April 18, 1967 W. LIBEN 3,314,866

METHOD OF FABRICATING DIAPHRAGM ASSEMBLIES

Filed Dec. 9, 1963

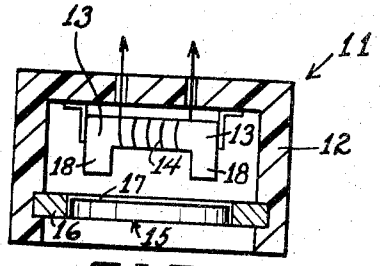


FIG. 1

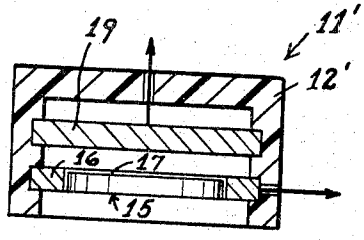


FIG. 2

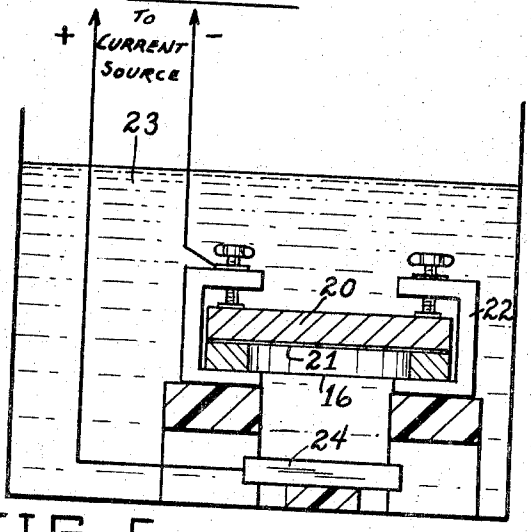


FIG. 5

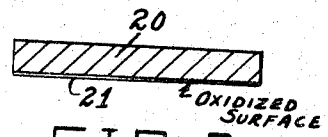


FIG. 3

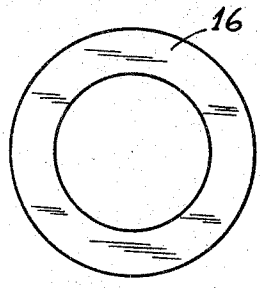


FIG. 4

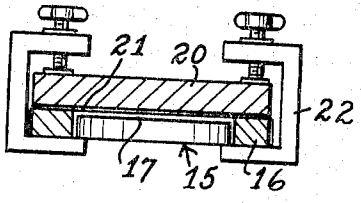


FIG. 6

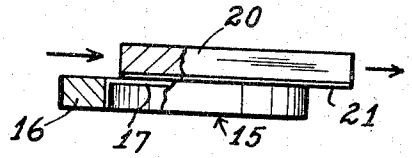


FIG. 7

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METHOD OF FABRICATING DIAPHRAGM ASSEMBLIES

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This invention relates to methods of fabricating electrical components, and more particularly to a method of making thin diaphragms for use in electromechanical transducers and similar applications.

A main object of the invention is to provide a novel and improved method of fabricating a diaphragm assembly for use in an electromechanical transducer, the method involving relatively simple apparatus, being easy to perform, and enabling an assembly having a very thin diaphragm element to be safely and economically fabricated.

A further object of the invention is to provide an improved method of fabricating a diaphragm assembly of the type having a very thin metal vibratory diaphragm element, said method providing a diaphragm element of uniform thickness and homogeneous composition, as well as greatly simplifying the process of forming the diaphragm assembly and subsequently handling same.

Further objects and advantages of the invention will become apparent from the following description and claims, and from the accompanying drawings, wherein:

FIGURE 1 is a vertical cross-sectional view taken through one form of electromechanical transducer employing a diaphragm assembly constructed by a method according to the present invention.

FIGURE 2 is a vertical cross-sectional view taken through another form of electromechanical transducer employing a diaphragm assembly constructed by the method of the present invention.

FIGURE 3 is a vertical cross-sectional view taken through a matrix member employed in forming a diaphragm assembly by the method of the present invention.

FIGURE 4 is a plan view of a frame member forming the main supporting means for the diaphragm element in a diaphragm assembly formed by the method of the present invention.

FIGURE 5 is a vertical cross-sectional view showing the frame member of FIGURE 4 clamped to the matrix member of FIGURE 3 and the clamped members supported in an electroplating bath during the diaphragm fabrication step of the method of the present invention.

FIGURE 6 is a vertical cross-sectional view taken through the clamped members and showing the diaphragm elements electroplated thereon.

FIGURE 7 is an elevational view, partly in vertical cross-section, showing how the matrix member is slid off the diaphragm assembly in the final stage of the fabrication method of the present invention.

Electromechanical transducers are used to convert a mechanical motion into an electrical signal. Two examples of such transducers are shown in FIGURES 1 and 2. In FIGURE 1, the transducer is designated generally at **11** and comprises a frame **12** in which is supported a U-shaped magnetic core **13** provided with a pickup winding **14**. Designated at **15** is a diaphragm assembly comprising a rigid supporting ring-shaped frame **16** carrying a vibratory diaphragm element **17** disposed adjacent the ends of the poles **48**, **18** of core **13**. Vibratory motion of the diaphragm element **17** produces changes in the reluctance of the magnetic circuit associated with the coil **14**, whereby corresponding electrical signals are induced in the coil. The signals are related to the motion of the diaphragm, and therefore to the cause of said

motion, such as changes in the gas or liquid pressure acting on the diaphragm.

In FIGURE 2, the transducer is designated generally at **11'** and comprises a rigid main frame **12'** in which is secured a rigid first condenser plate **19** and a transducer assembly **15**, constituting a second condenser plate, arranged parallel and adjacent said first condenser plate. Vibratory movements of the diaphragm element **17** produce changes in capacity between the plate **19** and the diaphragm assembly **15**, which provides a useful signal related to the motion of the diaphragm element.

It is often desirable to make the vibratory diaphragm element **17** very thin. With methods of fabrication employed in the past, the requirement for a very thin diaphragm element has created difficult problems in the fabrication and handling of the diaphragm element. The fabrication procedure of the present invention solves many of the problems previously encountered.

In accordance with the present invention, the diaphragm element **17** is fabricated onto the rigid supporting ring-shaped frame **16** in a manner to produce an integrated structure combining the support ring and the diaphragm element. A typical procedure according to the present invention comprises employing a rigid metal plate **20**, hereafter designated as the "matrix," having a surface **21** which is chemically passivated. For example, the member **20** may comprise a stainless steel plate whose surface **21** has been allowed to oxidize. A support ring **16** is secured to the surface **21** in any suitable manner, for example, by being clamped thereto by means of C-clamps **22**. Alternatively, other well known types of clamping or securing means may be employed. The ring **16** is of the same metal as the intended vibratory diaphragm element. The central opening in the ring-shaped frame **16** is the area in which the diaphragm element is to be fabricated. This assembly is now supported in an electroplating bath **23** containing an anode **24** of the metal to be deposited, the clamped assembly **20**, **16** constituting the cathode. The clamped assembly and anode are connected to a suitable source of current and the electroplating process is allowed to proceed until a film **17** of the appropriate metal thickness has been built up on the matrix surface **21** inside the opening of the frame **16**. This film is supported on the matrix and is firmly attached to the inside wall surface of the ring-shaped frame **16**.

When the desired film thickness has been built up, the clamped assembly is removed from the plating bath, is unclamped, and the matrix **20** is slid off the support ring **16**, as illustrated in FIGURE 7. The remaining assembly **15**, comprising the rigid support ring **16** and the thin vibratory diaphragm element **17**, is ready for use in a transducer.

The ring **16** and plated film **17** forming the thin vibratory diaphragm element may be composed of any suitable metal which can be electroplated, for example, nickel, or any other similar metal preferably having a low thermal coefficient of expansion.

The device formed by the method of the present invention is useful not only as a diaphragm assembly for a transducer in electro-mechanical systems, but also for other purposes, such as to separate two volumes of gas and to maintain independent pressures therein, where the diaphragm assembly prevents mixing of the two volumes. Another possible use is in a strain gage wherein the diaphragm deflection may be employed to operate an indicator. It will be apparent that the diaphragm assembly is useful in any application which requires a thin metal diaphragm element, and in applications wherein thin metal diaphragms must be fabricated, handled and assembled.

While a specific embodiment of an improved method

of fabricating a metal diaphragm assembly has been disclosed in the foregoing description, it will be understood that various modifications within the spirit of the invention may occur to those skilled in the art. Therefore it is intended that no limitations be placed on the invention except as defined by the scope of the appended claims.

What is claimed is:

1. A method of fabricating a diaphragm assembly comprising forming a passivated surface on a matrix plate, detachably securing a rigid metal frame ring to said matrix plate in contact with said passivated surface, electroplating a film of the same metal as said ring adherently onto the inside of the ring and across the central aperture of the ring, and then removing the matrix plate.

2. A method of fabricating a diaphragm assembly comprising forming an oxidized surface on a matrix plate on which plating is non-adherent, detachably securing a rigid metal frame ring to said matriv plate in contact with said oxidized surface, electroplating a film of the same metal as said ring adherently onto the inside of the ring and across the central aperture of the ring adjacent said oxidized surface, and then removing the matrix plate.

3. A method of fabricating a diaphragm assembly comprising forming an oxidized surface on a matrix plate on which platitng is non-adherent, detachably securing a rigid metal frame ring to said matrix plate in contact with said oxidized surface, placing the matrix plate and frame ring in an electroplating bath, electroplating a film of the same metal as said ring adherently onto the inside of the ring and across the central aperture of the ring adjacent said oxidized surface, removing the matrix plate, frame ring and plated film from the electroplating bath, and then detaching the matrix plate.

4. A method of fabricating a diaphragm assembly comprising forming an oxide coating on a flat surface of a matrix plate on which plating is non-adherent, detachably clamping a rigid metal frame ring to said matrix plate in contact with said oxide coatng, electroplatng a film of the same metal as said ring adherently onto the inside of the ring and across the central aperture of the ring adjacent said oxide coating, unclamping the matrix plate relative to the frame ring, and then sliding the matrix plate off the frame ring.

5. A method of fabricating a diaphragm assembly comprising forming an oxide coating on a flat surface of a matrix plate on which plating is non-adherent, detachably clamping a rigid metal frame ring to said matrix plate in contact with said oxide coating, placing the matrix plate and frame ring in an electroplating bath, electroplating a film of the same metal as said ring adherently onto the inside of the ring and across the central aperture of the ring adjacent said oxide coating, removing the matrix plate, frame ring and plated film from the electroplating bath, and then detaching the matrix plate.

6. A method of fabricating a diaphragm assembly comprising forming an oxide coating on a flat surface of a stainless steel matrix plate on which plating is non-adherent, detachably clamping a rigid metal frame ring to said matrix plate in contact with said oxide coating, placing the matrix plate and frame ring in an electroplating bath, electroplating a film of the same metal as said ring adherently onto the inside of the ring and across the central aperture of the ring, said film being adjacent the oxide coating in the area bounded by said central aperture, removing the matrix plate, frame ring and plated film from the plating bath, unclamping the matrix plate, and then sliding the matrix plate off the frame ring and plated film.

No references cited.

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