

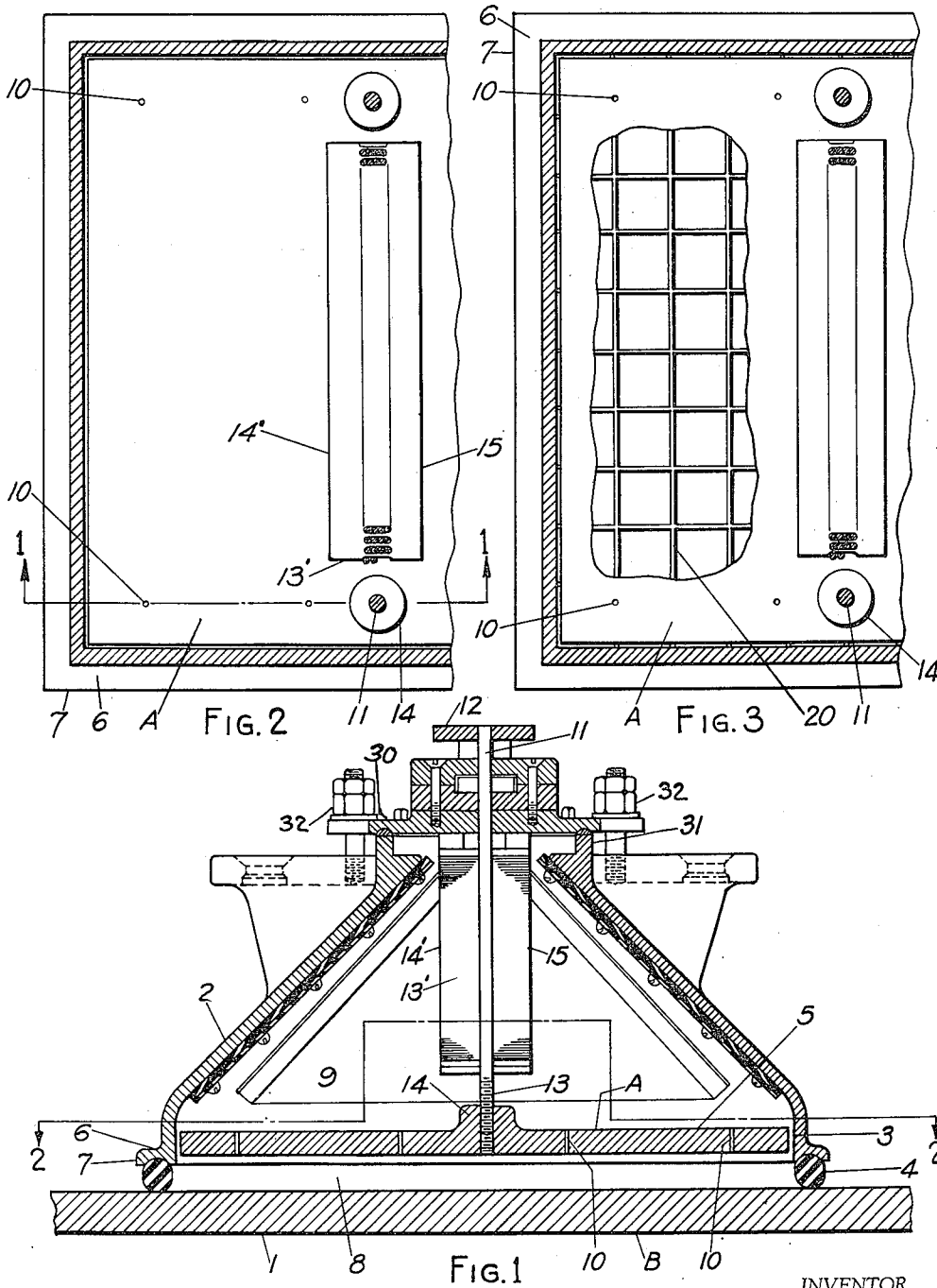
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SUBMARINE SIGNALING

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## SUBMARINE SIGNALING

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9 Claims. (Cl. 181—0.5)

The present invention relates to the transmission of compressional waves particularly in submarine signaling and more particularly to the transmission and reception of high frequency compressional waves near or above the range of audibility and through changing media as, for instance, from air to water or from water through metallic elements or other media.

It is a well-known fact that when sound waves are transmitted from one medium to another medium in which the densities and elasticities vary, reflections occur at the boundary surfaces which cause energy losses. Such losses are very detrimental. The higher the frequencies are and in the so-called range of supersonics, for instance, when sound is produced within the vessel, it is sometimes very difficult to radiate the sound through the skin of the vessel to the water medium beyond. In order to overcome this difficulty in such cases, for instance, where high frequency sound producers are used in depth sounding, the sound producer is sometimes mounted flush with the skin of the vessel or even projected beyond the skin of the vessel and this expedient greatly improves the quality of the sound transmission and reception.

However, the cutting of holes in the skin of vessels is sometimes objectionable for a number of reasons. In the first place, usually the vessel must be drydocked. Secondly, the expense of drydocking the vessel, if it must be done especially for the purpose of installation of the sound transmitter and the cutting of the plates of the vessel, is considerable. Thirdly, some ships' designers and underwriters object to the cutting of a hole in the vessel on the ground that it may weaken the vessel. This objection can, of course, be overcome by strengthening the section in which the cut has been made but this adds also to installation costs.

The most desirable form of sound installation on a vessel as far as convenience of installation is concerned is a so-called tank or skin mounting in which the sound must pass through the skin before entering the transmitting medium. In the so-called tank mounting the sound transmitter and receiver are immersed in a water or other liquid-filled tank within the vessel and the sound is transmitted to the external water medium through the liquid and skin of the vessel which usually forms one wall of the water tank. These tanks have been extensively used for low frequencies, frequencies well within the audible range of listening where the wave lengths are

long in comparison to the linear dimensions of the tank so that the skin thicknesses and the tank dimensions do not offer any substantially different medium between the liquid in contact with the sending or receiving device and the external water.

Where the skin of the vessel is thin in comparison to the wave length of the sound in the skin itself, the difference in phase between the reflections at the two steel surfaces is negligible so that the plate gives substantially no reaction to the transmitted wave travelling through it. Where the plate is, however, substantial compared to the wave length of the sound in the skin of the vessel, the reflections from the two steel surfaces may cause considerable loss. This condition begins to exist at approximately one-eighth of a wave length or greater. At a half wave length, however, the reflections again come into phase synchronism and therefore for this condition reflection losses are diminished. However, for a half wave length with steel plate at a frequency of 20,000 cycles the thickness of the plate would be about five inches. One way to overcome the reflection difficulty is to make the ship's skin one-half wave length of the sound to be transmitted through it, as the applicant has determined. This may, however, demand in the case of steel a very heavy plate since the velocity of sound in steel is high.

In the present invention the coupling between the transmitter or receiver in the tank and the external water is effected by means of a half wave length system in which the skin and a plate in the tank spaced away from the skin form with the medium between the two elements an effective half wave length system in which the node is in the medium. In such a system reflections from the plate back to the tank medium are avoided and a perfectly matched coupling unit is provided by proper choice of the relative thickness of the plate to that of the ship's skin.

In the present invention a reflecting tank is employed of the type similar to that disclosed in my copending application Serial No. 352,261, filed August 12, 1940, now Patent Number 2,332,541, granted October 26, 1943, and in connection with this arrangement any suitable magnetostriction oscillating source may be used.

Without further describing the merits and advantages of the present invention the invention will be described in connection with an embodiment of the same as illustrated in the drawing in which Fig. 1 shows a section through the invention; Fig. 2 shows a section on the line 2—2 of

Fig. 1; and Fig. 3 shows a modified detail of the invention illustrated in Figs. 1 and 2.

In Fig. 1 the skin of the vessel is represented at 1 against which may be mounted a reflector tank 2 which may be substantially similar in construction to the reflector tank illustrated in my above-mentioned copending application with the exception that the wall portion 3 just behind the watertight bushing 4 has straight sides for a short distance so as to enable adjustment towards and away from the plate 5. The reflector tank 2 has a peripheral groove 6 in the end flange holding a gasket 4 of rubber or other material which is pressed by the tank against the skin 1 of the vessel. Suitable clamping members, not shown, exert sufficient pressure on the ring 4 to prevent any water from leaking out between the joint made between the tank and the skin. It is also possible, of course, to mount the tank directly against the skin by bringing the flange 6 down to the skin and bolting, cementing or welding it directly to the skin. The plate 5 is provided with a sufficient clearance around its edges so that motion in a vertical direction with reference to its position in Fig. 1 would be free and not obstructed by the side wall of the tank in the section 3 near its base.

The space 8 between the plate 5 and the skin 1 and the space 9 within the rest of the reflector are completely filled with water or other sound-propagating liquid or fluid, the plate 5 being provided with small perforations 10, 10, etc., to permit the water or other liquid to fill both spaces. At either end of the casing there are provided rods 11 adjustably suspending and supporting the plate 5. These rods are provided with a cap or plate 12 at the external side of the casing and are threaded at their bottoms 13 into an embossed section 14 of the plate 5 so that the plate 5 may be adjusted in a vertical direction as seen in Fig. 1 by rotating the rods 11 one way or the other. Positioned within the reflector 2 centrally thereof is the magnetostriction oscillator 13' having a position similar to that in my copending application mentioned. The compressional waves are therefore radiating from the faces 14' and 15 in horizontal directions as viewed in Fig. 1 against the sloping walls of the reflecting tank which are given such an angle that the compressional waves reflected from the walls travel perpendicularly or normally towards the plate 5 and the skin 1 of the vessel.

It will be seen from a consideration of Fig. 1 that the wave travelling vertically downward is in phase over a horizontal plane since the path of travel from the surface of the oscillator 13' has the same length to a horizontal plane parallel to the plate 5 or the surface 1 of the skin of the vessel. The distance of travel of each portion of the compressional wave from its source of origin at the magnetostriction oscillator 13' to the surface A of the plate 5 should be one-half wave length or some integral multiple of one-half wave length in order to produce the most desirable effect in accordance with the present invention. The plate 5 must be given a chosen thickness and must be spaced a chosen distance from the skin 1 of the vessel, these factors being dependent upon a number of things including the acoustic characteristics of the plate 5 and the skin 1 and the acoustic characteristic of the medium in the space 8.

In the present invention the plate 5, the skin 1 embraced within the section enclosed by the walls of the tank and the space 8 with its liquid or fluid

medium are made and dimensioned to provide a system equivalent to a one-half wave length vibrator with a node existing somewhere in the medium in the space 8, this node extending in a plane parallel to the surface of the plate and skin. In this arrangement the medium in the space 8 may be considered as furnishing primarily the elastic forces of the vibrating system with the skin 1 and the plate 5 being the mass elements and adjusted in such proportions as to provide a transformation of motional amplitude between the innermost surface A of the plate 5 and the outermost surface B of the skin 1. The adjustment of the space 8 is fairly critical for the wave length to be used for best efficiency of the system, since it is highly desirable to have the vibrating system embracing the plate 5, the skin 1 and the medium in the space 8 at a point of natural resonance and to avoid reflections of sound energy in the one case from the surface A when the oscillator 13' is acting as a transmitter and in the second case from the surface B when the oscillator 13' is acting as a receiver. The width of the space 8 is usually not substantially greater than the thickness of the skin 1 and will therefore provide a one-half wave-length system without substantially increasing the size of the reflecting tank. It may also be remarked that while the thickness of the skin 1 is not ordinarily controllable for the present purposes, it is usually less than one-fourth the wave length of the chosen wave in the skin medium and the plate 5 usually has a thickness less than this. The plate 5 may have a thickness less than one-eighth of a wave length and the skin 1 a thickness also less than one-eighth of a wave length. For most purposes it is desirable to step down the motion amplitude from the plate 5 to the skin 1 and to increase the available mechanical forces and for this purpose the weight of the plate 5 will be proportionately less to that of the skin 1 substantially in the ratio of the increase of the available mechanical force at the surface B of the skin. In another aspect this provides a means for matching the impedance of the oscillator to that of the water system, at the same time avoiding reflection losses since the system is established as one-half wave length vibrator.

Various media may be used in the space 8 between the plate 5 and the skin 1 such as water, oils, semi-solid substances, solids and plastics or the like, and the medium in the space 8 may, in fact, be different from that in the space 9. This may be accomplished without any change in structure where the space 8 may be filled with solid, plastic or semi-plastic material and if necessary the plate 5 may at its edges be provided with rings or surfaces close to the tank walls so that the liquid within the space 8 can not escape externally. In such cases the perforations 10 will, of course, be omitted and the space 8 may be filled directly when the unit is being mounted.

Since the nodal plane is contained within the space 8 it may be desirable, in order to prevent transverse motion in the space 8, to cut up the space so as to avoid the lateral transmission of the sound waves and yet at the same time permit longitudinal vibration in the direction normal to the plate and the skin. A means for providing this feature is indicated in Fig. 3 by the lattice frame 20 which may be made of sound insulating material such, for example, as rubber having air cells, cork or some such similar material. This frame, as indicated in Fig. 3, may be molded or assembled in a square pattern or in any other

shape and extend over the whole space 8 between the plate 5 and the skin 1. While permitting unimpeded the vibrations through it normally to the surface of the plate and the skin, traverse vibrations will be greatly damped.

It has been previously mentioned that the distance of travel of each portion of the compressional wave to the surface A of the plate should be one-half wave length or some integral multiple thereof to obtain the most desirable effect in accordance with the present invention. There is an exception to this statement and that is the condition wherein the vibratory system comprising the plate 5, the skin 1 and the space 8 forms a symmetrical system with respect to the nodal plane, for instance, when the thickness of the skin and that of the plate is substantially the same and made of the same material. In such a case there is a true match of acoustical impedance between the tank and the external water medium so that no reflections would occur backwards from the surface A of the plate or from the surface B of the skin with the result that whatever length of path the sound waves had, no standing waves would be set up. It is only when reflections occur at boundary surfaces that standing waves will be set up and therefore the length of travel of the compressional waves in the tank itself only becomes critical when there is mismatching which results in standing waves. When this condition occurs, the tank should be adjusted to have maximum amplitudes at the oscillator surfaces and at the plate surface A; or, in other words, the tank should act as a tuned system. In order to tune the tank it may be necessary to compress the insulating ring 4 to bring the flange of the tank closer to the skin of the vessel, or, if desired, the plate 30 might be backed away from the upwardly projecting walls 31 and suitable shims or supporting elements put over the wall ends, after which the plate 30 may be fastened in place by means of the nuts 32, 32. The condition for best transmission is obtained under these adjustments.

Having now described my invention, I claim:

1. In combination with the skin of a vessel, a tank having sound reflecting walls mounted against said skin, said tank containing a compressional wave propagating medium, a high frequency compressional wave oscillating means mounted within said tank and adapted to produce in combination with said reflecting walls a substantially plane wave advancing normally to said skin and a vibrating system established as an effective one-half wave length vibrator comprising said skin of the vessel enclosed by the tank, a plate having a substantial mass positioned parallel to the skin and spaced therefrom and a compressional wave propagating medium occupying the space between said skin and said plate.

2. In combination with the skin of a vessel, a tank having sound reflecting walls mounted against said skin, said tank containing a compressional wave propagating medium, a high frequency compressional wave oscillating means mounted within said tank and adapted to produce in combination with said reflecting walls a substantially plane wave advancing normally to said skin and a vibrating system established as an effective one-half wave length vibrator comprising said skin of the vessel enclosed by the tank, a plate having a substantial mass positioned parallel to the skin and spaced therefrom and a compressional wave propagating medium occupy-

ing the space between said skin and said plate, the sound propagating distance between the surface of said oscillator and the surface of said plate nearest thereto being a half wave length or an integral multiple thereof.

3. In combination with the skin of a vessel, a tank having sound reflecting walls mounted against said skin, said tank containing a compressional wave propagating medium, a high frequency compressional wave oscillating means mounted within said tank and adapted to produce in combination with said reflecting walls a substantially plane wave advancing normally to said skin and a vibrating system established as an effective one-half wave length vibrator comprising said skin of the vessel enclosed by the tank, a plate having a substantial mass positioned parallel to the skin and spaced therefrom and a compressional wave propagating medium occupying the space between said skin and said plate, and means for adjusting the thickness of the space from the plate and the skin of the vessel.

4. In combination with the skin of a vessel, a tank having sound reflecting walls mounted against said skin, said tank containing a compressional wave propagating medium, a high frequency compressional wave oscillating means mounted within said tank and adapted to produce in combination with said reflecting walls a substantially plane wave advancing normally to said skin and a vibrating system established as an effective one-half wave length vibrator comprising said skin of the vessel enclosed by the tank, a plate having a substantial mass positioned parallel to the skin and spaced therefrom and a compressional wave propagating medium occupying the space between said skin and said plate, and means partitioning said space in sections, said partitioning means having sound-damping characteristics.

5. In combination with the skin of a vessel, a tank having sound reflecting walls mounted against said skin, said tank containing a compressional wave propagating medium, a high frequency compressional wave oscillating means mounted within said tank and adapted to produce in combination with said reflecting walls a substantially plane wave advancing normally to said skin and a vibrating system established as an effective one-half wave length vibrator comprising said skin of the vessel enclosed by the tank, a plate having a substantial mass positioned parallel to the skin and spaced therefrom and a compressional wave propagating medium occupying the space between said skin and said plate, said plate having a thickness at least not greater than that of the skin.

6. In combination with the skin of a vessel, a tank having sound reflecting walls mounted against said skin, said tank containing a compressional wave propagating medium, a high frequency compressional wave oscillating means mounted within said tank and adapted to produce in combination with said reflecting walls a substantially plane wave advancing normally to said skin and a vibrating system established as an effective one-half wave length vibrator comprising said skin of the vessel enclosed by the tank, a plate having a substantial mass positioned parallel to the skin and spaced therefrom and a compressional wave propagating medium occupying the space between said skin and said plate, said skin having a thickness less than one quarter of the wave length of the wave in the material

and said plate having a thickness less than that of the skin.

7. In a vessel having a metal skin, the combination with the latter, of a tank mounted against the skin, said tank containing a compressional wave propagating medium, a high frequency compressional wave oscillating means mounted within said tank and adapted to produce a substantially plane wave advancing normally to said skin, a plate having a mass of the same order of magnitude as the mass of the portion of the skin enclosed by said tank and being positioned parallel to the skin and spaced therefrom and a compressional wave propagating medium occupying the space between said plate and the skin, said plate, said portion of the skin and the medium between them being dimensioned in thickness to form a one-half wave length vibrating system at the signaling frequency.

8. A means for propagating a plane compressional wave through the skin of a vessel in a direction perpendicular to the plane of the skin of the vessel, a plate positioned parallel to the skin of the vessel and substantially unsupported to permit free vibration in a direction perpendicular to its surface and a free viscous medium

between the plate and the skin, said medium being dimensioned in thickness such that the combination of the plate, the medium and the skin in the direction of the propagation of the compressional waves form a one-half wave length vibrating system for the frequency to be transmitted or received with substantially uniform motion through the greater part of the transmitting elements.

9. Means for propagating a plane compressional wave through the skin of a vessel in a direction perpendicular to the plane of the skin of the vessel, a plate positioned parallel to the skin of the vessel and substantially unsupported to permit free vibration in a direction perpendicular to its surface and a free viscous medium between the plate and the skin, said medium being dimensioned in thickness such that the combination of the plate, the medium and the skin in the direction of the propagation of the compressional waves form a one-half wave length vibrating system, said plate being substantially non-resonant as a plate at the frequency for which the sound is to be transmitted and received.

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