fluid pressure generated in said passage is excluded.

5. In combination with a casing or shell adapted to be moved through a fluid medium, of mechanism in said shell operative when said shell is in motion, two closed compartments within said shell having a constricted passageway therebetween, one of said compartments being of variable capacity and having a fluid filling, means for utilizing pressure generated in said medium by the movement of said shell therethrough to reduce the size of said last-mentioned compartment and to thereby operate said mechanism, a passageway in said shell open to the surrounding medium at the front end of said casing, said passageway serving to transmit the pressure produced by movement through said medium to said pressure utilizing means, and a nose for said shell provided with a soft metal tip adapted to close said passageway when the casing strikes an object.

6. In combination with a casing or shell adapted to be moved through a fluid medium, of mechanism in said shell operative when said shell is in motion, two closed compartments within said shell having a constricted passageway therebetween, one of said compartments being of vari-

able capacity and having a fluid filling, means for utilizing pressure generated in said medium by the movement of said shell therethrough to reduce the size of said last-mentioned compartment and to thereby operate said mechanism, a passageway in said shell open to the surrounding medium at the front end of said casing, said passageway being at the front end of said casing and serving to transmit the pressure produced by movement through said medium to said pressure utilizing means, and means for automatically closing said passageway when the casing strikes an object.

7. A device for recording sound waves in a sound field while moving in said field, comprising a casing or shell adapted to be moved in said field, of a sound responsive diaphragm mounted in said casing, a motor member comprising a piston chamber and a piston, a recording drum mounted about an axis transverse to the path of travel of said casing or shell, a stylus attached to said diaphragm to record movement thereof on said drum, means including a passage within said casing open to the fluid medium through which said casing travels and extending to the vicinity of said diaphragm and to one side of said piston, means for causing the movement of said piston to rotate said drum, said piston chamber underneath said piston being closed except for a constricted opening into a compartment in said shell from which the fluid pressure generated in said passage is excluded, means for causing said drum to move along its axis as it is rotated, and means for applying a force along the axis of said recording drum which is opposite in direction to the centrifugal force set up by the movement of said recording drum about the path of travel of said shell.

8. A device for recording sound waves in a sound field in a fluid medium while moving in said field, comprising a casing or shell adapted to be moved in said field, of a sound responsive diaphragm mounted in said casing, a motor member comprising a piston chamber and a piston, a recording drum mounted about an axis transverse to the path of travel of said casing or shell, a stylus attached to said diaphragm to record movement thereof on said drum, means including a passageway within said casing open to said fluid medium through which said casing travels and extending to the vicinity of said diaphragm and to one side of said piston, means for causing the movement of said piston to rotate said drum, said piston chamber underneath said piston being closed except for a constricted opening into a compartment in said shell from which the fluid pressure generated in said passage is excluded, means for causing said drum to move along its axis as it is rotated, and means for applying a force along the axis of said recording drum which is opposite in direction to the centrifugal force set up by the movement of said recording drum about the path of travel of said shell, said force applying means comprising a ball and a spring.

9. In combination, a casing or shell adapted to be moved through a fluid medium, a fluid-filled compartment within said casing adapted to have its volume reduced under external pressure and having a constricted opening in the wall thereof to permit the escape of said fluid filling when the volume of said compartment is reduced, a closed compartment into which said fluid escapes, and means for applying pressure produced by movement of said casing through said medium to the exterior of said fluid-filled compartment to reduce its volume.

10. In combination, a casing or shell adapted to be moved through a fluid medium and to have a rotary movement during its travel, a motor member within said casing, said motor member comprising a cylinder containing a fluid and a piston within said cylinder for moving said fluid and being itself moved by pressure exerted by said medium during movement of said casing, an outlet for the fluid in said cylinder, said outlet comprising a constricted passageway having an orifice for regulating or timing the rate of fluid flow and a closed compartment surrounding said cylinder, and means controlled by the centrifugal force set up by said rotary movement for controlling the movement of said piston and causing flow of the fluid from said cylinder through said orifice and into said closed compartment.

11. In combination, a casing or shell adapted to be moved through a fluid medium, a motor member within said casing, said motor member comprising a cylinder containing a fluid, a piston within said cylinder for moving said fluid, means for transmitting to said piston to cause movement thereof within said cylinder pressure generated by the movement of said casing, a closed compartment connected to said cylinder through a constricted passageway, and means including an orifice in said constricted passageway for regulating or timing the flow of fluid from said cylinder.

12. The combination of elements as in claim 11 in further combination with a valve operable by the rotary movement of said casing to open said constricted passageway.

13. The combination with a generally cylindrical casing or shell adapted to be projected through a fluid medium so as to be given a rotary motion during its travel, of two closed compartments within said shell having a constricted passageway therebetween, one of said compartments having a liquid filling therein, said compartment being so positioned within the shell that centrifugal force generated by rotary motion of the shell tends to cause said liquid to flow through said passageway, mechanism in said shell under control of the flow of fluid through said passageway, and valve mechanism within said casing under joint control of fluid pressure produced by the movement of translation of said casing and energy derived from the rotary movement of said casing to control the flow of said liquid through said passageway.

14. The combination with a casing or shell adapted to be moved through a fluid medium with a motion of rotation about its longitudinal axis, of an element within said casing adapted to be moved transversely of the longitudinal axis of said casing having its center of gravity off said axis whereby said element tends to be moved outward by centrifugal force as the casing rotates, a spring member associated with said element to oppose said centrifugal force with a decreasing force as said center of gravity moves toward said axis and said centrifugal force is thereby decreased, and a fluid controlled member driven by energy derived from the forward movement of said casing for driving said element to cause its center of gravity to approach said axis as said casing revolves.

LLOYD A. ELMER.
CLARENCE A. LOVELL.