July 24, 1956 W. T. HARRIS 2,756,405

VARIABLE-POSITION TRANSDUCER

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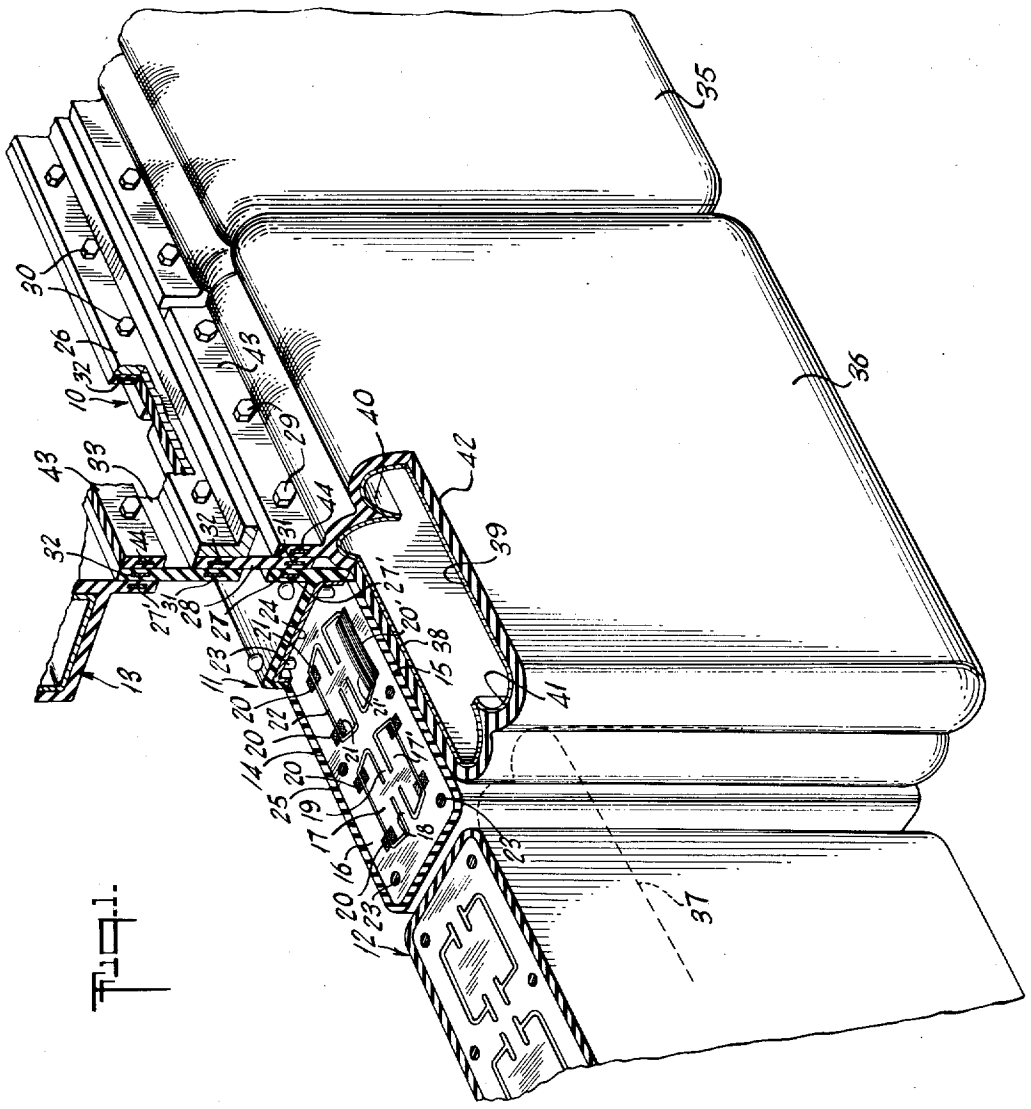


Fig. 1.

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Fig. 2.

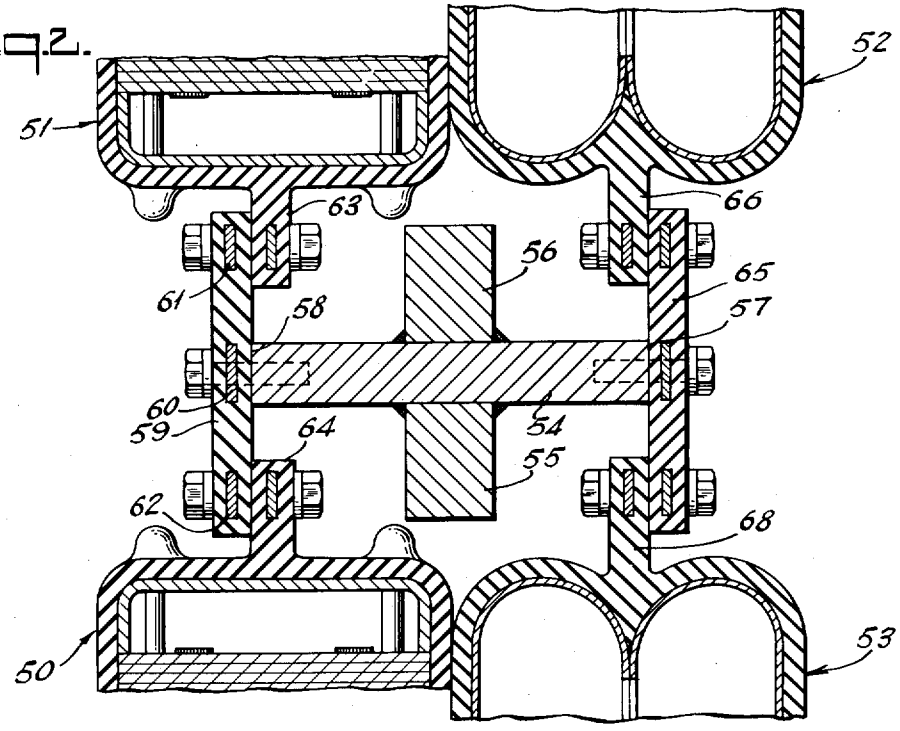
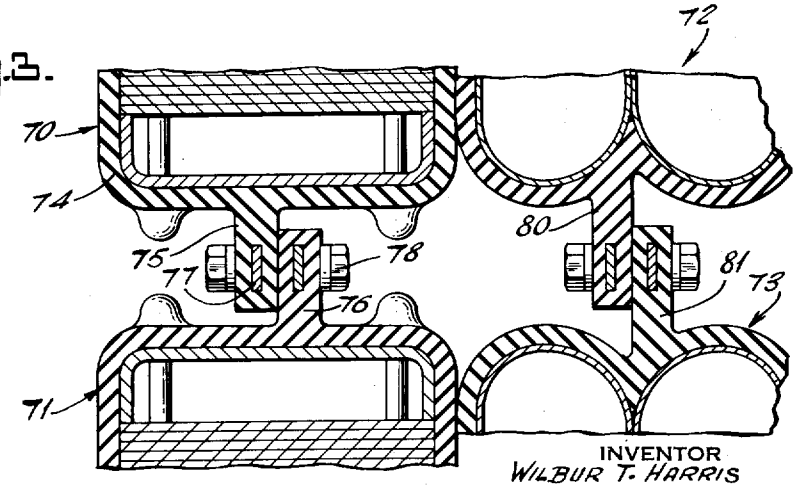


Fig. 3.



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VARIABLE-POSITION TRANSDUCER

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Application March 11, 1955, Serial No. 493,796

17 Claims. (Cl. 340—8)

My invention relates to so-called variable-position transducers, as for underwater use, and is concerned with improvements over and modifications of the structures disclosed in my copending applications, Serial No. 287,077, filed May 9, 1952, now Patent #2,713,127, issued July 12, 1955, and Serial No. 481,988, filed January 17, 1955.

In said patent applications, variable-position transducers are disclosed as comprising an armature or inner mass, spring-supported in a stator or outer mass, the stator mass completely surrounding the armature mass. The oscillatory system so formed is excited electromagnetically, and the device radiates by oscillating in position in a liquid medium. Variable-position transducers of this character may take various forms, depending upon the frequency range of application. In the first above-identified patent application, the arrangements disclosed are particularly useful in the frequency range 500 C. P. S. to 5000 C. P. S., whereas in the second-mentioned patent application the structures lend themselves more particularly to frequencies of 500 C. P. S. and much lower, as to 30 C. P. S.

Variable-position transducers of the character indicated are inherently efficient radiators but, because the entire transducer must be allowed to move and is not encased in a stationary housing or framework, mounting problems are presented; also, variable-position transducers are inherently bi-directional, and therefore to eliminate this ambiguity unique measures must be adopted.

It is, accordingly, an object of the invention to provide improved variable-position transducer constructions and combinations of the character indicated.

It is another object to provide an improved variable-position transducer construction lending itself to optimum mounting, particularly when such transducers are employed in array configurations.

It is also an object to provide improved means for reducing back response of variable-position transducers of the character indicated, and also for the mounting of such means.

It is a general object to meet the above objects with a structure whereby a large unidirectionally responsive variable-position transducer may be assembled from unitary components, all fully sealed and serviceable without maintenance, and performing without material dependence on depth of submergence.

Other objects and various further features of novelty and invention will be pointed out or will occur to those skilled in the art from a reading of the following specification in conjunction with the accompanying drawings. In said drawings, which show, for illustrative purposes only, preferred forms of the invention:

Fig. 1 is a simplified view in perspective, with parts

broken away and shown in section to reveal internal construction, of certain elements of an array incorporating features of the invention;

Fig. 2 is an enlarged, fragmentary, sectional view to reveal mounting details representing an alternative for the mounting detail shown in Fig. 1; and

Fig. 3 is a similar sectional view showing a further modification.

Briefly stated, my invention contemplates particular features of construction of variable-position transducer units whereby large numbers of such units may be assembled to a rigid supporting framework and may function so as to give the array essentially a unidirectional response, characterized by minimum back radiation. Back radiation may be reduced by employment of baffles, comprising gas-filled envelopes having principal opposed surfaces coextensive with the back-radiating surface of the transducer unit; each envelope may have pleated lateral edges to permit the envelope to yield expansively and compressively, as needed, both while the transducer is excited and as the transducer is exposed to varying depths of submergence. By providing the baffle units of effective front area to match the unit-transducer areas, there can be provided effective baffle surface coextensive with the full-array surface, no matter how many transducer units or elements are provided in the array. For mounting purposes, I form laterally projecting elongated flanges on the transducer elements and connect these flanges to corresponding flanged or other surfaces of the supporting framework, the connection being through an elongated strip of yieldable material such as rubber or neoprene, as in the manner discussed in greater detail in my copending patent application Serial No. 454,712, filed September 8, 1954.

Fig. 1 is illustrative of a small number of elements or units in a large array of transducer elements, said array comprising the elements **10—11—12** along one lateral (or horizontal) axis, and further elements such as the transducer element **13** along a transverse lateral (or vertical) axis. All transducer elements are preferably rectangular prismatic, as disclosed in the first two of the above-identified patent applications, and have opposed radiating faces, as at **14—15** on the transducer **11**, constituting opposed faces of the stator of the device. The mounting of all transducers is preferably such that the forwardly facing, or desired unidirectionally radiating, face **14** for all transducer units **10—11—12—13** shall be essentially in the same plane; and, of course, it is desired that the individual units of the array be mounted as close to each other as practicable. In this connection, it will be understood that the drawing of Fig. 1 has been exaggerated in order to show mounting details on a sufficiently large scale and so as to avoid unnecessary or excessive showing of the transducer primary surfaces; actually, I prefer that the unit-transducer radiating area shall be much greater in proportion to the spacing between transducer units **11—13** than that shown in Fig. 1.

The type of transducer shown at **11** is of the general character described in my said patent application Serial No. 287,077, to which reference may be had for further detail. Suffice it to say that the basic transducer may comprise a consolidated stack of laminations, such as the upper exposed lamination **16**, with slot formations defining inner-mass areas or armature parts **17—17'**, connected to the completely surrounding stator or outer-mass areas, solely through stiffly compliant means, such as the yeldable arms **18—19**.

The lamination **16** may be of non-critical magnetic material, such as silicon steel; and winding means, such as the winding **20** and the winding **21** (and corresponding windings **20'** and **21'**), may be linked to flux-loop paths including pole faces on the armature and on the stator at transversely extending gaps, as at **22**. The particular lamination shown at **16** happens to be slotted to define, within a single external mass area or stator, a plurality of like armature suspensions distributed along the length of lamination, and of course this plurality will depend upon the desired proportions of the transducer unit.

With the windings properly polarized and excited, all armature elements of a particular transducer unit, as at **11**, may be excited in phase, so that the reacting bodily displacement of the over-all stator may be achieved with efficiency. Since the stator is rigid and moves only bodily, the described assembly may be tied together by means of transversely extending bolts, as at **23**, and the top and bottom laminations may each be covered by a rigid cover cap or end bell, as at **24**, clamped by means of the bolts **23**. The overall transducer element **11** may be encased with a boot **25** of acoustically transparent material, such as rubber or neoprene, thus rendering the same immune to water and other corrosion.

In accordance with a feature of the invention, a plurality of rectangular prismatic transducers, such as the transducer element or unit **11**, may be mounted in side-by-side adjacency to form an array and may be connected to the same rigid external framework by means which will not impair transducer-radiating efficiency. As explained above, the mounting details in Fig. 1 have been exaggerated in their proportions for purposes of illustration. Suffice it to say that the rigid supporting framework may include a flanged or other member **26**, which may be elongated to an extent spanning a plurality of individual transducer-unit widths. Each transducer unit is integrally formed with a mounting flange **27** and, in the form shown, this mounting flange forms an integral part of the boot **25** and is thus of rubber or neoprene. The flange **27** may be directly bolted to the frame member **26**, but I prefer to employ the vibration-isolating mechanism described in my said patent application Serial No. 454,712. Thus, an elongated flat strip **28**, of yieldable material, such as rubber or neoprene, may be coextensive with frame member **26** and may be clamped, as by bolts **29**, at desired intervals to the transducer flanges **27**, and by bolts **30** at similar intervals to the frame flange **26**.

As discussed in said application Serial No. 454,712, I prefer to employ metal reinforcements, at least at points of connection of the flanges to the strip **28**, and in the form shown such metal reinforcements, as at **27'** for the flange **27** and **31—32** for the respective edges of the connecting strip **28**, are elongated strips bonded within the body of the part involved and thus more effectively providing the desired connection. I illustrate at **33** the provision of a further strip similar to the strip **28** and serving to connect the lower flange of the transducer unit **13** to the frame **26**.

As indicated generally above, I prefer to reduce back radiation or response of my transducer by employing baffles formed as sealed and gas-filled envelopes. Since all transducer elements are preferably of the same effective area, the baffles **35—36—37** behind these elements may also be of standardized construction. Suffice it to say that each envelope may comprise front and back primary surfaces **38—39** substantially coextensive with the radiating surfaces of the transducer unit involved, said surfaces **38—39** being connected to each other by an edge-pleated construction suggested at **40** on the upper edge of element **36**, and at **41** on one of the lateral edges of element **36**. The baffle envelopes (**36**) thus resemble an accordion and may be fully sealed with an internal charge of air. The complete baffle may be encased in a heavy boot **42** of acoustically transparent material, such as rubber or neoprene, and may be integrally formed with a mounting flange **43**, elongated as needed to correspond with the flange **27** on the corresponding transducer element **11**. The flange **43** is shown also to include internal reinforcement means **44**, and the same bolts **29** may secure both flanges **27—43** to the connecting strip **28**.

In Fig. 2, I show a modified arrangement for supporting adjacent elements **50—51** of a transducer array, together with their corresponding rear baffles **52—53**, on a rigid framework. The rigid framework is represented by flat members **54**, reinforced at **55—56**, and providing elongated surfaces at **57—58** for receiving the transducer and baffle mount connections. In the arrangements shown, a single connecting strip **59** with reinforcements at **60—61—62** provides edge connections for the lower flange **63** of the upper transducer **51**, and for the upper flange **64** of the lower transducer **50**. The single connecting piece **65** may be similarly secured to the supporting surface **57** and provides similar suspension for the flanges **66—68** of the baffles **52—53**.

The arrangement of Fig. 3 illustrates means for connecting two adjacent transducer elements **70—71** (and corresponding baffles **72—73**) at those adjacent edges which do not require direct frame suspension. In the arrangement shown, the boot **74** for transducer **70** is integrally formed with a mounting flange **75** slightly offset from the front-to-back center of the transducer, and a similar flange **76** is similarly formed in the boot for the transducer **71**. Both flanges are preferably reinforced, as at **77**, and may be overlapped and clamped by bolt means **78** in a manner to preserve the coplanar disposition of the radiating faces of the transducer unit **70—71**. The same organization of parts applies for connection of offset flanges **80—81** on baffle **72—73**, as will be understood.

In developing an array of elements of the character described, the desired array directivity may be attained either by employing transducer units **10—11—12—13** etc., all of the same nature and closely spaced so as to present a substantially continuously radiating face, or the number of active transducer elements employed in the array can be chosen in terms of the rated power desired. In the latter event, variable-position type resonating baffles or parasitic radiators may be arranged between the more widely spaced transducer elements, so that no more transducer elements need be employed than are required to process the power efficiently.

In my said copending application Serial No. 481,988, I disclose that variable-position resonant baffles or parasitic radiators may be exactly of the same construction as the transducers, the only difference being that one is energized, while the other oscillates only parasitically, by virtue of coupling through the medium in which both the active element and the parasite are immersed. In Fig. 1, I illustrate my preference for the latter arrangement and have shown, for the broken-open part of transducer unit **12**, the mere provision of slot formations corresponding to those of the excited transducer **11**, there being no windings and no need for windings in the parasitic transducer or baffle **12**. The inner and outer mass-area proportions in the transducer unit **12** are preferably the same as for the excited transducer unit **11** so that, when driven parasitically, the acoustic radiation from the parasite may closely approximate that from the driven element. In a large array, and depending upon the power output required, it may only be necessary to provide a few more widely spaced excited elements, as at **11**, all surrounding elements **10—12—13** being of the parasitically excited variety. In all cases, attenuating baffles **35—36—37** are desirable to reduce back response.

It will be seen that I have described improved transducer constructions particularly applicable to high-power, low-frequency use and providing no more bulk than that absolutely necessary to achieve the desired radiation. Efficiency may be in the range 80–95 percent, and this is

attainable in the low-frequency range 60–1000 C. P. S. The transducers are precisely reproducible, they use non-critical materials, and they are applicable to mass production. They contain no fragile parts or assemblies and no parts which are subject to wear or loosening. Furthermore, arrays as described are immune to pressures as high as a few thousand pounds per square inch.

While I have described the invention in detail for the preferred forms shown, it will be understood that modifications may be made within the scope of the invention as defined in the claims which follow.

I claim:

1. In combination, a variable-position electroacoustic transducer, comprising a stator mass completely surrounding an armature mass and connected thereto by a stiff compliance, said stator mass presenting an extensive radiating area across two opposed faces thereof, electromagnetic means reacting between said stator mass and said armature mass for exciting said masses relatively to each other for yieldable reaction through said compliance, and a separate unitary baffle supported adjacent one of said surfaces and substantially coextensive therewith and comprising a gas-filled enclosure of yieldable material.

2. In combination, an array of variable-position transducer units, each comprising an inner mass coupled to an outer mass through a stiff compliance, the outer mass presenting two opposed extensive radiating surfaces for radiation into a liquid medium, and the compliant connections being aligned for compliant yielding movement generally along axes normal to said radiating faces, the corresponding radiating faces of adjacent elements in said array being substantially coplanar, and individual baffles adjacent corresponding rear radiating faces of all said elements, said individual baffles each being substantially coextensive with the rear radiating face to which it is adjacent.

3. The combination of claim 2, in which each said baffle comprises a gas-filled envelope yieldable in the general direction of the response axis of the transducer immediately adjacent thereto.

4. The combination of claim 2, in which one of said variable-position transducer units includes electromagnetic means carried by the inner and outer masses thereof and reacting between said masses to excite said transducer unit, one of the transducer units adjacent said excited unit being unexcited and therefore driven parasitically through the fluid coupling established when driving the excited unit with said array immersed in liqud.

5. A transducer according to claim 2, in which said array includes three laterally adjacent variable-position transducer units, the intermediate one of said three variable-position transducer units including electromagnetic means carried by the inner and outer masses thereof and reacting between said masses to excite said transducer unit, the other two of said three transducer units being unexcited and therefore driven parasitically through the fluid coupling established when driving the excited unit with said array immersed in liquid.

6. In combination, a variable-position transducer comprising an inner mass reacting through a stiffly complaint connection to an outer mass, said outer mass completely surrounding said inner mass and being coupled to said inner mass only through said compliance, said outer mass being of rectangular prismatic proportions and having opposed radiating principal surfaces, the yieldable axis of said compliant connection being predominantly normal to said surfaces, mounting means for said transducer comprising means rigidly carried only by said stator mass, an external framework to which said transducer is to be mounted, and a yieldable connection between said framework and said mounting means.

7. A transducer according to claim 6, in which said mounting means carried by the stator mass includes an elongated laterally projecting flange, and in which said framework includes a flange substantially parallel to said first-mentioned flange but laterally offset therefrom, said yieldable connecting means comprising a flat elongated strip of rubber-like material, and means clamping the respective sides of said strip in overlapping relation with said respective flanges.

8. The combination of claim 7, in which said strip includes at least at locations of connection to said respective flanges an internal metallic reinforcement bonded within the body of said strip.

9. The combination according to claim 7, and including a boot of acoustically transparent yieldable material surrounding said transducer, said flange on said transducer being formed integrally with said boot, there being in said transducer flange at locations of securing said strip to said flange a reinforcement of metallic material bonded within the body of said flange.

10. The combination of claim 7, in which said transducer includes, coextensive with the rear radiating face thereof, a unitary baffle element comprising a gas-filled envelope yieldable in the general direction of the response axis of said transducer element, said envelope integrally including a mounting flange elongated substantially coextensive with the transducer mounting flange and secured to the same edge of said connecting strip as said transducer mounting flange.

11. The combination of claim 10, and a boot of acoustically transparent material completely surrounding said envelope, said flange of said envelope being integrally formed with said boot, there being at locations of securing said flange to said strip internal metallic reinforcement means bonded within the body of said flange.

12. In combination, two rectangular prismatic variable-position transducers, each said transducer having a principal radiating face with a response axis generally normal thereto, said transducers being adjacent with their principal radiating faces substantially in the same plane and with their response axes intersecting said plane in spaced relation, each of said transducer units being integrally formed with an elongated mounting flange along an edge thereof, said flanges projecting laterally of the response axes of said transducers, and means connecting said mounting flanges to each other and comprising an elongated strip of rubberlike material secured at its edges to said respective flanges.

13. The combination of claim 12, in which said flanges are integrally formed with a boot of acoustically transparent material fully encasing said transducer units, there being at locations of securing said strip to said flanges metal reinforcement means bonded within the body of each of said flanges and of said strip.

14. In combination, two rectangular prismatic variable-position transducers, each transducer having a principal radiating face with a response axis generally normal thereto, said transducers being disposed adjacent each other with their radiating faces in substantially the same plane and with their response axes facing in the same general direction in spaced substantially parallel relation, each of said transducers including an outer protective boot of acoustically transparent material integrally formed with an elongated flange along the adjacent sides of said transducer units, and means clamping said flanges to each other.

15. The combination of claim 14, in which each of said flanges includes, at locations of clamping, internal metallic reinforcement means bonded within the body of each of such flanges.

16. In combination, a rectangular prismatic variable-position transducer having opposed radiating faces and with a response axis generally normal to said faces, said transducer including mounting means carried thereby and projecting laterally of said response axis, a rectangular prismatic baffle having opposed faces substantially coextensive with said opposed faces of said transducer and mounted adjacent the rear radiating face of said trans-

ducer and including mounting means projecting laterally of said response axis, a rigid framework, and elongated rubber-strip means connected to said framework and to each of said mounting means of said transducer unit and of said baffle.

17. In combination, a rectangular prismatic variable-position transducer having opposed radiating faces, and a rectangular prismatic baffle comprising a metallic envelope having opposed spaced faces substantially coextensive with said opposed faces of said transducer and mounted adjacent the rear radiating face of said transducer, said faces of said envelope being connected to each other by pleated edge formations of the material of said envelope.

No references cited.