

June 16, 1964

M. BIELECKI ETAL

3,137,835

UNDERWATER SOUND GENERATOR

Filed June 13, 1957

6 Sheets-Sheet 1

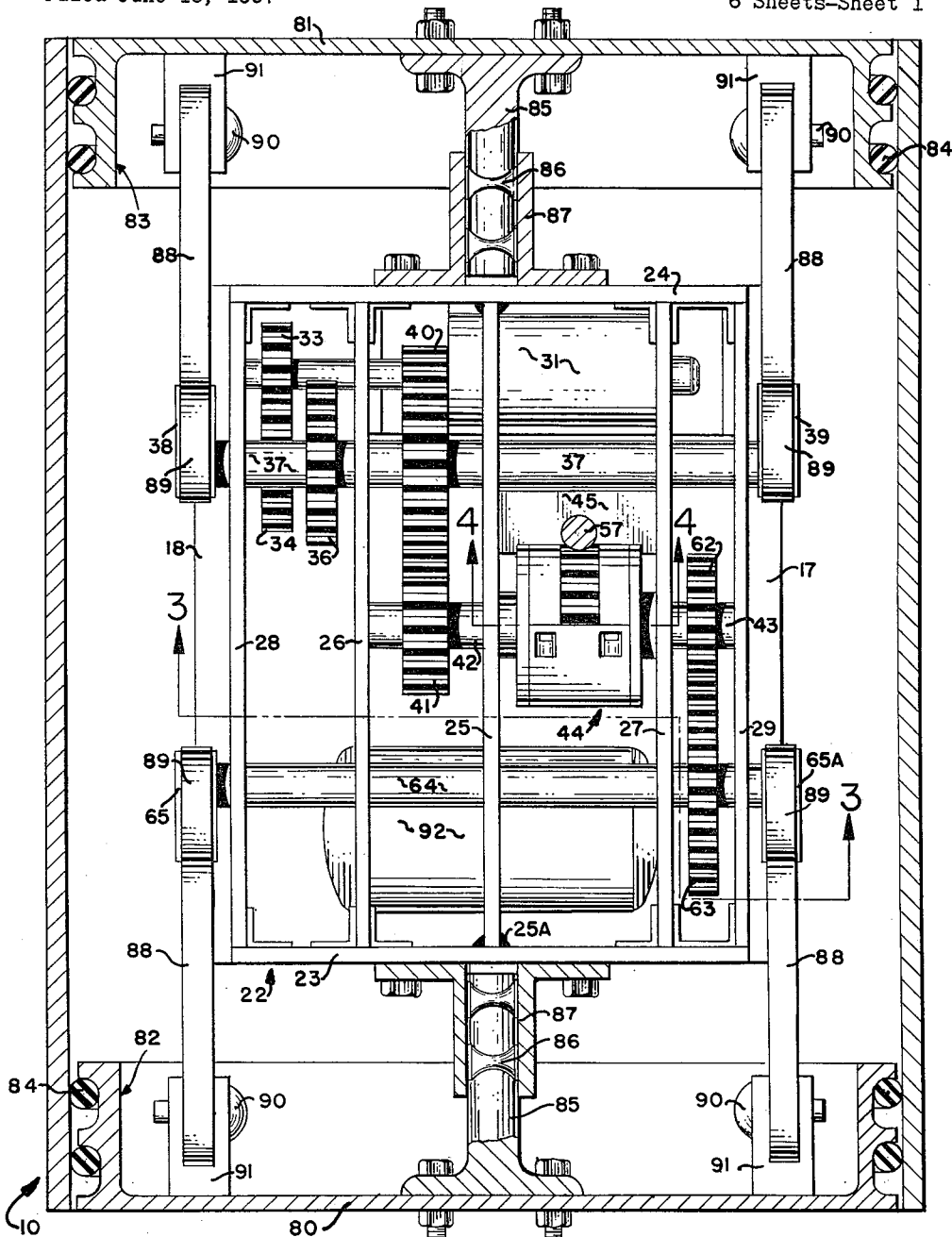


Fig 1

INVENTORS
MAC BIELECKI
BERNARD M. WILNER

BY

J. Gordon Angus
ATTORNEY

June 16, 1964

M. BIELECKI ETAL

3,137,835

UNDERWATER SOUND GENERATOR

Filed June 13, 1957

6 Sheets-Sheet 2

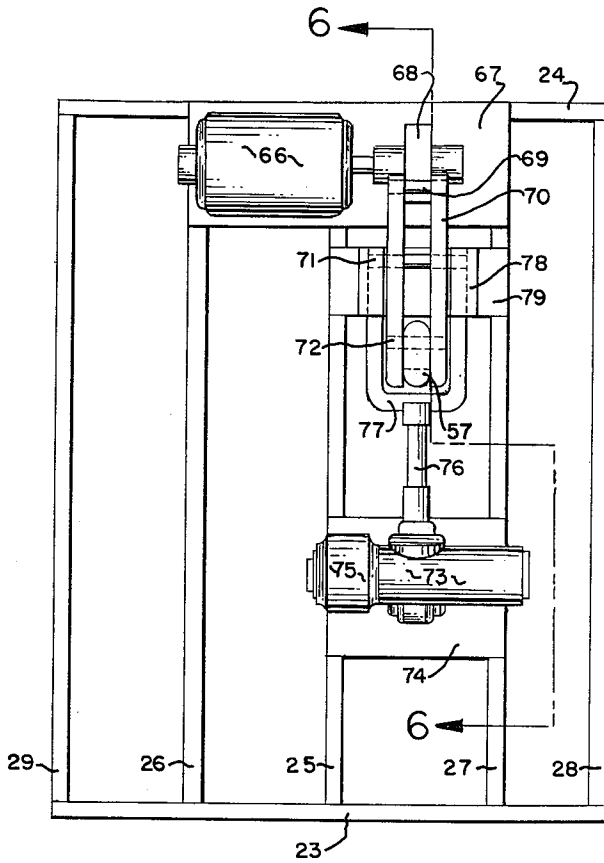


Fig 2

INVENTORS
MAC BIELECKI
BERNARD M. WILNER

BY

D. Gordon Rogers
ATTORNEY

June 16, 1964

M. BIELECKI ET AL

3,137,835

UNDERWATER SOUND GENERATOR

Filed June 13, 1957

6 Sheets-Sheet 3

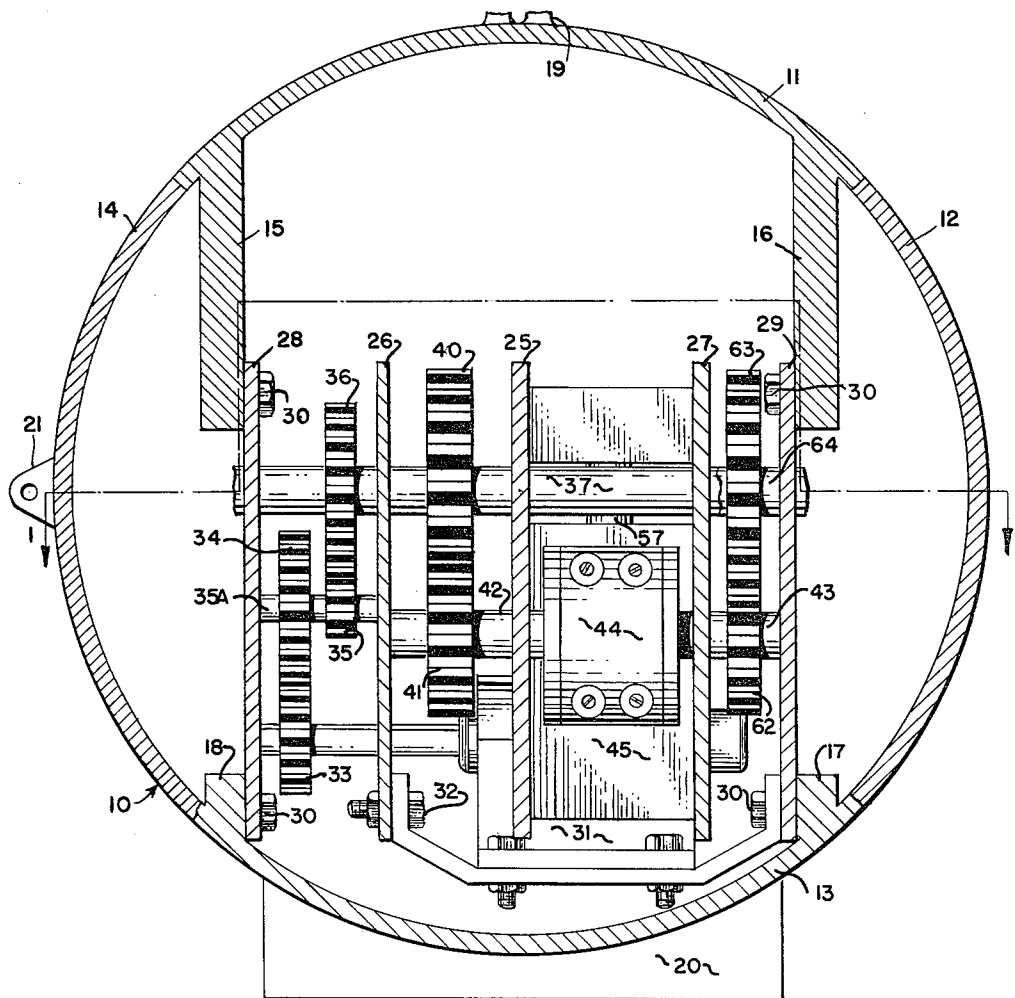


Fig 3

INVENTORS
MAC BIELECKI
BERNARD M. WILNER

BY

D. Gordon Angus
ATTORNEY

June 16, 1964

M. BIELECKI ETAL
UNDERWATER SOUND GENERATOR

3,137,835

Filed June 13, 1957

6 Sheets-Sheet 4

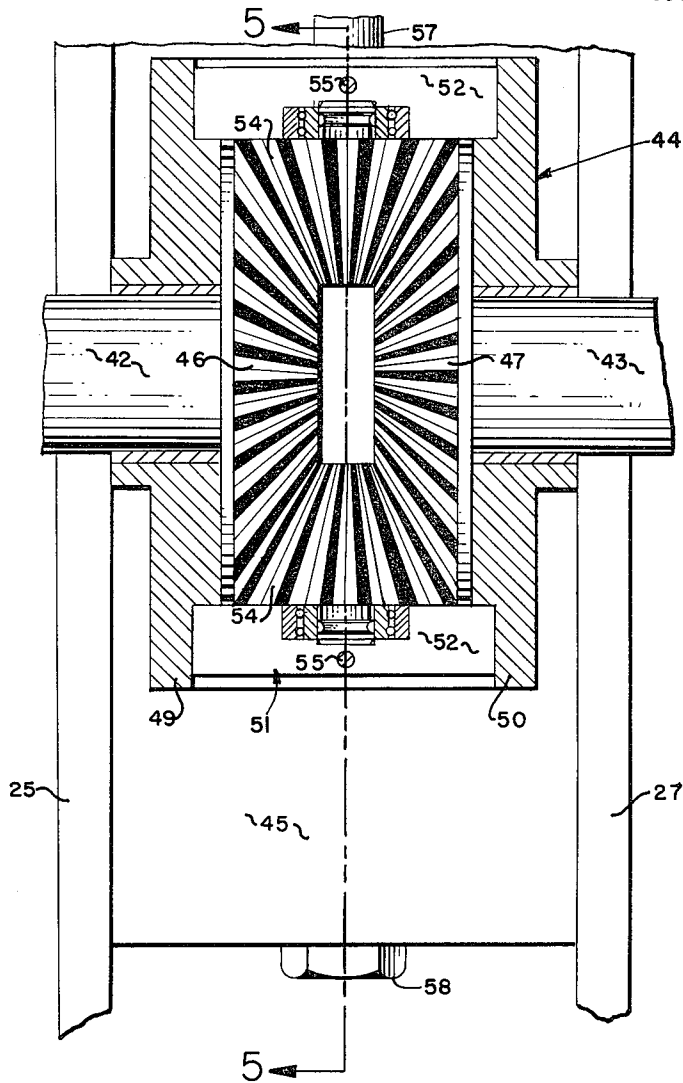


Fig 4

INVENTORS
MAC BIELECKI
BERNARD M. WILNER

BY
J. Gordon Rogers
ATTORNEY

June 16, 1964

M. BIELECKI ETAL
UNDERWATER SOUND GENERATOR

3,137,835

Filed June 13, 1957

6 Sheets-Sheet 5

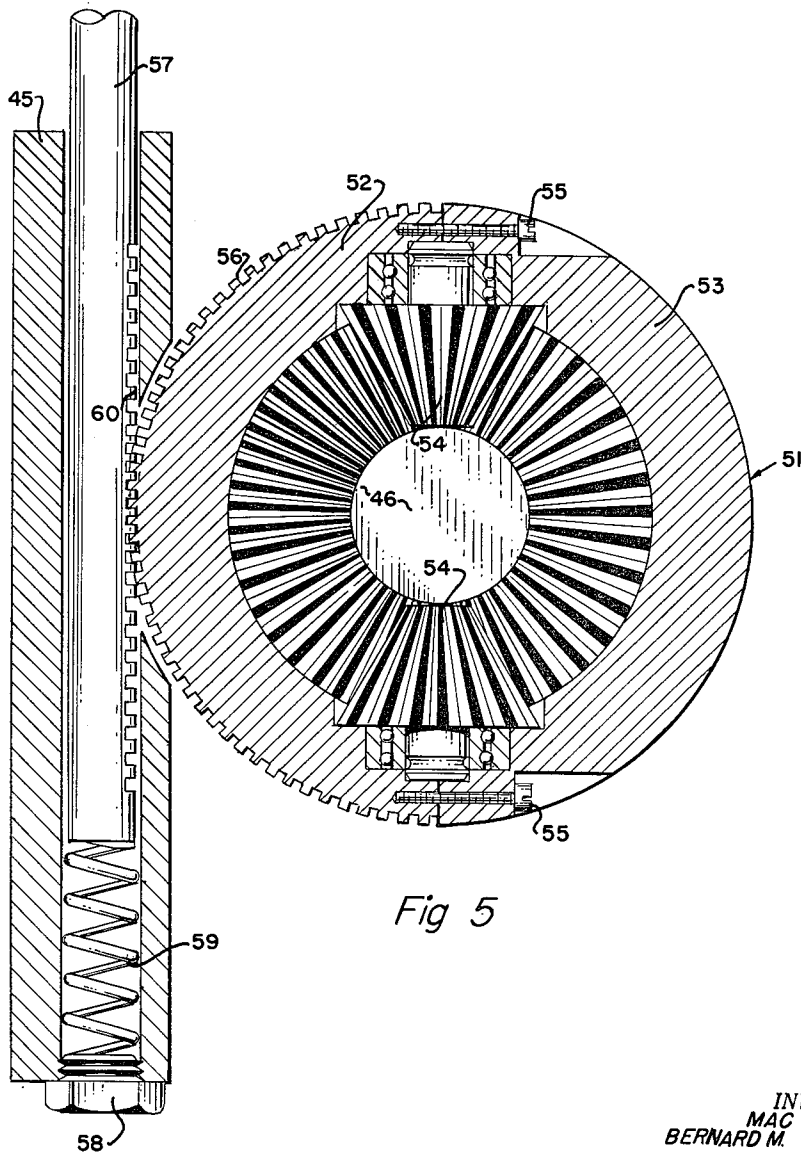


Fig 5

INVENTORS
MAC BIELECKI
BERNARD M. WILNER

BY
J. Gordon Rogers
ATTORNEY

June 16, 1964

M. BIELECKI ETAL

3,137,835

UNDERWATER SOUND GENERATOR

Filed June 13, 1957

6 Sheets-Sheet 6

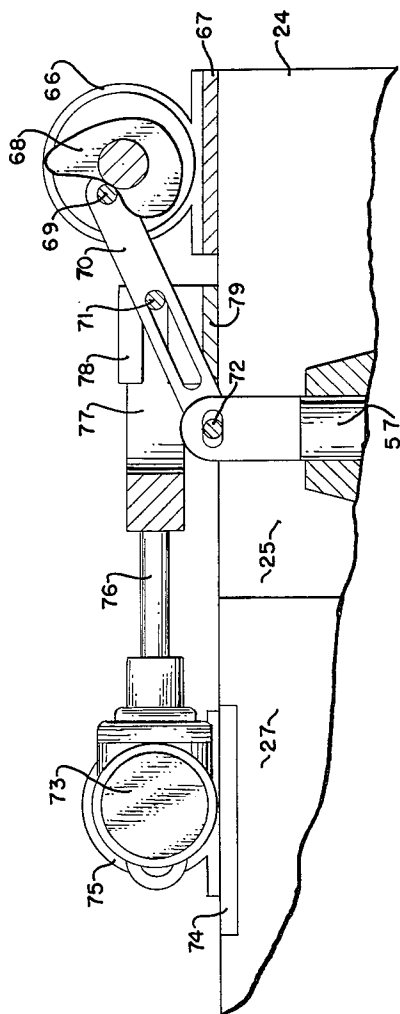


Fig 6

INVENTORS
MAC BIELECKI
BERNARD M. WILNER

BY

D. Gordon Angus
ATTORNEY

1

3,137,835

UNDERWATER SOUND GENERATOR

Mac Bielecki, Glendora, and Bernard M. Wilner, West Covina, Calif., assignors to Aerojet-General Corporation, Azusa, Calif., a corporation of Ohio
Filed June 13, 1957, Ser. No. 666,279
9 Claims. (Cl. 340—8)

This invention relates generally to sound generating devices of a mechanical nature and particularly to such devices having variable power and frequency output.

Some types of sea mines are arranged to be detonated by sounds emanating from passing vessels, being adjusted for actuation in response to sounds within a definite band of frequencies and above a selected intensity threshold. For optimum safety in mine-sweeping operations it is preferable to provide a sound generator for towing behind a vessel, such generators being capable of emitting sonic energy in a manner causing detonation of the mines. Because of the dangers involved, such generators are frequently towed by small craft which produce sounds ordinarily outside the band of frequencies triggering such mines, making it desirable for the generator to be compact and light in weight. Where such a device is of weight and dimensions permitting towing by aircraft, such as a helicopter, additional protection to personnel and equipment is afforded. Conventional mine sweeping devices used for sweeping mines of the sound responsive type are ponderous and heavy, largely precluding the use of small craft for sweeping purposes.

The positive displacement piston type sweeping device is frequently employed in acoustic mine-sweeping. While it is possible to obtain variable frequency and power output with certain previous devices, these characteristics have been inter-related, and it has not been possible to vary one without affecting the other. In order to detonate certain of the modern types of sea mines, it is necessary to be able to vary the power of the sweeping device independently of the frequency output, or to vary the frequency independent of the power output in order that at some instant the intensity and frequency necessary to detonate the mine, which may be unknown to the operators of the device, are simultaneously produced.

It is, therefore, the principal object of the present invention to provide an improved mechanical sound generator of the positive piston displacement type.

Another object of the present invention is to provide a novel method of and improved means for detonation of acoustic mines.

Still another object is to provide a novel method of and improved means for frequency and amplitude modulation of the output of a mechanical sound generator in a manner whereby the change in each is independent of the other.

Yet another object of the present invention is to provide a novel method of and improved means for varying the frequency and power output of a mechanical sound generator in a given manner with respect to time, as for example to simulate the passage of a moving vessel.

And still another object of the present invention is to provide a light acoustic mine detonator of simple and rugged construction.

In its principal aspect, the invention comprises a mechanical sound generator of the positive displacement piston type adapted to be towed through the water while submerged. A plurality of movable pistons are arranged in water-tight relationship within and forming a portion of the outer surface of a carrying container. Remote controlling means are provided for varying the speed of piston travel, varying the relative movement of each

2

piston with regard to other pistons, and changing the rate and manner in which these factors may be varied in order that frequency and power output may be varied independently of the other.

These and other objects, aspects, features and advantages of the present invention will be apparent to those skilled in the art from the following more detailed description taken in conjunction with the appended drawings wherein:

FIGURE 1 is a plan view of operating mechanism of the present invention taken along the line 1—1 of FIGURE 3 and illustrating its arrangement with regard to the maximum width of the structure housing the mechanism.

FIGURE 2 is a plan view showing additional mechanism mounted above that shown in FIGURE 1 in the common cylindrical housing.

FIGURE 3 is a cross-sectional view taken on line 3—3 of FIGURE 1, showing the mechanism of FIGURE 1 as enclosed in the cylindrical housing.

FIGURE 4 is a cross-sectional view taken on the line 4—4 of FIGURE 1 drawn on a larger scale.

FIGURE 5 is a cross-sectional view taken on the line 5—5 of FIGURE 4; and

FIG. 6 is a cross section on the line 6—6 of FIG. 2, drawn on a larger scale and showing controlling mechanism with the parts of the device.

Referring now to FIG. 3, the numeral 10 indicates generally a cylindrical housing comprising segments 11, 12, 13 and 14, which may be welded together. Segments 11 and 13 may be cast integral with inwardly projecting marginal flanges 15, 16, 17 and 18, which are shorter than the length of the segments. A cable attachment eye 19 is welded to segment 11, and a sheet metal stand 20 is welded to segment 13. Cable attachment eyes 21, one of which is shown, may be welded to segments 14 and 12. The inner surface of the cylindrical housing 10 is carefully ground for a distance inwardly of each end thereof for a purpose that will later appear.

Referring now to FIGURE 1, the operating mechanism of the device is mounted in a frame 22 and comprises a front plate 23, a back plate 24 connected by a center plate 25, which may be welded thereto, as indicated at 25a.

Intermediate plates 26 and 27, parallel to the center plate 25 may be secured in any suitable way to the back and front plates 23, 24, for instance, as shown by angle material and machine screws. As shown in FIG. 3, outer plates 28 and 29 are also secured similarly to the front and back plates but extend across the width of the cylindrical housing 10 and are secured as by bolts 30 to the longitudinal marginal flanges 15, 16, 17 and 18 of segments 11 and 13. A main drive motor 31 is secured by bolts 32 between frame plates 29 and 26 toward the back of the housing.

A drive pinion 33 (FIG. 3) on the shaft of the motor 31 engages with speed reduction gearing comprising a gear 34 and a pinion 35 on a lay shaft 35a, pinion 35 engaging with a gear 36 mounted on shaft 37.

Referring to FIG. 1, shaft 37 extends across the frame 22 and has mounted thereon eccentrics 38, 39 outside the frame side plates 28 and 29 respectively. A gear 40 mounted on shaft 37 drives a gear 41, mounted on a two-part intermediate shaft 42, 43 connected by differential gearing generally indicated at 44 which is effective to vary the phase of rotation of shaft 43 with respect to the motor driven shaft 42 from rotation in unison therewith to rotation at 180° from that of shaft 42 in which condition substantially no signal will be generated, since the piston moving outwardly will merely cause the suspended housing 10 to move in the opposite direction to that of an outwardly moving piston.

Shaft 43 will be rotated in the opposite direction to shaft 42 at all times.

In FIG. 4 a block 45 is secured between frame members 25 and 27 and supports a controlling member for the differential gear assembly 44, as later described. The differential gear assembly 44 comprises bevel gear 46 mounted on shaft 42 and a bevel gear 47 mounted on shaft 43. Between the gear 46 and frame center plate 25, by which shaft 42 is supported, and between gear 47 and frame side plate 27, by which shaft 43 is supported, spacing and locating discs 49 and 50 are positioned to rotate freely on shafts 42, 43. A split ring planet gear carrier 51 (FIG. 4) is mounted on said discs 49, 50. As best illustrated in FIG. 5 the halves 52 and 53 of ring carrier 51 each carry planet gears 54 and the halves of the carrier 51 are secured together by heavy machine screws 55. On the half 52 of the carrier 51, a toothed segment 56 is cut around the periphery.

Block 45 is bored to receive a rod 57 for reciprocatory movement, the bore being closed at its lower end by threaded plug 58. A coiled spring 59 is mounted under compression between the end of rod 57 and plug 58. Intermediate the ends of the rod 57 a rack 60 is cut, the block 45 being cut away at the location of the rack 60 and so positioned in the frame 22 that the teeth of the toothed segment 56 on planet carrier half 52 mesh with the rack 60. The upper end of rod 57 is engaged by operating means, later described.

Referring once more to FIG. 1, shaft 43 has mounted thereon a gear 62 which engages with a gear 63 on a shaft 64 extending across the frame 22, and eccentrics 65 and 65A are mounted on the shaft 64 on the outside of the side frames 28 and 29.

The operating means for the mechanism comprise, in addition to motor 31, a motor 66 (FIG. 2) mounted on a base plate 67 supported on the upper edge of frame plates 26, 25, 24 and 27. Motor 66 rotates a cam 68, best shown in the view of FIG. 6, which oscillates a follower 69 mounted at one end of a lever 70 on an adjustable fulcrum 71 and pivoted at its opposite end, as indicated at 72, to the end of rod 57. The position of the fulcrum 71 is adjusted by a linear actuator 73 mounted on a base plate 74 supported on and secured to the upper edge of the frame plates 27 and 25. The actuator is operated by the small high speed reversible motor 75 through a speed reduction gear (not shown) that causes the rod 76 to reciprocate. The rod 76 is connected to a yoke 77 having slotted arms guided in slides 78 mounted on a plate 79 secured on frame plates 27 and 25. The fulcrum 71 is mounted in the slotted arms of the yoke 77; it will be evident that the nearer to the follower 69 the fulcrum 71 is moved, the longer will be the stroke given to the rod 57 and vice versa. Spring 59, shown on FIG. 5, effects return of rod 57 and holds the follower 69 against cam 68.

Referring again to FIG. 1, the ends of the housing 10 are closed by pistons 80, 81 working on the ground inner periphery of the end portions of the casing and having deep skirts 82 and 83, O-ring seals 84 being provided to seal between the skirts 82, 83 and casing 10.

Weight carrying and centering members each comprising a flanged tubular stem 85 are bolted to the center of each piston 80, 81 and supported on inwardly curved rollers 86 carried in pairs of brackets 87 mounted on the end plates 23, 24 of the frame 22. By using two pairs of such brackets and rollers for each piston, the weight of each can be taken in any angular position of the housing about its longitudinal axis, while the housing is maintained in horizontal position, which is the normal operating position of the device, and the pistons accurately centered in the housing.

Pistons 80, 81 are reciprocated by pitmans 88 mounted at their inner ends, as shown at 89 on the eccentrics 38, 39, 65 and 65A, and connected at their forward ends by

pivots 90 secured in brackets 91 bolted or riveted to the inner face of the pistons 80, 81.

A tank 92 is preferably provided which may be filled with air under pressure and controlled by a valve effective to maintain a predetermined air pressure in the casing 10 to prevent entry of water therein.

Operation

The device is intended primarily to detonate sea mines and is intended to be towed through the water at a predetermined depth by the provision of any suitable means, not shown. Because of the relatively small weight of the device, the towing cable may be of small cross section and the electrical cables may be incorporated with the cable in a covering of buoyant material, the cross section of the sheathed material being small enough to be readily wound on standard winches carried by relatively small vessels.

The motor 31 directly drives gears 40 and 41 and shaft 42 as shown in FIGURE 1. Referring now to FIGURE 4, the rotation of shaft 42 drives the bevel gear 46 that is a part of the differential gear assembly 44. As previously stated, rotation of shafts 42 and 43 are always in opposite directions. The shafts 42 and 43 would rotate at the same r.p.m., after gear carrier 51 is held stationary. The reciprocation of the rod 57 rotates the gear carrier 51, along with the planetary gears 54, to thus vary the rotation of the shaft 43 and the movement of the piston 80. In essence, the piston 81 reciprocates at a rate relative to the rotation of the driving motor 31, while the piston 80 reciprocates in a constantly changing rate relative to the rotation of motors 66, 75 and the shape of the cam 68, thereby varying the phase relationship between the two pistons in a well known manner.

The acoustic frequencies induced in the surrounding water by the present invention are dependent upon the volume of water displaced by the pistons 80, 81, a function of piston speed. The output frequency can therefore be selected by choice of operating speed of the main drive motor 31. It is seen that the speed of the motor 31 may be changed in any desired manner, thereby producing frequency modulation of the acoustic signal.

The power output of the sound generated is dependent upon the degree with which the two pistons are synchronized in their excursions. When both pistons 80, 81 are moving oppositely, that is, they are at their maximum outward excursions at the same instant, maximum output intensity results. When one piston is 180° behind the other, that is, where one is at the maximum excursion point while the other at its minimum excursion point, minimum output intensity results. Intermediate degrees of phase relation may be selected through adjustment of the differential gearing 44 and continuously varying the phase relation in a manner determined by the shape of the cam 68 and speed of its rotation provides amplitude modulation of the output signal. The modulation of the generated sound may be carried out in any desired manner by controlling the electrical elements by manual or automatic control of the energizing circuits thereof as is well understood in the art.

By varying the movement of the pistons 80, 81 in a cyclic manner by any appropriate means, signals will be generated by the device which will sweep a very wide band of volume and frequency, in all probability covering the frequency and volume for which particular mines have been set and cause their detonation.

While a preferred embodiment of the invention has been specifically described, it is to be understood that various other arrangements of the parts of the device may be made as, for instance, by arranging a number of pistons rather than a pair of pistons in the casing with their faces in contact with the water, or by using inner pistons surrounded by annular pistons instead of opposed pistons of usual types, and it is not intended,

5

therefore, to limit the scope of the invention otherwise than as defined by the appended claims.

We claim:

1. An underwater sound generator comprising: a water-tight submersible housing; a plurality of pistons, the outer faces of which form a portion of the outer surface of said housing; sealing means in water-tight engagement between said pistons and said housing; means reciprocating said pistons through a constant distance; and means for varying the phase relation of each of the pistons to each other.

2. An underwater sound generator comprising: a hollow cylindrical housing; a plurality of piston means arranged within and forming the ends of said housing; sealing means arranged between said piston means and said housing to afford a water-tight enclosure; means to reciprocate said piston means in rectilinear motion through a constant distance; and means to vary the reciprocating movement of each of the piston means relative to the movement of each other.

3. An underwater sound generator comprising: a cylindrical housing having open ends; a piston having skirts arranged to reciprocate in each open end to form a closure therein; sealing means between the skirts of said piston and the inner walls of said housing and affording with said pistons a water-tight enclosure; variable speed means to reciprocate one of said pistons through a constant distance; and means to vary the reciprocating movement of the other piston relative to the movement of said first piston.

4. An underwater sound generator comprising: a submersible housing having reciprocable portions forming part of the fluid-tight enclosure of said housing; a variable speed motor arranged within said housing directly driving certain of said reciprocable portions; a differential gearing means having a driving gear and planet pinions arranged within said housing; said motor driving other of said reciprocable portions through said differential gearing means; and means effective to continuously move the planet pinions relative to the driving gear of the differential gearing whereby the phase of the movement of said reciprocable portions of the housing driven through said differential gearing relative to the movement of the reciprocable portions of the housing directly driven by said motor is continuously varied.

6

5. An underwater sound generator as set forth in claim 4 in which the means effective to continuously move the planet pinions comprise: a separate motor; a cam driven thereby; a lever oscillated by said cam; and a driving connection between said lever and a member on which said planet pinions are mounted.

6. An underwater sound generator as set forth in claim 5, and in addition, means effective to vary the amount of movement imparted by said lever to the member on which said planet pinions are mounted.

7. An underwater sound generator as set forth in claim 6, and in which said means effective to vary the amount of movement imparted by said lever comprise: a fulcrum mounted intermediate the ends of the lever; and separate electrically operated means for varying the position of said fulcrum.

8. An underwater sound generator, comprising: a plurality of means for displacing water; variable speed actuating means; means for directly coupling said actuating means to one of said displacing means; a second means for coupling said actuating means to another of said displacing means; and means for controlling said second coupling means to vary the extent to which one of said displacing means will be in synchronous motion with another of said displacing means.

9. An underwater sound generator comprising: a submersible housing having reciprocable portions forming part of the fluid tight enclosure of said housing; a variable speed motor within said housing directly driving certain of said reciprocable portions, a differential gearing means arranged within said housing, said motor driving other of said reciprocable portions through said differential gearing means, and means for controlling said differential gearing means and engaged thereto whereby the relative motion of the several reciprocable portions of the housing is variable.

References Cited in the file of this patent

UNITED STATES PATENTS

2,081,619	Ebert	May 25, 1937
2,395,862	Freeman et al.	Mar. 5, 1946
2,419,603	Smith	Apr. 29, 1947
2,424,357	Horsley	July 22, 1947
2,587,848	Horsley et al.	Mar. 4, 1952