March 21, 1967 H. T. SAWYER 3,310,129

SONAR WAND

Filed Sept. 8, 1964

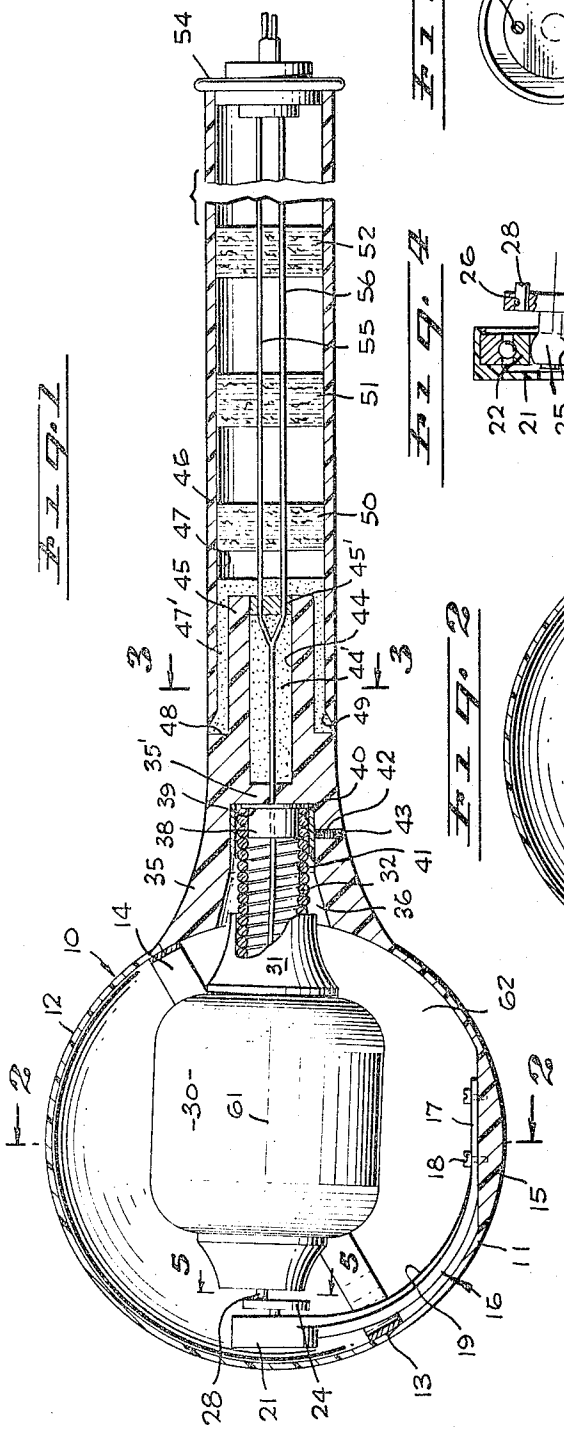


Fig. 1

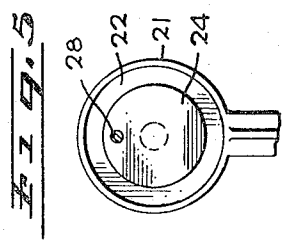


Fig. 5

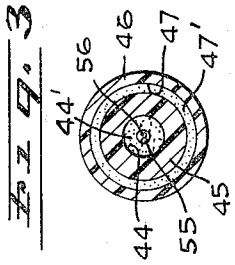


Fig. 3

Fig. 4

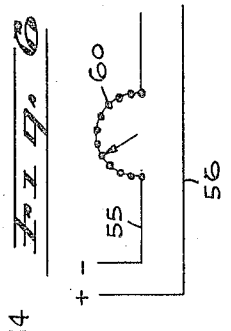


Fig. 6

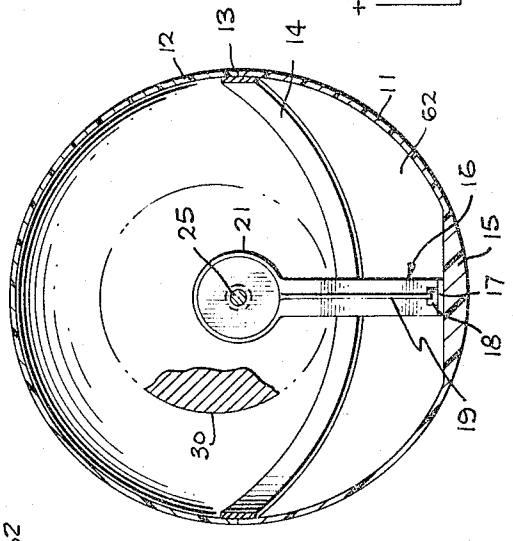


Fig. 2

HAROLD T. SAWYER
INVENTOR.

BY

Beehler & Arant

ATTORNEYS

United States Patent Office 3,310,129 Patented Mar. 21, 1967

3,310,129

SONAR WAND

Harold T. Sawyer, Los Angeles, Calif., assignor of seventeen and one-half percent to Vernon D. Beehler, Los Angeles, Calif.

Filed Sept. 8, 1964, Ser. No. 394,686
17 Claims. (Cl. 181—0.5)

This invention relates to a low power sonic energy source device for generating and transmitting omni-directional sound waves of high energy amplitude and intensity in the lower sonic frequency range when submerged below the surface of liquids of virtually any kind or nature, a combination of a fluid and materials which are located in relatively small containers such as basins, sinks or tubs—and more particularly a hand operated light weight portable sonic energy source mounted in such a fashion that it resembles generally the configuration of a wand and may be safely immersed and freely moved or located below the surface of the aqueous medium. The invention utilizes very low sonic power typically between 45 and 70 watts and generates relatively low frequency sound waves typically between 50 and 150 cycles per second.

The invention is useful as a manually portable household appliance which is capable of washing and rinsing household clothing materials and in a matter of minutes which are now hand washed as a precaution against damage which is generally known to occur by machine washing or for other reasons. Such materials for example, might include fine ladies undergarments, stockings, sweaters, dyed clothing materials, robes, jackets, sports shirts, men's washable slacks, drip dry shirts, cotton and fine woolen dresses, throw rugs, synthetic clothing materials, garments with elastic material, curtains, fine table cloths and linens, etc. This list might also include many materials which might otherwise be solvent cleaned or those requiring special detergents and wash water temperature.

The invention is also useful as a portable industrial device for blending and mixing of one or more liquid chemicals in vats or tubs.

It is also useful as a medical instrument for therapeutic treatment where deep therapy treatment is required in baths and at a desired degree of intensity.

It is therefore among the objects of the invention to provide a new and improved small, low power hand operated portable sonic energy wand for various under liquid uses within fluid containers such as basins or tubs and which is highly efficient in the conversion of energy from an appropriate source to sound wave energy in the lower sonic range.

Another object of the invention is to provide a new and improved portable sonic wand capable of confining most of the emittent sonic energy to the most advantageous and useful location and blocking transmission of the sonic energy to a handle or other supporting structure.

Another object of the invention is to provide a new and improved power operated portable wand of such design and inexpensive construction that it can be immersed and safely moved about by hand in a liquid such as a water solution of soap or detergent and stirred about the bath at will thereby to work the sonic wave energy around in the most advantageous fashion so as to thoroughly impregnate whatever materials may be in the bath which will benefit from sonic wave penetration and to permit the released dirt and contamination to freely drop from the washed materials.

Still another object of the invention is to provide a new and improved hand operated sonic energy wand for conversion of energy into sound waves in the lower sonic

energy range thereby making possible an instrument or device of low power and inexpensive to construct and operate. Still another object of the invention is to provide a new and improved hand operated portable sonic energy wand which is of very simple physical construction, made up of relatively few parts wherein all parts are advantageously located and thoroughly sealed and protected thereby to insure a minimum of maintenance and a maximum of years of use.

Further included among the objects of the invention is to provide a new and improved handy low cost sonic energy wand which is capable of effectively generating and transmitting sound waves of such amplitude and intensity when immersed in a container of liquid and washable materials that the resultant penetration and cavitation of the liquid and materials is sufficiently intense that the device may be used about the home for washing small or large quantities of washable materials or other objects needing frequent cleaning, or for dyeing of materials in an aqueous or other solution, or for industrial blending of one or more liquid chemicals where the combination of sonic energy penetration, cavitation and stirring is essential for a thorough blend of the mix.

Among the objects are further included the provision of an effective source of sound wave energy in the lower sonic range which is portable and which may be immersed in water with perfect safety and which thusly lends itself to treatment of the human body where the penetration of sound waves in the lower sonic range is beneficial when administered through a water bath for therapeutic treatment.

Still another object of the invention is to provide a means adaptive to remote manual control of the frequency of the sonic sound waves being emitted by the sonic energy source and in combination thereof correspondingly producing a proportional variation in amplitude and intensity of the sonic sound waves, which has been determined as useful in water bath therapy.

Another object of the invention is to provide a sonic energy source which is free of agitation or gyration effects during its production and trransmission of sound wave energy whether operating freely in air or when immersed in liquid, thereby eliminating any disturbing effect to the human hand which may support the sonar wand during such operation and also as a precaution against a loss of efficiency of the sonar wand device due to energy losses produced thereby.

Still another object is to provide a rotating gearless mass driving force which may be mounted in a fixed position within a supporting and protecting cavity shell which represents the radiator shell of the sonor wand device so that the sonar source can be turned and translated by the human hand by means of the handle or sonar source supporting means in any direction or plane without causing torques that disturb the angular orientation of the rotating mass axis relative to its normal axis.

Another object is to provide a portable hand operated sonar wand of such configuration that when in use within a liquid by an operator it will be essentially weightless to the human hand and nearly completely submerged by its own weight.

It is still a further object of this invention to refine the suspension of the gearless rotating mass and in such fashion that it may be suspended and anchored at one end by means of a flexible semirigid supporting means and which supporting means shall also have an excellent property of blocking substantially the passage of sound waves to the anchor position, and the anchor position and associated mechanism to be at a considerable distance from and completely without and withdrawn from the cavity or radiator shell and to be located within the

handle or supporting means, and said flexible supporting means to be substantially central and in the same directional plane as a dimensional line passing through the center of the handle or supporting structure and the eccentric bearing which provides the driving force.

It is another object that the driving force pedestal which causes the cavity to oscillate be provided by a bearing at one end of the rotating self-powered mass to which is attached an eccentric and pedestal, and that the rotational axis of the rotating mass does not coincide with the center of mass of the eccentric.

It is further an object in terms of cost, simplicity of design, weight and efficiency that the rotational mass within the cavity shell include both the driven mass and the mass supplying the rotational velocity and to be as one integral unit or mechanism.

It is another object to provide a source of sound energy making use of a radiator shell which is essentially a non-rigid spherical structure and stiff thin wall material which is perturbed and flectured at a single location within the spherical shell by the driving pedestal supporting means, a pedestal base within the spherical cavity being at a position which is vertically below a directional line which passes through the center line of the eccentric bearing and the centerline of the handle structure and at a point vertically in line with the center of the spherical cavity.

It is also an object of the invention to provide a sound source wherein the center of the radius of gyration of the total rotational mass is at a position which coincides with the center of the spherical cavity.

It is also an object of the invention to provide a sound source such that the radiator shell of the sonic energy source is capable of transmitting sound waves in the lower sonic range substantially in spherical fashion and omni-directional character, and spherically radiated with respect to the spherical radiator shell surface and substantially directional in respect to lines shown from the center of the radiator shell.

It is also an object of this invention to provide a sound source such that the complete enclosure of the sonar wand may be constructed of insulating material of high dielectric strength and totally sealed so that the entire configuration may be in effect an insulator.

It is also an object of the invention to provide a source of sound energy such that the liquid loaded radiator shell therefore is capable of radiating or transmitting sound waves in an alternating sinusoidal fashion and in synchronism with the rotating mass and in such a fashion that the fundamental frequency of the sound waves emitted are directly related and in synchronism with the rotational velocity of the rotating mass.

It is also an object of the invention that the sonic energy source have exceptionally stable frequency control over a limited lower sonic frequency range as previously subscribed and indicated as being pertinent for purposes applicable to the usefulness and application of this invention, and it is also an object of the invention to provide a radiator shell which has its first resonant frequency many times above the frequency of the rotational driven mass within the cavity shell.

It is also an object of the invention to provide a hand operated portable wand sonic energy source which has a low noise factor which is not at all objectional to the human ear whether operated below or above the surface of the liquid.

It is also an object of this invention to provide a sound radiator wherein the surface area of the radiator shell is sufficiently small to provide the necessary radiation intensity of the sound waves for which its use is to be applied, and wherein the radiator shell is constructed with sufficient liquid loaded radiator area to radiate and transmit heat energy which may be generated from within the shell cavity to the liquid medium and in much the same manner that known liquid cooled radiators operate and to radiate sufficient heat energy to the liquid medium

to protect the physical equipment within the cavity from exceeding its operation temperature design values during operation of the device.

It is also helpful to an understanding of the invention to note that ultrasonic energy as used for surface cleaning is identified also as to form of high frequency sound waves, and which has its approximate lower limit at 20,000 cycles per second or just above.

It has been demonstrated that ultrasonic energy in the form of ultrasonic sound waves are useful in cleaning the surfaces of solid objects from grease or other contamination which may have been deposited on such surfaces in the form of a thin film even as small as a structure of molecules. The desired working range of frequencies for surface cleaning has been established to be within a range approximating 23,000 to 40,000 cycles per second. The cleaning action on the surface contamination film has been described as one causing rapid formation and violent collapse of minute microscopic bubbles within the cleaning solvent of the liquid combined with an effect known as implosion. Implosion is an effect created by the combination of inherent reflection and cavitation associated with ultrasonic waves. The reflection energy thus created at the surface and with little penetration effect into the solid material, is aided by minute cavitation bubbles of the solvent, which causes an implosion that pulls or rips off the molecules of the contamination surface film from the solid surfaces.

This manner of cleaning has been demonstrated to be restricted to the use of ultrasonic energy for several reasons. Ultrasonic waves for example, are minutely shorter in wave length than are those in the lower sonic range, and their tendency to efficiently reflect their wave energy from solid surfaces is analogous to microwaves and are therefore an important element in ultrasonic energy surface cleaning. Since ultrasonic wave lengths are shorter as compared to sonic energy wave lengths, they correspondingly produce substantially less and small penetration of solids and less cavitation within the liquid medium than sonic energy at the same energy levels.

Also, ultrasonic energy sound waves are usually associated with small amplitudes and the resultant cavitation within the liquid is thusly small but desirable for ultrasonic cleaning.

It has also been established that ultrasonic energy may be generated to produce high energy amplitudes but only at extremely high and inefficient powers which has been demonstrated to produce undesirable effects such as damage to the material to be cleaned in the form of chipped surfaces and requirements leading to a high degree of ultrasonic frequency shielding to comply with the Federal Communications Regulations.

It has also been demonstrated that when ultrasonic energy sound waves are generated for surface cleaning even slightly below 20,000 cycles per second as designated by the higher limit of the audible or sonic wave energy range, an effect is produced whereby a penetrable high pitch and audible sound is produced which is unhealthy to the human body and many times causing broken ear drums and thusly requiring the use of ear plugs. Therefore, ultrasonic energy cleaning equipment has been designated to operate safely above the lower ultrasonic energy value of 20,000 cycles per second, and the practical lower limit operating value has been established commercially to be at 23,000 cycles per second.

In addition, practically all devices heretofore constructed for ultrasonic surface cleaning have been relatively massive, permanent and stationary in character necessitating many precautions.

Ultrasonic sound waves by nature are highly directional and their application to ultrasonic cleaning requires a number of energy sources per fluid tank to insure radiation coverage of the solid materials to be surface cleaned. Also by nature, ultrasonic energy waves are easily absorbed by the liquid medium and solid materials to be

cleaned. The efficiency of such devices is considered to be extremely low. Because of this and other factors, very high powers are generally required and typically one kilowatt is required for cleaning tanks, from 13 to 15 gallons capacity, and in each case the power supplies are remotely located and are carefully shielded to comply with FCC regulations. There are no known harmful effects to the human body by ultrasonic radiation other than the danger of the sound effects to the ear.

It is recognized that vibrators have been in use for a considerable length of time and are used for various sundry purposes such for example, mechanical shakers for bins, mechanical shakers for conveyors, agitators for expelling air and water from cement during placement of concrete, hand vibrators for massage treatment, agitation of material such as grain being transported from one place to another through conduits, compaction of molding materials in mold form, impulse and gyration devices used in washing machines and impulse machine mechanisms, etc., it is of interest to note in these cases that a relatively small powered vibratory mass is utilized to impact and physically disturb large masses at periodic cycles generally considered to be at 60 cycles or lower. The effect produced in the relatively heavy large masses is one of shaking, vibratory, impulse, pulsation, gyration, movement, displacement, pushing, etc.

The differences in the generation and transmission of energy as exemplified by the two latter examples are at considerable variance with each other and are limited to their own usefulness by the manner in which their energy is produced and transmitted. Likewise, it is also known that the use of under liquid sonic energy sound waves in the lower sonic range for useful applications relative to this invention are by their physical nature also pertinent to the successful use of this invention.

Unlike ultrasonic energy cleaning equipment which requires relatively high power high frequency waves at extremely low amplitude and minute cavitation, the sonar wand device essential requirements dictate a small hand operated sonic energy source of extraordinary high efficiency and low power and of particular importance to the invention the requirements have been demonstrated to dictate the use of sound wave energy in the low sonic range for production of large wave energy amplitudes at high intensity for the production of underwater energy having the necessary degree of penetration and cavitation for its useful application.

Sonic sound waves in the lower sonic range have longer wave lengths than ultrasonic energy waves and therefore by nature are conducive of a much higher degree of penetration of the submerged materials within a liquid; and they are also more conducive by nature to the production of high energy amplitudes at low powers. The continuous reversals of these high amplitude energy waves produce an exceptionally high degree of penetration and cavitation within the liquid and the submerged materials. The continuous reversal of the high amplitude energy at the desired frequency within the liquid and submerged materials, causes the alternate production and collapse of millions of bubbles within the liquid and submerged materials thus creating an implosion effect which rips away the dirt and contamination from the submerged materials.

The implosion bubbles increase in size with a reduction of frequency and are therefore a function of wave length. For example, at 20,000 cycles per second the bubble size is 40 microns, and at 10,000 cycles per second the bubble size is 100 microns and barely visible. In the lower sonic range at 150 cycles the implosion bubble size is approximately 158 microns and clearly visible. It is therefore evident that the implosion effect and resulting cavitation within the liquid and submerged materials is of higher intensity at frequencies in the lower sonic range.

It is also known that high frequency or ultrasonic wave energy waves are highly reflective and by nature do not have the ability to penetrate submerged materials deeply and which thusly has been demonstrated by ultrasonic cleaning equipment, microwaves and underwater acoustic range finding equipment. The degree of penetration is therefore a function of wave length.

Since underwater sound waves travel at a speed of 4800 feet per second, the wave length of ultrasonic energy waves of 24,000 cycles per second is 0.2 feet as compared to a wave length of 40 feet for sonic waves of 120 cycles. By comparison therefore, sonic energy waves in the low frequency range have by comparison therefore a far greater penetration effect than those referred to by comparison.

In accordance with the invention there is herein provided a low power sonar wand device which utilizes a small rugged low power sonic energy source typically between 45 and 70 watts which is reliable, self contained, sound wave and electrically sealed and isolated from the handle or supporting means. The rotating mass driving force body consists typically of a standard gearless shaded pole or series motor approximately 1¼ pounds, or may be any rotating mass which may be powered by air, water or by other means and which may be suspended and substantially sound wave isolated at one end, and directly coupled at the other end through an appropriate eccentric shaft and bearing to a singular pedestal mechanism to its counterpart and supporting structure which consists of a thin wall spherical radiator shell whose non-rigid cavity supports and encompasses the entire sonic energy producing mechanism.

The radiator shell supporting structure approximately 4 inches in diameter, has an infinitely small mass as compared to the rotating mass within its cavity since its shell thickness approximates 1/32 or 1/16 inch in thickness. Representatives of radiator shell weight of 1¼ or 2½ ounces. Because of the small mass of the supporting radiator shell body as compared to the infinitely large mass of the contained driving force assembly body within the cavity, there is but a small velocity reduction between the large rotational body and the supporting body.

Because of these factors, the driving force mass assembly moves with a large energy velocity that produces an extraordinary efficient energy output which is capable of generating and transmitting sound waves in the desired lower sonic range typically from 50 to 150 cycles per second at exceptional high energy amplitudes. Since the radiator shell mass is small relative to the rotational driving force mass, the sound waves radiated from the outer surface of the radiator shell are of exceptionally high intensity when the radiator shell is liquid loaded. The combination of these factors when produced in their proper parametric relationship produces a highly efficient sonic source of energy as compared to other known sonar devices which results in an exceptional production of cavitation and penetration of the materials within the contained aqueous medium, and which in turn is an important element of the invention.

A prerequisite to a good understanding of the present invention involves a full understanding of the sonic energy producing source which consists of a rotating body driving force which is mounted within its supporting radiator shell, and in the aspect of meeting the problems such as physical size, weight, wave amplitude, desired frequency, omni-directional radiation, efficiency, desired wave energy intensity, and stable frequency transmission.

The driving force which causes the radiator shell to oscillate at any desired frequency typically at a value between 50 to 150 cycles per second is provided by the bearing at one end of the motor to which is attached a rotating eccentric. The fact that the rotational axis does not coincide with the center of mass of the eccentric provides a force much in the same manner that an unbalanced automobile wheel produces whose frequency is proportional to the velocity. The structure of the radiator shell is being flectured in cyclical manner at a rate com-

mensurate with the speed of the rotational mass in revolutions per second as caused by the eccentric offset of the symmetry axis of the rotor with respect to the end bearing and as transmitted thereon by the driving force pedestal to the cavity shell. The alternating sinusoidal sound waves of compression and tension are launched by the surface of the radiator shell which is acoustically coupled to the liquid.

There is a parametric relationship between the rotational velocity and the rotational mass and offset of the eccentric and the sonic energy drive force transmitted into the aqueous medium which has been examined experimentally, and over a limited range, from 50 to 150 cycles per second, the amount of sonic energy transmitted into the liquid medium is proportioned to the angular velocity of the rotor mass and the product of the mass of the eccentric and the displacement of its center of mass from the rotational axis.

The problems of efficiency and weight are related chiefly to the sonic energy source configuration. In order to obtain an extraordinary degree of efficiency and wave energy amplitude a self powered gearless rotating mass of sufficient weight and desired rotational velocity was chosen since the driving force thus generated is directed related thereto. In order to take full advantage of this driving force relationship in terms of the essential requirements set forth, the rotating mass was located within the spherical thin radiator shell in such a fashion that the resultant force is coupled to the radiator shell by a single pedestal base and in such a position that its radius of gyration was located at the center of the spherical radiator shell.

The other main direction was to refine the suspension means for the rotating mass, in order that the full effect of the rotational driving force velocity mass be coupled to the radiator shell at a single location. This was accomplished by suspending and anchoring one end of the rotating mass by means of a cylindrical coil spring having the necessary rigidity and flexibility to support the rotating mass. The outer end of the suspension spring is supported and isolated from the cavity shell, thus permitting a free transmission of cyclical driving force energy to flecture the supporting radiator shell at a single location.

Although other means of suspension are possible, the spring method was chosen because it is also an excellent economical means of reducing and substantially isolating any energy loss which might otherwise reach the handle supporting structure, and to also permit the total rotating mass structure to be turned and translated in any direction without causing torques that disturb the angular orientation of the rotor axis relative to the supporting structure. Also and of equal importance the driving force pedestal coupling to the radiator shell is located within the cavity and at a single point which is directly below the horizontal axis of the driving force and vertically below the center of the radius of gyration of the rotating mass.

The particular location was chosen in order to obtain a maximum of flecturing energy being coupled to the shell, and to eliminate any gyration effect which might cause a loss of effective radiator shell energy transmission and produce an uncomfortable effect to one who would hold the sonar wand.

It is also of equal importance that the spherical radiator shell be vastly smaller nonrigid mass and of thin wall stiff material such as Fiberglas, for example, which has exceptional strength, flexural and insulating qualities. Since the spherical shell cavity is nonrigid and is perturbed cyclically at only one location, it is by design and demonstrated to be capable of being flectured sinusoidally with maximized cyclic velocity amplitude and in a manner inherently conducive to transmitting a fundamental frequency commensurate and in synchronism to the fundamental frequency as developed by the velocity of the rotating mass.

It should be pointed out that other known sonic energy devices are rigid in character with supporting means for the driving force at several positions within a radiator shell which in turn limits the flecture capacity of the radiator shell and generates sound waves at more than one location within the radiator shell which is highly conducive to wave interference thus leading to a substantial loss of transmitted energy and efficiency.

It is therefore an important element of this invention as substantiated in the prior two paragraphs that the design of the sonic energy source is extremely simple and inherently efficient. The simplicity involves the full utilization of the integral mass driving force to produce unusually high amplitudes of wave energy at low power thus utilizing to advantage a minimum of weight. It is efficient because rotating mass is vastly greater than the supporting radiator shell, and the suspension means is removed and isolated from the cavity shell thusly transmitting effectively all of the driving force energy to the radiator shell which is nonrigid and perturbed at only a single location thus permitting radiation of a single and fundamental wave pattern without interference from other sources, and also that it is free of gyration effects which would inherently reduce the effective transmission of useful sound wave energy.

An important feature of my invention in terms of efficiency is that the sonic energy source operates at a stable frequency through its effective operating range. The inherent design previously described in the foregoing paragraphs lends itself particularly to a stabilized frequency source since a large internal rotating mass is driving an infinitely smaller supporting structure radiator shell mass which has its own resonant frequency infinitely higher than that of the rotating force velocity. It is also an important feature of this invention that such frequency stability adds to the controllability of the sonic energy source by remote means.

The problem of omni-directional sound waves from the sonic energy source is an essential element of this invention in order to fully meet the requirements for the useful applications heretofore described. It has been demonstrated that a nonrigid thin spherical shell radiator cavity when flectured, internally and cyclically as heretofore described, emits sinusoidal sound waves in spherical fashion from the outer shell surface which is in direct contact with a liquid. The radiator shell encompasses and is an integral part of the sonic energy source. The sonic energy source of this invention is somewhat analogous to a conventional radio loud speaker wherein the oscillator driving force coil having relatively large mass is mounted on a rigid frame, the parameter of which encompasses a very thin wall transmitter diaphragm.

The armature of the driving force frequency generated coil is fastened by a single pedestal to the center of the diaphragm shell and in such a manner that the diaphragm shell of smaller mass is perturbed and flectured in synchronism with the oscillator coil, and thusly transmitting sonic sound waves which are directional only as related to the shape of the diaphragm and audible in air.

The present invention likewise develops sound wave energy and in sinusoidal fashion, however the total driving force mass is mounted within a spherical radiator shell in order to produce a maximum intensity of sound wave amplitude and to radiate omni-directional sound wave energy.

The selection of a spherical radiator shell also was conducive to the solution of other problems which are necessary elements of this invention such as physical size, weight. Since a spherical object has a maximum surface area relative to its physical volume, it therefore provides a configuration for low power operation whereby a maximum cavity sheet volume may be utilized for encompassing the driving force physical mass while having the advantage of utilizing the maximum surface area to in turn transmit the sonic energy waves of high intensity.

Since the spherical cavity shell in terms of efficiency

must be free of internal structural members, the spherical shape by nature is known to be strong and freely flexured with a minimum of surface stress since the entire surface is free to move when being perturbed in a cyclic manner. It has also been demonstrated that the sonar wand device having a spherical shell approximately 4 inches in diameter would provide sufficient buoyancy to float the device in a nearly submerged condition when in liquid and to be substantially weightless when used by the hand.

Also, another important element of this invention is to eliminate gyration or low frequency vibratory conditions within the desired operating frequency range and which might be present should an improper sonic source be contemplated. It has been demonstrated that a spherical shell is ideally adaptive to this solution since the center of the radius of gyration of the rotating mass driving force mechanism may be accurately located at the center of the supporting spherical cavity, and under such conditions gyration effects are only noted at a near stall condition of the rotating mass. And under operation the dynamic balanced system tends to produce a gyro effect which is desirable and indicative of an inherently stable system.

Another essential element of this invention concerns safety. It has been demonstrated that a radiator shell material such as by example reinforced Fiberglas, has among the best physical properties for construction of the cavity shell. It is also known to be one of the best materials known for insulation properties and having one of the highest values of dielectric strength. Therefore, should the device be powered by electrical means, the entire wand would be fabricated of similar material and the total device would in itself be an excellent insulator. In addition the sonar source portion of the device is independently constructed, insulated and sealed. Similarly the handle of the wand is constructed for safety.

Another important element of the invention concerns the object of isolating the passage of sound wave energy from the handle of the wand, the requirements being to isolate and conserve the sound wave energy to the radiator shell structure of the sonar source in order to provide maximum efficiency and to also eliminate any undesirable transfer of energy to a human who might hold the sonar wand in his hand. The solution was accomplished by sealing the handle to the sonic energy source with a material which has both the property of excellent sealing strength, high dielectric strength and the additional desired property of isolating and absorption of sound wave energy in the frequency operating range of this device.

As an additional precaution against further sound wave leakage, the handle stock material at the point of isolation was provided with a sharp tapered edge to limit the passage of sound wave energy.

As a further precaution, a multitude of compressed wafers of similar sound wave material are sealed at unequal distances from each other in order to block any further sound wave leakage to the handle. The wafers in addition to having inherent sound wave absorption properties are unequally spaced in order to break up and cancel sound wave length pattern which might exist.

It has been demonstrated that the solution as outlined has effectively cancelled the penetration of sound waves to the handle when the sonic source is liquid loaded, and only a minor leakage is noticeable when operating in air.

I have thusly accomplished the difficult problem of providing a low power, light weight, hand operated and sound wave isolated source of sonic energy sound waves having extraordinary efficiency, and which radiates omnidirectional sound waves in spherical fashion, high amplitude and intensity and with excellent frequency stability from a thin shell non-rigid liquid loaded sound radiator having an unusually small surface area, which receives its driving force from a simple inexpensive but relatively large integral driving force mass.

With these and other objects in view, the invention consists in the construction, arrangement, and combination of the various parts of the device, whereby the objects contemplated are attained, as hereinafter set forth, pointed out in the appended claims and illustrated in the accompanying drawings.

With reference now to the drawings:

FIGURE 1 is a longitudinal sectional view of one form of the invention.

FIGURE 2 is a cross sectional view taken on the line 2—2 in FIGURE 1.

FIGURE 3 is a cross sectional view taken on the line 3—3 of FIGURE 1.

FIGURE 4 is a fragmentary sectional view showing the eccentric mounting at the outside end of the rotational driving force motor.

FIGURE 5 is a cross sectional view on the line 5—5 of FIGURE 1.

FIGURE 6 is a schematic drawing of a controlling rheostat.

In the embodiment herein disclosed for illustrative purposes there is shown a sonic energy source radiator shell indicated generally by reference character 10 consisting of two parts namely, what may aptly be described as a base section 11 and a cover section 12. The shell is typically spherical, the parting line 13 lying in an oblique direction as shown in FIGURES 1 and 2 wherein an annular ring 14 which may be separate or an integral part of either the base section 11 or the cover section 12 forms a means of attaching the sections together in sealed relationship. An example of an effective material having excellent dielectric strength for the radiator shell 10 has been found to be reinforced glass fiber. It is important that the material be strong and stiff and of exceptional flectural and dielectric strength so that the thickness or gauge of the shell can be kept to a relative minimum for purposes that are pertinent to efficient transmission of energy and to provide a minimum mass.

In the base section there is provided a cavity shell pedestal base 15 which is preferably cast or molded contemporaneously with the molding or casting of the base section as a whole. It is significant that the pedestal be located midway between opposite right and left hand ends of the spherical cavity portion 62 of the shell as viewed in FIGURE 1.

It is also significant relative to FIGURE 1 that the vertical centerline position of the cavity shell pedestal base 15 is also vertically in line and directly below location 61 which is also the center of the radius of gyration of the rotational mass 30 which may be typically a motor as shown.

A driving force pedestal 16 has a pedestal mounting base 17 anchored to the cavity shell pedestal base 15 by means of epoxy and screws 18. A reinforcing flange 19 extends throughout the length of the pedestal. As shown the pedestal is arcuate and has substantially the same radius of curvature as the inside of the radiator shell cavity 62 in order to permit the driving force pedestal to hug the cavity shell as much as possible thereby to preserve a maximum amount of space within the cavity for other equipment. At the end of the driving force pedestal 16 remote from the base mounting 17 is a bearing housing 21 in which is located a roller bearing assembly 22 in which is a cylindrical bore 23. A crank 24 has a stub shaft 25 freely inserted in the cylindrical bearing 22 at the centerline. It is significant that the exterior of the stub shaft have the proper symmetrical curvature for insertion within roller cylindrical bearing 22 so that the stub shaft 25 will be freely aligned and supported at any angle within the range of the angular rotational relationship provided for in the device. In the crank 24 is a bore 26 eccentric with respect to the center line of the stub shaft 25, the bore 26 providing a means by which a motor shaft 28 can be secured to the crank 24. Mounted in this fashion the rotational axis of the rotating driving force mass or motor 30 does not coin-

cide with the center line of the cylindrical bore of the supporting roller bearing 22. For a relatively small device having a radiator shell of about 4 inches in diameter the eccentricity can be between about 3/16 to 7/32 inch.

At the end of the housing of the motor 30 opposite from the bearing housing 21 the motor shaft terminates within its own supporting motor bearing and a motor supporting suspension means in the form of a coiled resilient spring 32 is secured internally to the motor housing casing 31.

Molded with and forming part of the base section 11 is a yoke 35. In the yoke is a bore 36, having a tapered outer end, and a cylindrical inner end. A cylindrical portion 38 lying within the supporting suspension spring 32 has a flange 39 underlying the innermost coil of the spring. A key 40 positioned in a keyway 41 is forced against the mounting spring 32 in order to anchor it in a position within the bore 36 by means of a set screw 42. A sealant plug 43 is used to seal the set screw mounting once the spring is properly positioned.

In the yoke 35 at the end opposite from that occupied by the spring is a passage 44. At about the area of the passage the yoke has a portion 45 of reduced diameter. A tubular handle 46 of material such as Fiberglas has an inside wall 47 substantially larger in diameter than the outside diameter of the portion 45 leaving a space therebetween which is filled with a sealant 47' which has excellent sonic sound wave isolation and absorbing properties for the proposed operating frequencies in the lower sonic range. The sealant material having high temperature and dielectric strength properties, is employed to isolate the tubular handle 46 from the yoke 35 and this accomplished additionally by a seperating shoulder and sealant filled spacing 48 of the yoke 35 from a feathered edge 49 of the handle 46. In order to prevent and absorb any further leakage of sound waves beyond this point and outwardly through the handle, there are provided low frequency sound wave absorbent wafers 50, 51 and 52 which are compressed and sealed at staggered intervals through the interior of the handle. The wafers are placed at predetermined distances apart with care being taken that the distance between any two wafers is different from the distance between every other pair of wafers, regardless of how many wafers may be used and that the distances are not even multiples or fractions of the maximum distance. A cap 54 of material such as Fiberglas seals the outermost end of the handle.

Electric leads 55 and 56 extend from a terminal base which is mounted centrally in the motor housing 31 and at a position near to but slightly remote from the secured position of the supporting suspension spring 32. The leads thusly are extended from the terminal base and pass centrally and outwardly through the motor housing 31 and spring 32, and thence outwardly a yoke section 35' which has two small bores for passage of each wire and which is sealed with insulating material. The wires are thence extended and continued outwardly through passage 44 and in which passage the wires are encapsulated and sealed with a potting compound 44' containing excellent properties of exceptional dielectric strength and sound wave isolation. Continuing and outwardly from passage 44 the wires pass through two bores in a seal plug 45' of material such as Fiberglas and in turn the wire passages are sealed with insulating material and the seal plug 45' is seated within the yoke portion 45 thus closing the passage 44. The wires then continue outwardly through the insulation supporting wafers 50, 51 and 52 and to the exterior for suitable connection to a source of power.

On occasions there may be some need to vary the speed of the rotating mass or typically the speed of motor 30 whose speed may be controlled by employing a rheostat 60 with power supplied by some external wires 55 and 56. By varying the speed of rotation of the motor, the frequency of the sonic energy sound waves are thus varied and in synchronism, which may be desirable when sonic energy sound waves are made use of for medical therapy.

In operation the rotational driving force mass 30 may be typically a low power gearless series or shaded pole motor 30 having a power rating in a range between 40 and 70 watts and which may be operated with A.C. or D.C. power and at a speed range which may be selected between 3000 and 9000 r.p.m. One end of the motor mass has a suspension mounting supporting means which is in the form of the cylindrical coiled spring 32 which has the proper combined support and flectural characteristics to permit a freedom of motion between the rotational motor mass and the resultant motion produced by the offset of the eccentric 24 with respect to its supporting bearing 22.

It is also significant relative to FIGURE 1 that the location of the radius of gyration 61 of the rotational mass of the motor 30 is located at a point which is at the center of the volumetric space encompassed and within the spherical shell chamber or cavity 62, and which also is in line with the sectional line 2—2.

Although the spherical form of shell has been stressed as being the most ideally efficient, departure may be made from the spherical shape, wherein roundness may be confined, for example, to only one plane. Shells of such varied shapes may be employed as effective sound sources when the rotationally gyrating energizer is secured to the shell at a single point.

Further still, although there may be a substantial range of amplitude or eccentric throw within which the sound waves generated are effective, the more useful range in a hand portable device for effective operation at a moderate consumption of power is between about 11/64 and 29/64 inch for a shell of approximately 4 inches in diameter wherein a motor operating on 40 to 70 watts is made use of.

In the chosen embodiment the cyclical mass driving force has been described as an eccentrically mounted motor mass. Other means however, may be productive of such a driving force, as for example, a weight on one side only of the axis of rotation or an unbalanced armature in the motor.

What is claimed is:

1. A portable sound source comprising a hollow substantially rounded liquid tight shell of resonating character and of relatively stiff resilient consistency having a chamber therein, a power actuated cyclically movable mass, said shell being substantially homogeneous and enveloping said mass on all sides, a connecting area on an unsupported portion of said shell in line with the direction of cyclical motion of said mass and a positive non-yielding mounting for said mass on said shell having a connection at one location only thereof to said connecting area and having another connection to said mass.

2. A portable sound source comprising a hollow substantially rounded liquid tight shell of resonating character and of relatively stiff resilient consistency having a chamber therein, a power actuated cyclically movable mass having a rate of motion of from about 50 to about 150 cycles per second, said shell being substantially homogeneous and of uniform thickness and enveloping said mass on all sides, a connecting area on an unsupported portion of said shell in line with the direction of motion of said mass and a positive non-yielding mounting for said mass on said shell having a connection at one location only thereof to said connecting area and having another connection to said mass.

3. A portable sound source comprising a hollow substantially rounded liquid tight shell of resonating character and of relatively stiff resilient consistency having a chamber therein, a power actuated cyclically movable mass having a rate of motion of from about 50 to about 150 cycles per second and having an amplitude of from about 3/16 to 7/32 inch, said shell being substantially homogeneous and enveloping said mass on all sides, a connecting area on said shell in line with the direction of motion on said mass and a positive non-yielding mounting for said mass

on said shell having a connection at one location only thereof to said connecting area and having another connection to said mass.

4. A portable sound source comprising a hollow resonating shell forming a source of sound energy and having a chamber therein, holding means attached to said shell, a power actuated energizer having a longitudinal axis extending across said chamber substantially in alignment with said holding means and having opposite ends adjacent opposite sides of said shell, the mass of said energizer being many times greater than the mass of said shell, and a positive non-yielding connection anchoring said energizer to said shell comprising mounting means attached respectively to an unsupported portion of the shell at a location spaced from the holding means and to the energizer thereby to support said energizer in the shell.

5. A portable sound source comprising a hollow resonating shell forming a source of sound energy and having a chamber therein, holding means attached to said shell, a power actuated cyclically movable mass in said chamber having a radius of motion about a selected point with the center of said radius adjacent the center of said chamber, and mounting means supporting said mass in the shell, said mounting means at one location thereon having a connection to the mass at a location in alignment with the axis of the radius of motion and at another location thereon having a connection to the shell at a location spaced from the holding means, said last connection being laterally opposite said center of the radius of motion.

6. A portable sound source comprising a hollow resonating shell forming a source of sound energy and having a chamber therein, holding means attached to said shell, a power actuated cyclically movable object in said chamber having a radius of motion about a selected point with the center of said radius adjacent the center of said chamber, the mass of said object being many times greater than the mass of said shell, and mounting means supporting said object in the shell, said mounting means at one location thereon having a connection to the object at a location in alignment with the axis of said radius of motion and at another location thereon having a connection to the shell at a location spaced from the holding means, said last connection being laterally opposite said center of the radius of motion and intermediate opposite ends of the object.

7. A portable sound source comprising a hollow resonating shell forming a source of sound energy and having a chamber therein, holding means attached to the shell, and a power actuated energizer mounted on the interior of the shell in said chamber, said shell having an arcuate exterior wall, said energizer being substantially at the center of curvature of said wall, the mass of said energizer being many times greater than the mass of said shell and a positive non-yielding connection between said energizer and said shell at one location only on the shell anchoring said energizer on said shell.

8. A portable sound source comprising a hollow resonating shell forming a source of sound energy and having a chamber therein, holding means attached to the shell, and a power actuated energizer mounted on the interior of the shell in said chamber, said shell having an arcuate exterior wall, said energizer having a radius of gyration with the center of said radius of gyration thereof substantially at the center of curvature of said wall, the mass of said energizer being many times the mass of said shell, said energizer being attached to the shell at a location spaced from said holding means, said holding means comprising a tubular handle, energy transfer means through said handle to the energizer, sound isolation means between said handle and said shell and a series of sound isolation wafers at staggered locations in said handle.

9. A portable sound source comprising a hollow resonating shell forming a source of sound energy and having a chamber therein, holding means attached to the shell, and a power actuated cyclically movable mass mounted on the shell in said chamber, said shell having an arcuate exterior wall, said mass having a radius of motion with the center of the radius of motion thereof substantially at the center of curvature of said wall, said mass being many times the mass of said shell, said holding means comprising a tubular handle connected to the arcuate exterior of said shell, and mounting means holding said cyclically movable mass in said shell, one portion of said mounting means being secured to the shell where the holding means is attached and another portion of said mounting means being secured to said shell opposite said center of said radius of motion and at a location spaced from said holding means.

10. A portable sound source comprising a hollow resonating shell forming a source of sound energy and having a chamber therein, holding means attached to the shell comprising an exterior support for the shell, and a power actuated energizer mounted on an unsupported portion of the shell and located in said chamber, said shell having an arcuate exterior wall, said energizer being substantially at the center of curvature of said wall, the mass of said energizer being many times greater than the mass of said shell, said shell comprising a relatively thin walled oblate spheroid, said energizer comprising an electric motor with the axis of rotation thereof on a diametric line across said spheroid.

11. A portable sound source comprising a hollow resonating shell forming a source of sound energy and having a chamber therein, holding means attached to the shell comprising an exterior support for the shell, and a power actuated energizer mounted on an unsupported portion of the shell and located in said chamber, said shell having an arcuate exterior wall, said energizer being substantially at the center of curvature of said wall, the mass of said energizer being many times greater than the mass of said shell, said shell comprising a relatively thin walled oblate spheroid, said energizer comprising an electric motor with the axis of rotation thereof on a diametric line across said spheroid, said holding means comprising a handle in axial alignment with said axis of rotation.

12. A portable sound source comprising a hollow resonating shell forming a source of sound energy and having a chamber therein, holding means attached to the shell, and a power actuated cyclically rotating energizer mounted on the shell in said chamber, said shell having an arcuate exterior wall, said energizer having a mass many times greater than the mass of said shell and having a longitudinal axis of rotation extending transversely across the chamber, and mounting means holding said energizer in said chamber comprising a flexible bearing at one end of the longitudinal axis of said energizer and a bracket at the other end of said axis, said bracket being attached to said shell at a location along a line extending transversely to said longitudinal axis and in a plane adjacent a plane passing through the center of radius of gyration of said energizer.

13. A portable sound source comprising a hollow nonrigid shell forming a source of sound energy and having a chamber therein, holding means attached to the shell, and a power actuated energizer mounted on the shell in said chamber, said shell having an arcuate exterior wall, said energizer being substantially at the center of curvature of said wall, the mass of said energizer being many times greater than the mass of said shell, said shell comprising a relatively thin walled oblate spheroid, said energizer comprising an electric motor with the axis of rotation thereof on a diametric line across said spheroid, and mounting means holding said energizer in said chamber comprising a flexible bearing at one end of the longitudinal axis of said energizer and a bracket at one end of said axis, said bracket being attached to said shell at a location along a line extending transversely to said longitudinal axis and adjacent the center of radius of gyration of said energizer.

14. A manually portable sound source for operation

in a liquid bath comprising a hollow non-rigid substantially rounded liquid tight resonating shell having a chamber therein, an electric power actuated cyclically movable mass having an electric power consumption of from about 40 watts to about 75 watts and a rate of motion of from about 50 to about 150 cycles per second, and a cyclical throw of from about $^{11}/_{64}$ to about $^{29}/_{64}$ inch, a connecting location on one rounded unsupported portion of said shell in line with the direction of motion and a mounting for said mass having a connection at one location only thereof to said connecting location and having another connection to said mass.

15. A portable sound source comprising a hollow non-rigid flexible shell forming a source of sound energy and having a chamber therein, holding means attached to the shell, and a power actuated energizer mounted on the shell in said chamber, said shell having an arcuate exterior wall, said energizer being substantially at the center of curvature of said wall, the mass of said energizer being many times greater than the mass of said shell, said shell comprising a relatively thin walled oblate spheroid of relatively stiff resilient consistency, said energizer comprising an electric motor having a housing and a rotating shaft rotatably mounted in the housing with the axis of rotation thereof on a diametric line across said spheroid, and mounting means holding said motor in said chamber comprising a flexible self aligning and eccentric bearing adjacent one end of the longitudinal axis of said shaft connecting the housing to the shell at a location adjacent the holding means, and a bracket mounting the other end of said shaft, said bracket being attached to said shell at a location along a line extending

transversely to said longitudinal axis and in a plane adjacent a plane passing through the center of radius of gyration of said energizer, said location being spaced from said holding means.

16. A portable tool for sound energy application comprising a relatively thin resonating hollow shell of resilient consistency having a chamber therein, holding means having an attachment on the shell and extending outwardly therefrom, a power actuated cyclically moving mass in the chamber having a direction of movement substantially transversely of the attachment, a connection mounting the mass on the shell at an unsupported portion of said shell and at a location spaced from said attachment, said connection being in line with the direction of cyclical movement of said cyclically moving mass.

17. A tool according to claim 16 wherein said connection is at one location only on the interior of the resonating hollow shell and at one side only of said cyclically moving mass.

References Cited by the Examiner

UNITED STATES PATENTS

1,105,324	7/1914	Dean	181—.5
1,658,327	2/1928	Dodge	181—.5
1,730,532	10/1929	Robbins	181—.5
2,384,465	9/1945	Harrison	181—.5
2,597,005	5/1952	Kendall	181—.5
2,753,948	7/1956	Ongaro	181—.5

BENJAMIN A. BORCHELT, *Primary Examiner.*

W. KUJAWA, *Assistant Examiner.*