

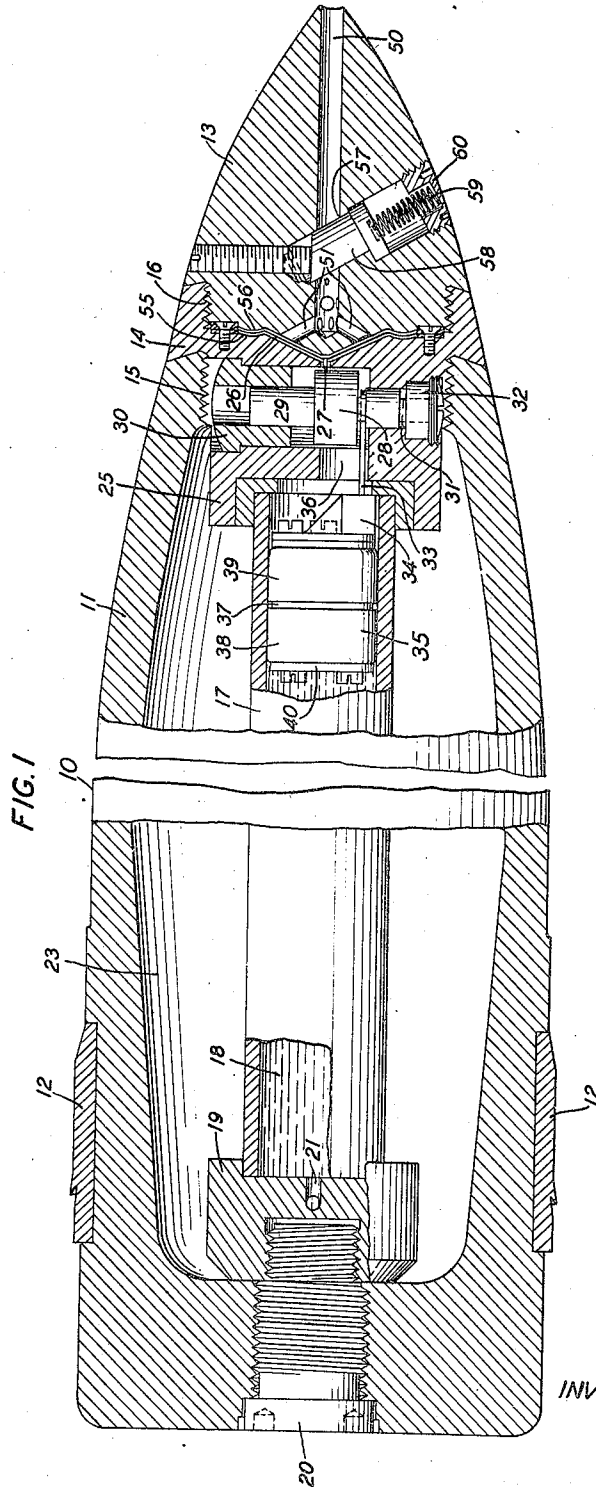
Feb. 24, 1948.

H. FLETCHER ET AL
SOUND RECORDING DEVICE

2,436,384

Filed Dec. 19, 1941

3 Sheets-Sheet 1



H. FLETCHER
INVENTORS J. F. MULLER
K. D. SWARTZEL JR.
BY *C. B. Sprague*
ATTORNEY

Feb. 24, 1948.

H. FLETCHER ET AL
SOUND RECORDING DEVICE

2,436,384

Filed Dec. 19, 1941

3 Sheets-Sheet 2

FIG. 2

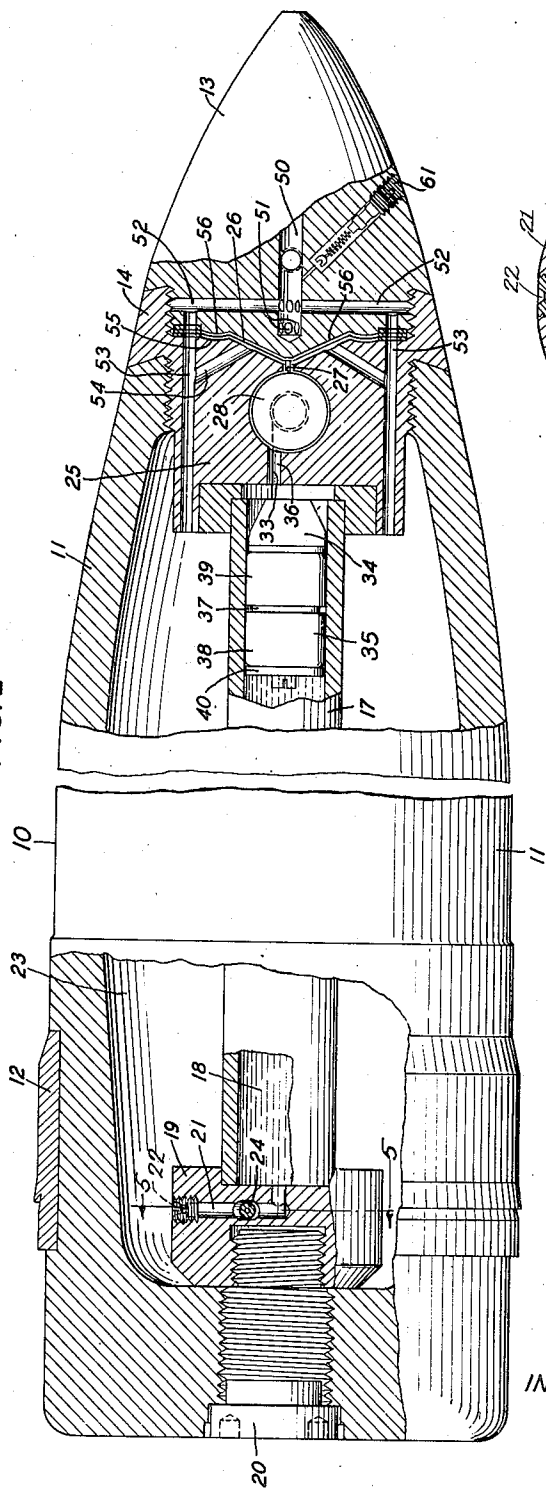
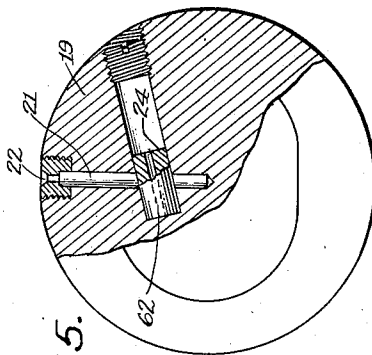


FIG. 5.



H. FLETCHER
INVENTORS: J. F. MULLER
BY K. D. SWARTZEL JR.
C. Sprague
ATTORNEY

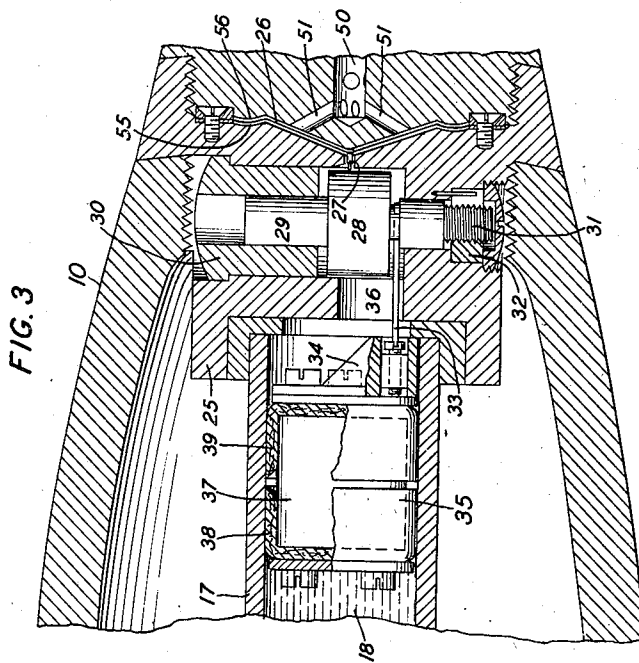
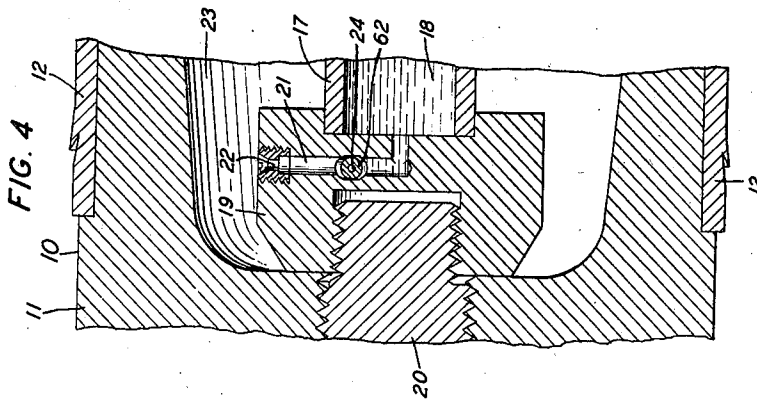
Feb. 24, 1948.

H. FLETCHER ET AL
SOUND RECORDING DEVICE

2,436,384

Filed Dec. 19, 1941

3 Sheets-Sheet 3



INVENTORS: H. FLETCHER
J. F. MULLER
BY K. D. SWARTZEL JR.
C. D. Sprague
ATTORNEY

UNITED STATES PATENT OFFICE

2,436,384

SOUND RECORDING DEVICE

Harvey Fletcher, Summit, John F. Müller, Montclair, and Karl D. Swartzel, Jr., Teaneck, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 19, 1941, Serial No. 423,568

12 Claims. (Cl. 274—1)

1

This invention relates primarily, but not necessarily, to casings or shells adapted to be moved through a fluid medium and more specifically to casings or shells containing apparatus for recording the intensity of sound fields within said medium.

It has been suggested that an anti-aircraft shell or projectile be exploded by the noise made by the propellers of an aeroplane. In order to devise a satisfactory form of such mechanism it is necessary to investigate the noise from the propellers of an aeroplane and that created by the passage of the shell through the air. The present invention, in an important aspect thereof, relates to a mechanism for recording both the noise made by the shell in its passage through the air and the noise made by the propellers of an aeroplane. Other aspects of the invention will be apparent from the objects and the description of the invention which appear hereinafter.

It is an important object of this invention to provide a novel mechanism which is adapted to be propelled or moved through a sound field and which will make a record of sounds encountered throughout at least a portion of the time of its travel.

It is another object of this invention to provide a projectile or other moving casing member having a sound recording mechanism housed therein.

It is another object of this invention to provide a novel motor mechanism within a casing adapted to move through a fluid medium which mechanism is actuated, for example, by energy derived from the movement of the casing.

It is a further object of this invention to provide a shell or projectile, adapted to be fired or otherwise projected into the air or other sound transmitting medium, containing a recording mechanism which derives energy for its operation from the energy of motion of the shell.

Related and more specific objects and features will be apparent from the description which follows and from the claims appended thereto.

In accordance with an important aspect of the invention, a projectile or shell of steel or other suitable material is provided which contains therewithin a recording mechanism actuated by a piston caused to be moved within a cylinder by energy derived from the movement of said shell along its longitudinal axis and by its rotation, as it is projected through a sound field. It will be readily apparent, however, from the following description that certain features used in this projectile or shell are capable of other uses.

2

In an illustrative embodiment of the invention, a projectile, such as an anti-aircraft shell, housing a recording mechanism is provided. This mechanism is primarily adapted to record the noise created by the shell in flight in relation to the noise of an aeroplane flying near the path of the shell although it will be understood that in certain of its aspects the invention is not limited to such a use. The sounds to be recorded are conducted to the vicinity of a diaphragm in the interior of the shell through a central passageway in its nose, the central passageway connecting with a plurality of smaller passageways leading to the immediate vicinity of the diaphragm. To aid in equalizing the air pressure on the diaphragm a plurality of other 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 material which is cut or engraved by the stylus to form a record. The drum is mounted around an axis which is transverse to the central axis of the shell and is preferably adapted to move along its axis as it rotates. Driving mechanism for the device 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 cylinder casing. The liquid in the cylinder is drawn out through a carefully adjusted orifice (to regulate its rate of flow) into a 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 fluid 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. The pressure on the top side of the piston may be derived by air compressed within the shell by pumping up the projectile or by the flight of the projectile through the medium. A valve is adapted to cut off the central passageway until the linear acceleration is reduced to such a value that the centrifugal force acting on the valve against the force due to the linear acceleration is sufficient to cause this valve to open. A somewhat similar valve mechanism is provided in the passageway leading to the calibrated orifice. The interior of the shell is preferably pumped up to a pressure corresponding to about 6 to 10 atmos-

3
pheres (that is, to an internal pressure slightly greater than that anticipated at the nose at the beginning of the flight). By this means, the pressure in the compartment enclosing the cylinder, the pressure on the upper side of the piston, and the pressure on both sides of the diaphragm are equal to each other and correspond to (or are slightly higher than) a pressure to which the diaphragm will be subjected due to the velocity of the shell. When the valve in the nose is opened the shock on the diaphragm is thus minimized and only a relatively short time is required before pressures throughout the shell are equalized with the pressure due to the velocity of the shell. While the air pressures are equalized on both sides of the diaphragm, the sound pressures at any particular instant are not, due to the difference in phase of the sound waves on the two sides of the diaphragm which phase difference is caused by the difference in transmission characteristics (principally in lengths) of the passageways to the front and back of the diaphragm, respectively. The diaphragm is mounted in a cavity which corresponds in shape to that of the diaphragm. This cavity is very narrow so that the members bordering the cavity lend support to the diaphragm even when relatively large pressures are applied to it.

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 longitudinal cross-sectional view taken through the central axis of a shell or projectile made in accordance with this invention;

Fig. 2 is a longitudinal view, partially in cross section taken through the central axis in a plane 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;

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 cross-sectional view taken in a plane through line 5-5 in Fig. 2.

Referring more specifically to the drawings, Figs. 1 and 2 are longitudinal views of a shell representing an illustrative embodiment of the present invention. Fig. 1 is a cross-sectional view taken through the longitudinal axis of the shell while Fig. 2 is a longitudinal view, a portion of which is in cross section taken at right angles to the plane of the section of Fig. 1. The outer portion of the shell of projectile 10 comprises 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 a rotation about the central or longitudinal axis, and a cap or nose 13. Mounted between the body or casing member 11 and the cap 13 is an assembly 14 which will be designated the "recording block." The recording block 14 has screw threads 15 which engage complementary internal screw threads on the member 11 and has screw threads 16 which engage complementary screw threads in a cut-in portion of the nose 13. The recorder block 14 and the nose 13 are machined to continue the contours of the body member 11.

Between the recording block mechanism 14 and the base of the body member 11 is mounted a cylinder 17, preferably made of a light, strong metal such as duralumin. This cylinder 17 may be of circular cross section but it is preferably

made elliptical as shown in the drawings in order to prevent turning movement between the cylinder casing 17 and the body member 11. The cylinder contains a suitable fluid 18, preferably one which will not ignite or explode when the shell strikes the target, such as, for example, water or carbon tetrachloride. At the base end of the body member 11, the cylinder 17 is firmly held within a supporting member 19 which in turn is screwed to the base by a screw plug 20. The fluid in the cylinder 17 passes out through an elbow member 21 and an orifice 22 of predetermined size at the extremity thereof at the periphery of the supporting member 19 into a compartment or chamber 23 surrounding the cylinder 17. This chamber 23, as will be pointed out more fully below, is connected by means of air passages to other portions of the shell. A valve 24 is placed in the elbow member 21 which valve will be referred to more particularly below.

The recording drum assembly 14 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 29 which is free to run in two bearings, one in the removable bushing 30 and the other in the main steel housing 25. A screw-threaded portion 31 on one end of the shaft 29 is screwed into a nut 32 which cannot rotate because it is loosely pinned 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 coating surface on the drum. Preferably this coating surface is cellulose acetate, although it can be of any other suitable material. One end of a metal tape 33 (preferably of strong thin steel) is connected to the shaft 29 and the other end of the tape is fastened to the top portion 34 of the piston 35. The recording block 14 has a passageway 36 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 35 to drive it downward (to the left in Figs. 1, 2 and 3). The top portion 34 of the piston 35 is connected to the body portion 37 of the piston by any suitable means. Two leather washers 38 and 39 are placed around the lower and upper portions of the body member 37 and are shaped and proportioned so as to make a fluid-tight seal at the top of the cylinder 17 to prevent leakage of air to the fluid 18 filling the cylinder 17 and to prevent leakage of the fluid 18 through the opening or passageway 36 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 13 and various smaller passageways 51 and 52 connecting to this 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 in a plane at right angles to the longitudinal axis of the shell and which connect with an equal number of passageways 53 leading to the interior compartment 23 and the axes of which are parallel to the longi-

tudinal axis of the shell. There are also a similar number of passageways 54 each leading from a passageway 53 to the back of the diaphragm 26. 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 that the transmission characteristics differ, the sound waves on the front of the diaphragm have not at any particular instant 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 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 coating on the drum 28 and thus recording signals representative of the sound wave which enters the shell from outside. This sound may be caused by the motion of the shell itself (for instance, a whistle) or by sound caused by other elements such as by an aeroplane, 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 the heavier medium. By means of the various passageways the pressure on the two sides of the diaphragm is made equal to that of the interior 23 of the shell body.

For protective purposes, the face 55 of the housing 25 clears the diaphragm 26 by only a very small amount, for example, by about fifteen thousandths of an inch. Similarly, the rear surface 56 of the nose piece 13 clears the diaphragm surface by only a few mils. As the diaphragm cavity formed between the faces 55 and 56 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 57 which comprises a sliding plug member 58 held in place across the passageway 50 by a spring 59 which is backed by a screw plug 60. When the centrifugal force due to the rotation of the shell is sufficiently great, the plug 58 compresses the spring 59 to such an extent that the passageway 50 is opened to the smaller passageways 51 and 52. A hole stopped by a plug 61 also runs into the passageway 50 on the diaphragm side of the valve 57 and can be used to pump the inside of the shell to higher than atmospheric pressure. As pointed out above, previous to loading the shell in the gun the shell interior is pumped to an internal pressure slightly greater than that anticipated on the nose at the beginning of flight. The valve 24 (see Fig. 5) is likewise a slide valve, it being a plug 62 normally in a position to shut off the passageway leading from the cylinder 17 to the orifice 22 but, as soon as the centrifugal force due to the rotation of the shell is great enough, it is moved to one side thus opening the passageway 21 and allowing the liquid to flow from the cylinder 17 into the chamber 23 at a rate determined by the dimensions of the orifice 22. The force driving the piston is that due to the increased air pressure on the top side of the piston minus that on the lower side of the piston which is the difference between

that caused by the same air pressure (since the air in the chamber 23 tends to assume the same pressure as that applied to the diaphragm) and the centrifugal force acting on the liquid passing through the orifice.

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 57 in the nose and the valve 24 in the block 19 containing the orifice 22 tend to open these valves. However, their design is such that the linear acceleration forces exert sufficient friction on the valve members to overcome these centrifugal forces and the valves stay closed. This relieves the diaphragm 26 of the nose pressure when the shell is pushing air out of the barrel of the gun. Thus, during this period, the fluid motor piston 35 remains essentially at rest. As soon as the shell is a few feet from the barrel, however, the linear acceleration changes from a high positive to a small negative value and the valves 57 and 24 open. When the valve 24 opens, fluid from the cylinder 17 begins to be discharged through the orifice 22 by the centrifugal action of the spinning shell, and the piston 35 is forced down in the cylinder 17 by the air pressure on the top side 34. The air reaches the top side 34 of the piston 35 by means of the nose passageway 50, small passageways 52 and passageways 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 36 to the top side of the piston 35. The movement of the piston downward in the cylinder 17 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 31 in the nut 32. Inasmuch as the stylus 27 rests upon the drum 28 and is moved up and down (to the left or the right in Figs. 1, 2 and 3) a helical record of the sounds reaching the diaphragm after the valve 57 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 of the orifice 22 as well as upon other factors such as the linear and rotational velocities of the shell, distance to estimated sound source, etc. The moment the valve 57 in the nose of the shell opens, air will flow either in or out depending upon whether the outside or the inside pressure is greater. As pointed out above, the inside pressure is caused by pumping up the shell previous to inserting it in the gun. Due to the fact that the passageways 51, 52, 53 and 54 are restricted, equalization of the pressure in the nose passageway 50 and the pressure in the internal compartment 23 and in the space behind the diaphragm 26 takes a finite time. During this interval a large static pressure will act upon the diaphragm in one direction or the other but due to the narrowness of the cavity containing the diaphragm 26, the movement is restricted to a distance of the order of 12 mils and the diaphragm will not be harmed. As soon as the pressure is equalized the stylus will resume a normal position and make a normal depth of the 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. The reason for pumping up the shell is, as pointed out above, to reduce the interval required for equalization. Due to the fact that the distance to the back of the diaphragm is greater than the distance to the front, the sound pressure at any particular instant on the front of the diaphragm 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 23 is representative of the sound pressure encountered by the nose of the shell as it moves through the fluid medium. The recording drum 23 is enclosed as much as possible by the steel housing to give it maximum protection when the shell lands. Preferably the shell should land 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 fuzes for discharging explosive charges contained in anti-aircraft shells.

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, a casing or shell adapted to be moved through a fluid medium with a spinning motion by energy imparted to it at the beginning of its movement, said casing not being provided with means for driving it, a motor member within said casing and coaxially positioned with respect to the longitudinal axis thereof, and means controlled by energy derived from the spinning movement of said casing through said medium for operating said motor member in one direction only during the movement of said casing, said one direction being opposite to the direction of movement of translation of said casing.

2. In combination, a casing or shell adapted to be moved through a fluid medium with a spinning motion by energy imparted to it at the beginning of its movement, said casing not being provided with means for driving it, a cavity in said casing, a fluid-filled compartment within said casing adapted to have its volume gradually reduced under external pressure during a predetermined period of movement of translation of said casing through said medium and having a constricted opening in the wall thereof to permit the escape of said fluid filling into said cavity when the volume of said compartment is reduced, means for applying pressure in one direction only during the movement of said casing to the exterior of said compartment to reduce its volume, and means operated by said spinning

motion for starting the operation of the volume reduction of said fluid-filled compartment.

3. In combination, a casing or shell adapted to be moved through a fluid medium with a spinning motion by energy imparted to it at the beginning of its movement, said casing not being provided with means for driving it, a cavity in said casing, a fluid-filled compartment within said casing adapted to have its volume gradually reduced under external pressure during a predetermined period of movement of translation of said casing through said medium and having a constricted opening in the wall thereof to permit the escape of said fluid filling into said cavity when the volume of said compartment is reduced, means for applying pressure produced by the movement of said shell through said medium and in one direction only during the movement of said casing to the outside of said compartment, and means operated by said spinning motion for starting the operation of the volume reduction of said fluid-filled compartment.

4. In combination, a casing or shell adapted to be moved through a fluid medium with a spinning motion about its longitudinal axis, a rotatable member mounted therein around an axis which is transverse to said longitudinal axis, and means controlled by the spinning movement of said casing for rotating said member about its axis and also moving it laterally thereof.

5. The combination with a casing or shell adapted to be passed through a medium capable of propagating sound, of mechanism inside said casing comprising means actuated by sound in the surrounding medium, and movable means cooperating therewith having its movement controlled by energy derived from the movement of said casing through said medium, said movable means being located inside said casing or shell.

6. A device for recording sound waves in a sound field produced by a moving or remote sound source comprising a casing or shell adapted to be projected into said sound field in proximity to said source, a sound responsive member mounted within said casing, a sound record medium in cooperative relation thereto to record the sounds causing responses from said sound-responsive member, and means operated by the movement of said casing to and through the sound field to move said recording medium relative to said sound responsive element, said last-mentioned means being located inside said casing or shell.

7. In combination, a casing or shell adapted to be moved through a medium capable of propagating sound, a member mounted within said casing which is adapted to be responsive to sound in the surrounding medium, a sound record medium in cooperative relation thereto to record the sounds causing responses from said sound-responsive member, means including a passageway from the exterior of said casing and which surrounds at least a portion of and is coaxial with the linear axis of said casing for conducting sound waves from the front portion of said casing to said sound responsive member, and means controlled by energy derived from the movement of said casing through said medium to cause relative movement between said recording medium and said sound responsive member.

8. In combination, a casing or shell adapted to be moved through a medium capable of propagating sound, a diaphragm member mounted within said casing which is adapted to be responsive to

sound in the surrounding medium, a stylus carried by said diaphragm member, a sound recording medium in cooperative relation thereto, means including a passageway from the exterior of said casing and which surrounds at least a portion of and is coaxial with the linear axis of said casing for conducting sound waves from the front portion of said casing to said sound responsive member, means including passageways from said means to both front and rear surfaces of said diaphragm members for equalizing the static pressure on both surfaces of said diaphragm member, and means controlled by energy derived from the movement of said casing through said medium to cause relative movement between said recording medium and said stylus.

9. In combination, a casing or shell adapted to be moved through a medium capable of propagating sound, a sound responsive diaphragm mounted within said casing, a main passageway within said casing for conducting sound waves from the outside of said casing to the neighborhood of said diaphragm, a first group of supplementary passageways leading from said main passage to different portions of one face of said diaphragm, a second group of supplementary passageways for connecting said main passage to various portions of the other face of said diaphragm, the passageways in said second group being larger than those in said first group, a sound recording member, a stylus positioned so as to make tracks on said sound recording member in response to movements of said diaphragm, and means controlled by energy derived from the movement of said casing through said medium to cause relative movement between said stylus and said sound recording member.

10. In combination, a casing or shell adapted to be moved through a medium capable of propagating sound, a sound responsive member mounted within said casing, said sound responsive member comprising a stylus connected to a diaphragm which is adapted to be actuated by sound waves entering said shell from the exterior thereof, a drum member adapted to be contacted by said stylus, said drum being mounted about an axis which is substantially transverse to the path of movement of said casing and which is coated with a material which is capable of being engraved by said stylus to produce recordings thereon as said drum is turned, a cylinder within said casing, said cylinder containing a fluid, a piston within said cylinder, means for connecting said piston to said drum to produce rotation thereof when said piston is moved within said cylinder, and means controlled by energy derived from the movement of said casing through said medium to cause said piston to move within said cylinder and thereby rotate said drum.

11. In combination, a casing or shell adapted to be moved through a fluid medium, a rotatable drum mounted within said casing about an axis which is substantially transverse to the path of movement of said casing, and means controlled by the movement of said shell for rotating said drum and for simultaneously causing a lateral movement thereof along its axis.

12. In combination, a casing or shell adapted to be moved through a fluid medium and having a passageway therein open to the surrounding medium at the front end of said casing as it moves through said medium, and movable mechanism within said casing subjected to and having its movement controlled by pressures produced in said passageway by the movement of said casing, said movable mechanism comprising a sound sensitive vibratable element positioned to be subjected on opposite sides thereof to opposing pressures from said passageway.

HARVEY FLETCHER.

JOHN F. MÜLLER.

KARL D. SWARTZEL, JR.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
748,159	Briggs	Dec. 29, 1903
1,842,160	Ford	Jan. 19, 1932
1,870,405	Doe	Aug. 9, 1932
1,990,052	Sosa	Feb. 5, 1935
1,850,196	Bardsley	Mar. 22, 1932
909,502	Woodruff	Jan. 12, 1909
1,581,586	McCauley et al.	Apr. 20, 1926
1,666,503	Niethamer	Apr. 17, 1928
1,472,941	Schneider	Nov. 6, 1923
1,490,253	Blosky	Apr. 15, 1924
1,415,933	Hume	May 16, 1922
2,053,108	Rabald	Sept. 1, 1936
676,139	Klumak	June 11, 1901
1,785,724	Brant	Dec. 16, 1930
2,109,475	Fanning	Mar. 1, 1938
1,588,932	Blair	June 15, 1926
1,085,849	Catucci	Feb. 3, 1914
227,679	Edison	May 18, 1880
200,521	Edison	Feb. 19, 1878
2,406,816	Elmer et al.	Sept. 3, 1946

FOREIGN PATENTS

Number	Country	Date
703,319	Germany	1941
22,651	Great Britain	1900
546,488	Great Britain	July 16, 1942
5,301	Great Britain	Nov. 20, 1913