



US007912241B1

(12) **United States Patent**
Graber

(10) **Patent No.:** **US 7,912,241 B1**
(45) **Date of Patent:** **Mar. 22, 2011**

(54) **FIELD SERVICEABLE PLANAR LOUDSPEAKER**

(76) Inventor: **Curtis E. Graber**, Woodburn, IN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1270 days.

(21) Appl. No.: **11/492,495**

(22) Filed: **Jul. 25, 2006**

(51) **Int. Cl.**
H04R 25/00 (2006.01)

(52) **U.S. Cl.** **381/431**; 381/398; 381/408

(58) **Field of Classification Search** 381/176, 381/398, 399, 408, 423, 431; 181/171, 172; 29/592.1, 594, 609.1; 16/353, 380, 381; 335/209, 306

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,188,686 A *	6/1965	Orcutt	16/263
3,733,649 A *	5/1973	Nagy et al.	16/380
4,156,801 A	5/1979	Whelan et al.	

4,385,418 A *	5/1983	Lofis et al.	16/381
4,803,733 A	2/1989	Carver et al.	
5,850,461 A	12/1998	Zelinka	
6,317,928 B1 *	11/2001	Guillemette	16/353
6,934,402 B2	8/2005	Croft, III et al.	
2004/0022407 A1 *	2/2004	Steere et al.	381/398
2004/0022408 A1 *	2/2004	Mango et al.	381/408

* cited by examiner

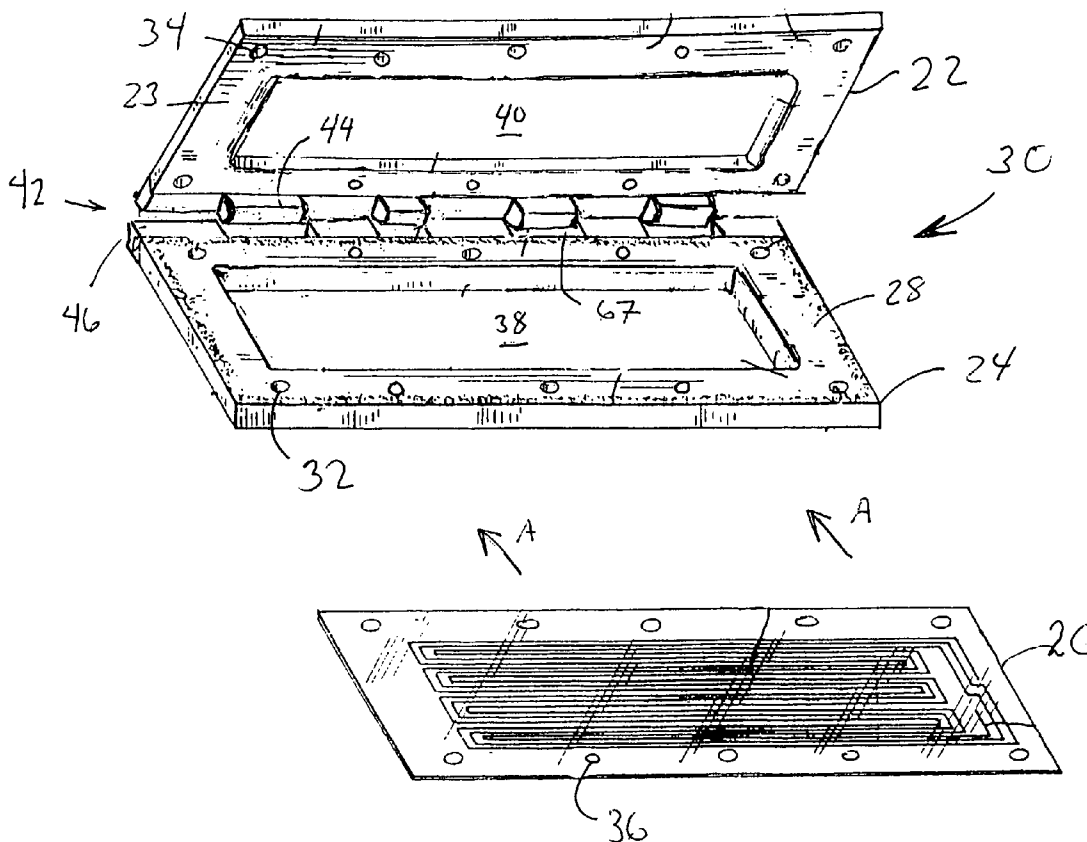
Primary Examiner — Huyen D Le

(74) *Attorney, Agent, or Firm* — Paul W. O'Malley

(57) **ABSTRACT**

A push-pull magnetic-planar acoustic transducer provides easy field replacement of a diaphragm. Push-pull magnetic-planar acoustic transducers are known for the relative vulnerability of their diaphragms to damage. Replacement of the transducers in the field as been problematic because of the high repulsive force between the front and back panels and the need to obtain even tension across the diaphragm. The push-pull transducer assembly incorporates an edge hinge on which the panels can be pivoted to bring the panels into facing positions and a plurality of set screws to be fitted around the perimeter of the panels allowing essentially flat closure of the panels on one another to a working spacing engaging the diaphragm.

6 Claims, 8 Drawing Sheets



20

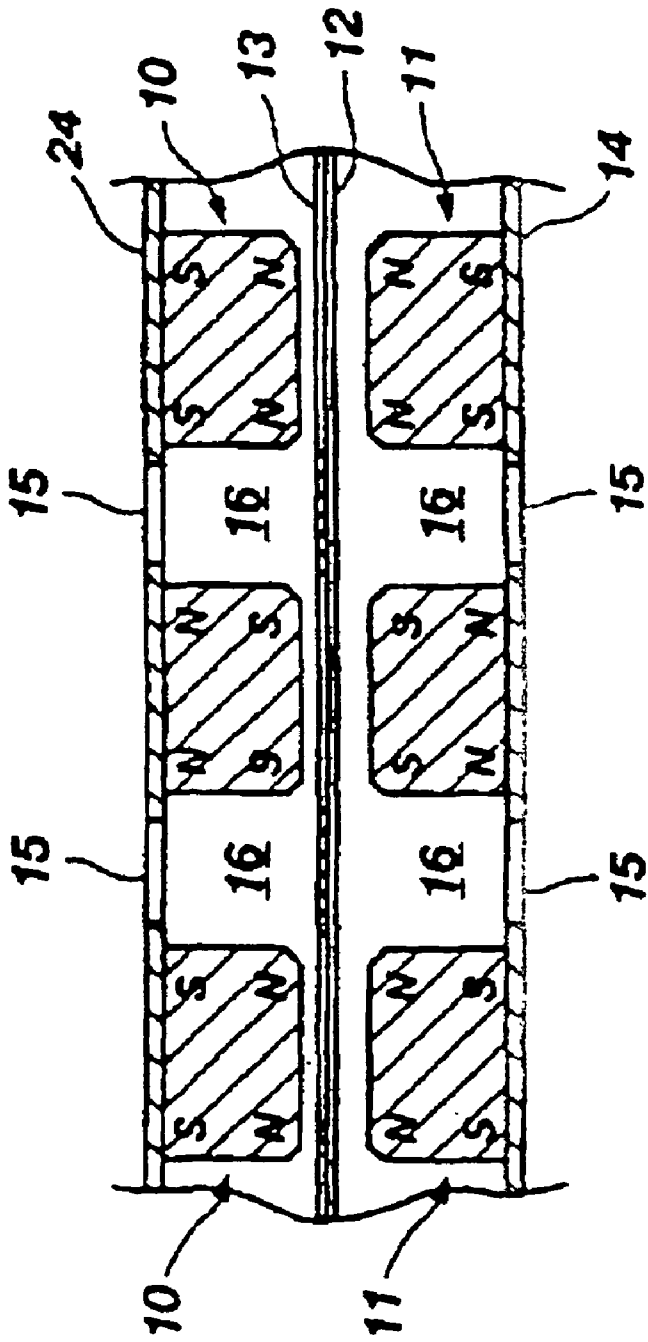
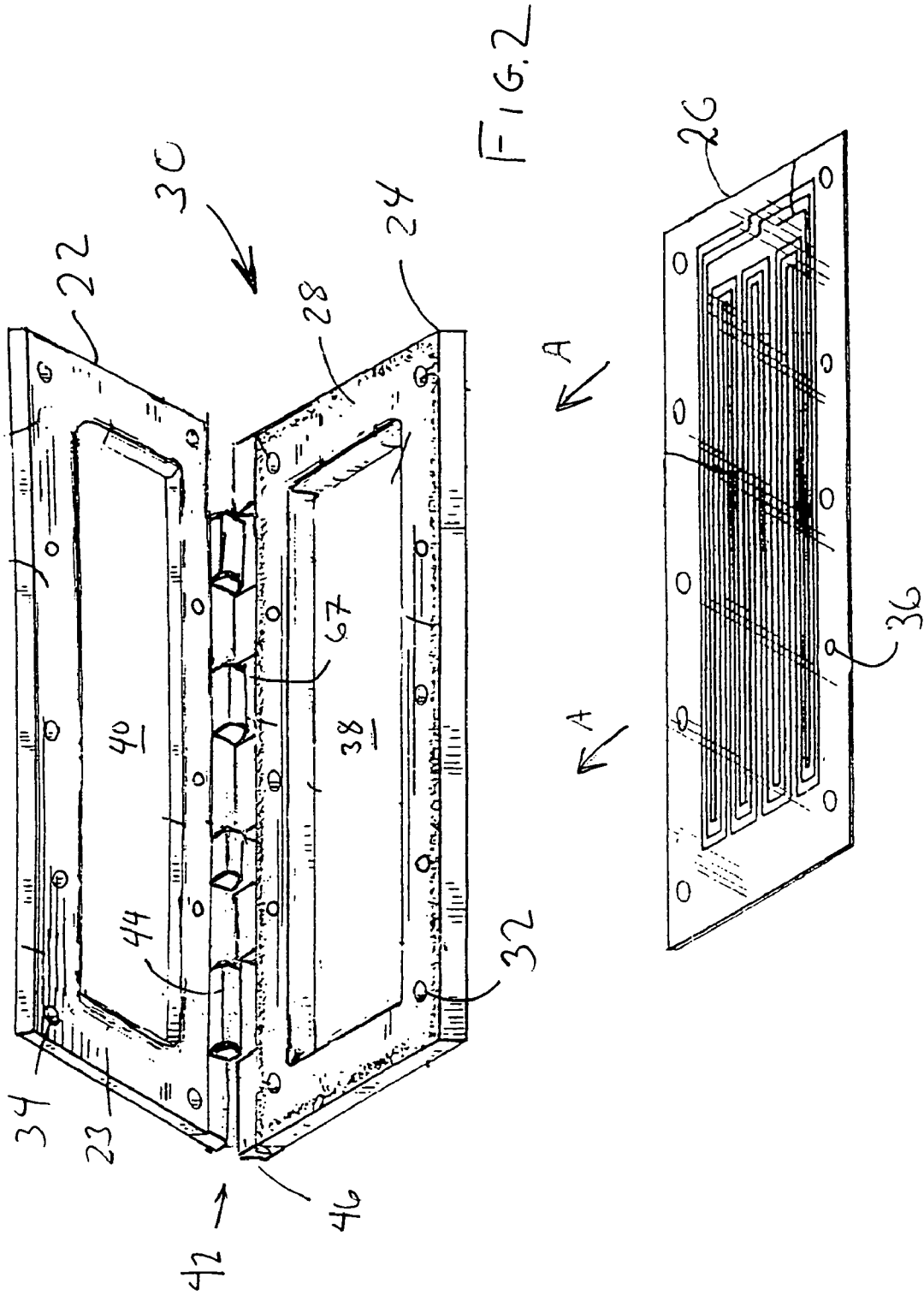


Fig. 1
(PRIOR ART)



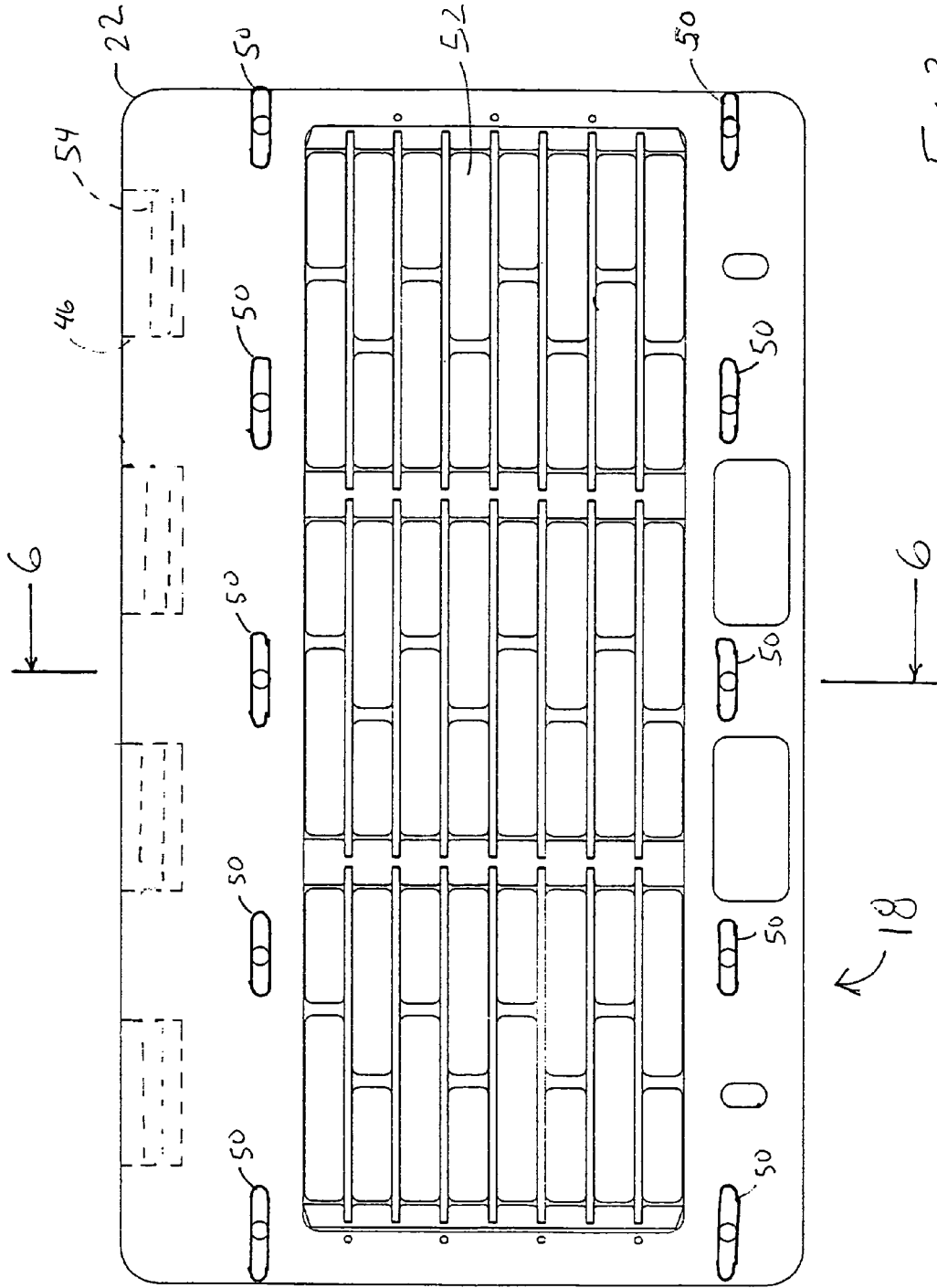


FIG. 3

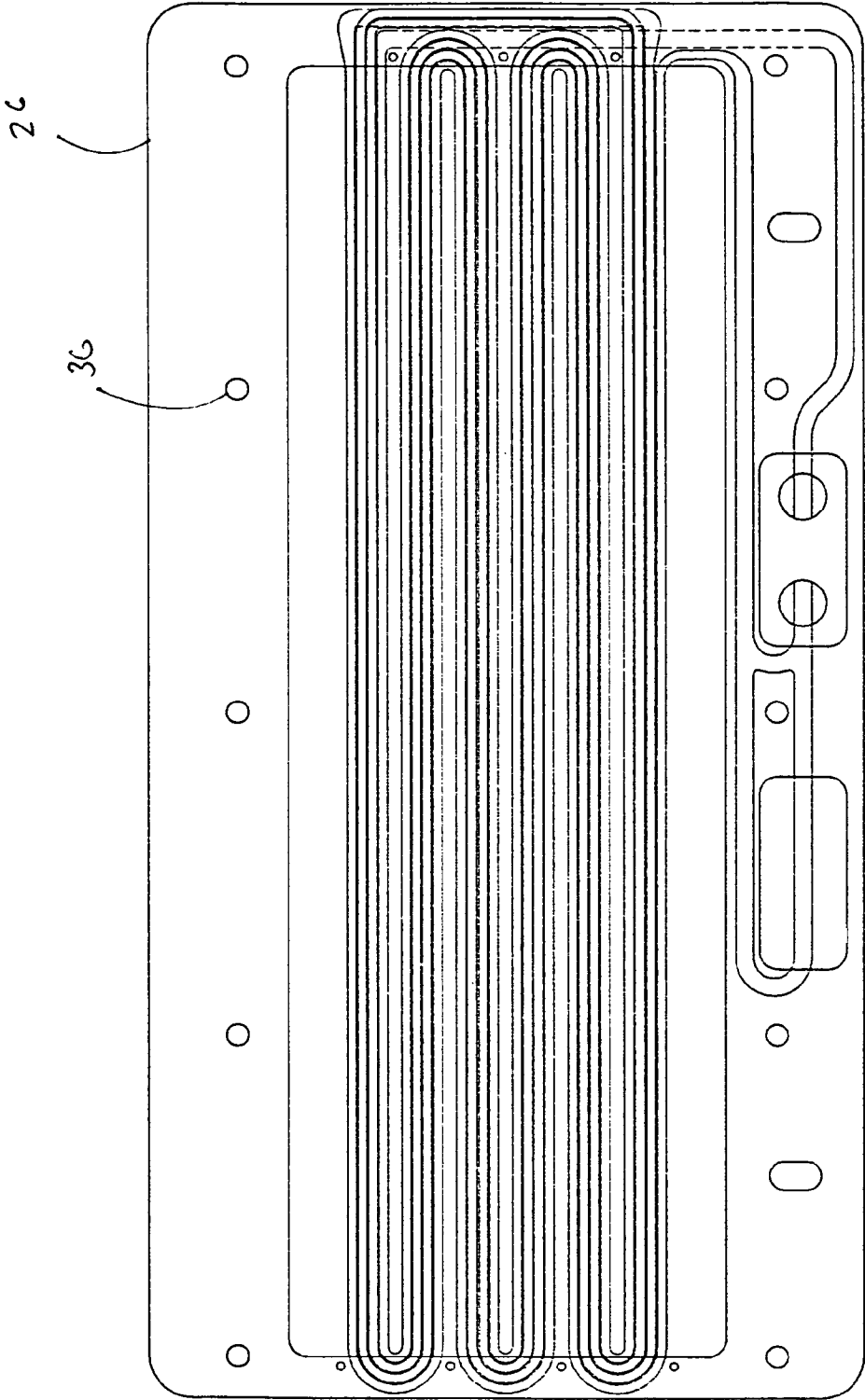


FIG. 4

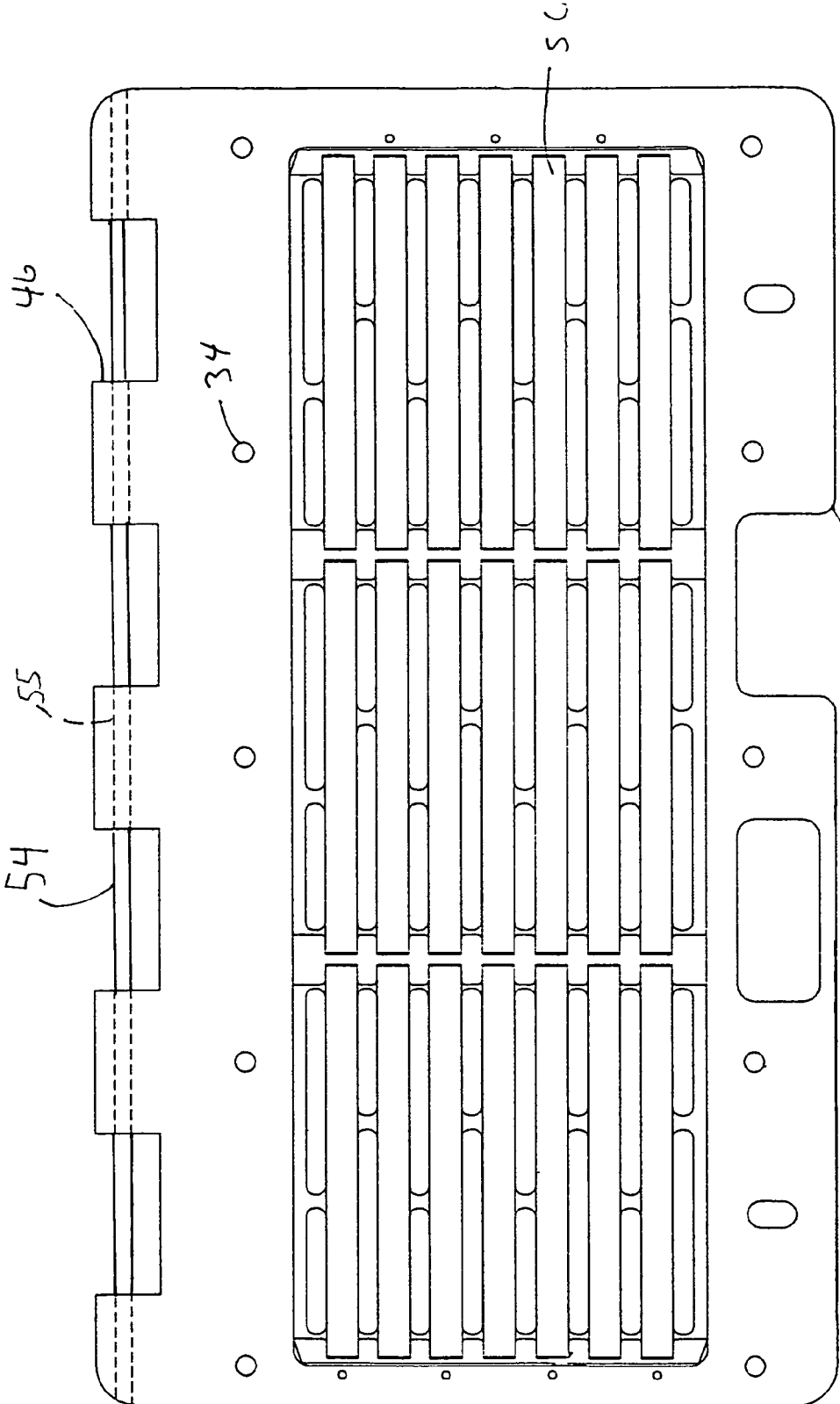
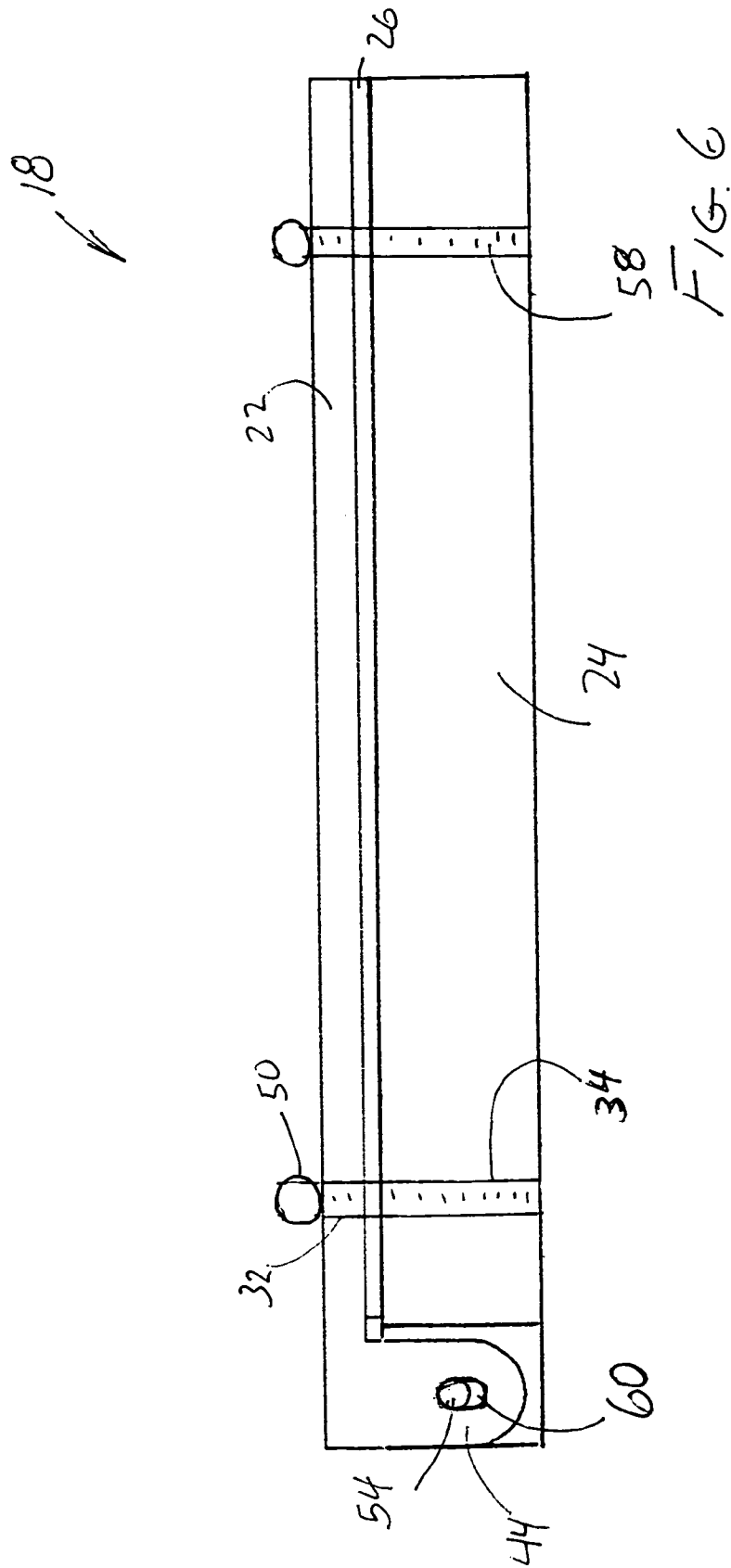


FIG. 5



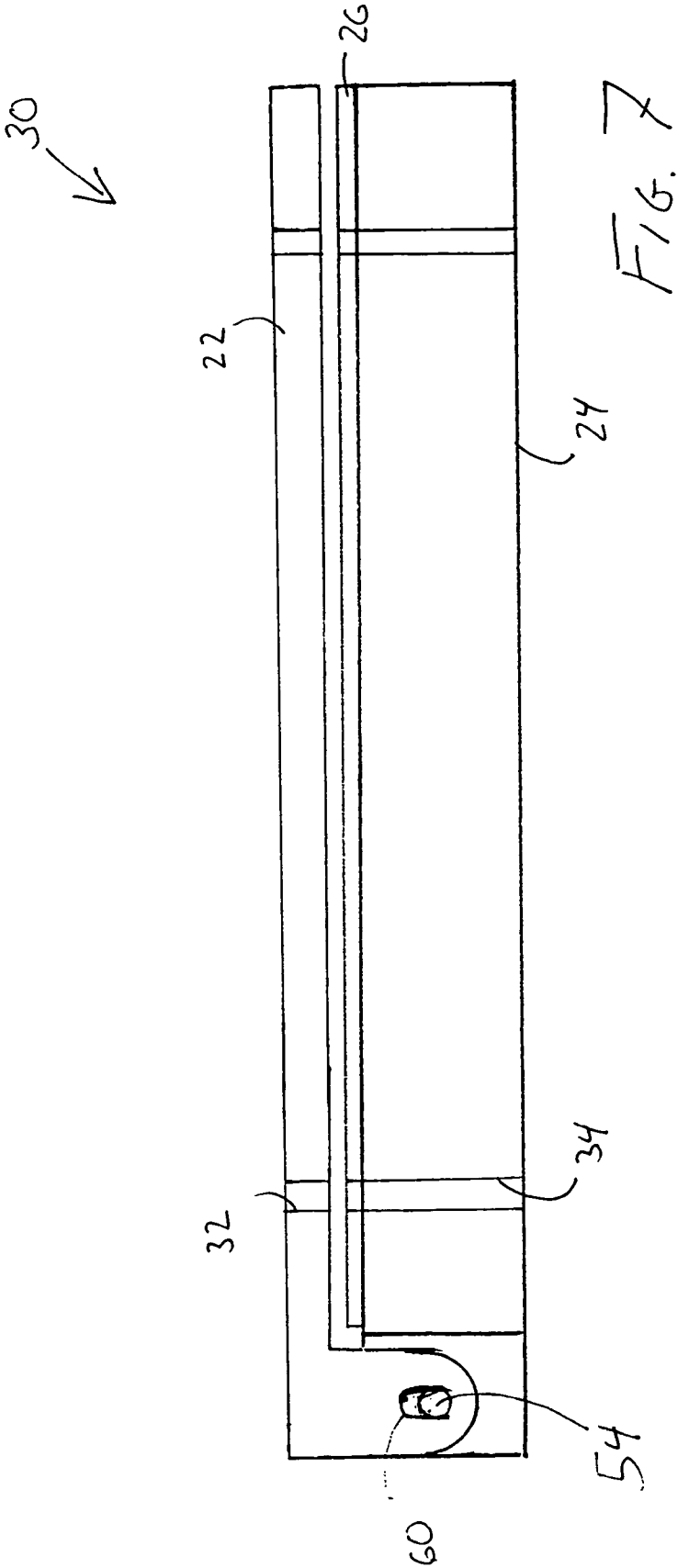


FIG. 7

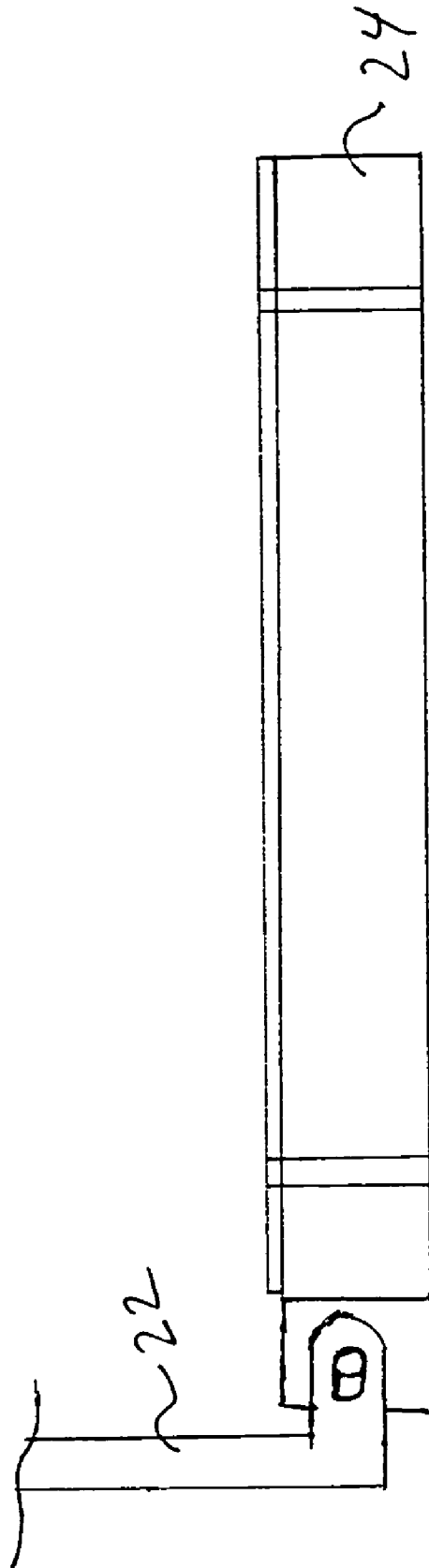


FIG. 8

1

FIELD SERVICEABLE PLANAR LOUDSPEAKER

BACKGROUND OF THE INVENTION

1. Technical Field

The invention relates to planar-magnetic loudspeakers and more particularly to a push-pull, planar-magnetic loudspeaker allowing field replacement of the diaphragm.

2. Description of the Problem

FIG. 1 illustrates a double-ended, or push-pull, magnetic-planar transducer **20**, conventional in the prior art. This structure is characterized by two magnetic arrays **10** and **11** supported by perforate substrates **14**, **24** positioned on opposite sides of a flexible diaphragm **12**, which includes a conductive coil **13**. The film is tensioned into a planar configuration. An audio frequency drive signal is supplied to the coil **13**, and a variable voltage and current thereby provided in the coil gives rise to a variable magnetic field, which interacts with the fixed magnetic field set up by and between the magnet arrays **10** and **11**. The diaphragm is displaced in accordance with the audio frequency drive signal, thereby generating a desired acoustic output. An example representing this art area is found in U.S. Pat. No. 4,156,801 issued to Whelan.

Because of a doubled-up, front/back magnet layout of the prior art push-pull magnetic structures, double-ended systems have been generally regarded as more efficient, but also as more complex to build. Double-ended designs are also particularly sensitive to deformation from repulsive magnetic forces that tend to deform the devices outward. Outward bowing draws the edges of the diaphragm closer together, and alters the tension of the diaphragm. This can seriously degrade performance and, over time, can render the speaker unusable necessitating disposal or repair of the unit.

Assembly of push-pull structures presents its own difficulties. As observed in U.S. Pat. No. 6,934,402 issued to Croft III, et al., the magnetic circuits of the front and back magnetic structures interact. The repulsion forces make it difficult to have a stable mechanical structure, while providing a focused field and making better use of magnetic material than single-ended devices. Assembly of push-pull structures presents its own difficulties. Like magnetic poles are brought into close proximity, requiring substantial force to bring the assembly together.

In U.S. Pat. No. 5,850,461 it was further observed that in the field of planar magnetic acoustic transducers and related flat type transducers utilized for sound reproduction, the tensioning of the sound producing diaphragms is important to obtain uniform sound reproduction. The proper tensioning of a diaphragm within a support frame has created difficulty in manufacturing processes. In planar magnetic transducers, if sufficient diaphragm tensioning is not provided, the diaphragm may vibrate into one of the stators formed by spaced magnets mounted within a support frame in spaced relationship with respect to an electrical circuit applied to the diaphragm. Improper tensioning throughout the diaphragm also results in changes in the vibrational characteristics of the diaphragm throughout its "sound producing" or "active" area which is generally that area defined internally of the diaphragm support frame.

SUMMARY OF THE INVENTION

According to the invention a push-pull, planar-magnetic acoustic transducer comprises a front panel incorporating an array of magnets set in an aperture and a back panel including an array of magnets set in an aperture, where upon assembly

2

the front and back panels are held parallel to one another in close proximity with like polarity poles of the magnets aligned on one another. The front and back panels are coupled together along one major side of each on a pivot/hinge bar.

The pivot bar extends through slots in alternating sections of the front and back panels where the slots through the sections of one of either the front or back panels are elongated in the front to back direction of the panel. Set screws are fitted to hold the front and back panels together in the facing, parallel assembly.

Additional effects, features and advantages will be apparent in the written description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a cross-sectional fragmentary view of a prior art push-pull planar-magnetic transducer;

FIG. 2 is a perspective view of a planar magnetic transducer according to the invention opened for replacement of its diaphragm;

FIG. 3 is a top plan view of a planar-magnetic transducer in accordance with the invention;

FIG. 4 is a top plan view of a diaphragm for the planar-magnetic transducer of FIG. 3;

FIG. 5 is a top plan view of a base plate for the planar-magnetic transducer of FIG. 3;

FIG. 6 is a cross sectional view of the planar-magnetic transducer of FIG. 3 taken along section lines 6-6;

FIG. 7 is a cross sectional view of the planar-magnetic transducer with set screws released; and

FIG. 8 is a cross sectional view of the planar-magnetic transducer opened for replacement of a diaphragm.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the figures and in particular to FIG. 2 an opened clam shell **30** for use in constructing a double-ended, or push-pull, magnetic-planar transducer is shown. Clam-shell **30** comprises a front panel **22** and a back panel **24** which are linked by a hinge structure **42** along one of major (i.e. longer) edges of each panel. Front panel **22** and back panel **24** include central apertures **40** and **38** respectively, in which may be placed any preferred arrangement of magnets. Central apertures **40**, **38** connect opposite major surfaces of the front and back panels **22**, **24**. A diaphragm **26** (shown more particularly in FIG. 4) for introduction to the clam shell **30** as indicated by arrows A is placed on the forward major surface **28** to be pressed between the front panel **22** and back panel **24** upon closure of clam shell **30**.

An important characteristic of front and rear panels **22**, **24** are threaded holes **34**, **32**, visible on the rearward facing major surface **23** and the forward facing surface **28** of the front and back panels, respectively. Upon assembly the alignment holes **36** of diaphragm **26** align on and between threaded holes **34**, **32**. Upon placement of diaphragm **26** on the forward face **28** alignment holes **36** must be brought into precise alignment with alignment holes **32**.

Hinge **42** is constructed between interlaced blocks **44**, **46**. Four blocks **44** extend downwardly from rearward surface **23** into gaps **67** between blocks **46** extending outwardly from the

relatively rear surface of back panel **24**. In this way the blocks **44**, **46** of the respective panels alternate in sequence along a major edge of each of the panels. The hinge itself, as described below, allows the front panel **22** to translate or move front to back or back to front a short distance while the panels remain in a flat, parallel orientation with respect to each other. That is to say, the direction of movement of the front panel **22** may upon opening be kept perpendicular to the panel's major surfaces for a short distance. Conversely, upon closure, the front panel **22** may be brought into a parallel, facing position with the back panel **24** manually at a spacing where the repulsive force generated by the magnets is not too strong to prevent such movement.

Referring to FIG. 3, a planar-magnetic transducer **18** is shown constructed in accordance with the invention from clamshell **30**. Bar magnets **52** are placed in aperture **40** and the clamshell **30** is held closed by set screws threaded into the alignment holes **34**, **32** of the front and back panels **22**, **24**. Front panel **22** is linked to back panel **24** by a hinge bar **54** located in the gaps **67** between the blocks **46** and which passes through blocks **44**. The relatively elongated heads **50** of the set screws enables turning the set screws to bring the front and back panels **22**, **24** into closer proximity against the strong repulsive force of the magnets.

Referring to FIG. 5, a hinge bar **54** is shown inserted through slots **55** in blocks **46** of back panel **24**. Normally the hinge bar **54** is normally inserted to attach a front panel to the back panel. Magnets **56** are also illustrated placed in aperture **38**.

Referring to FIG. 6 planar-magnetic transducer **18** is shown in a cross sectional view with front panel **22** clamping diaphragm **26** against rear panel **24**. The panels are held against each other by ten set-screws **58** which have been inserted into alignment holes **34** and tightened only fully inserted. In order to maintain the panels in a nearly parallel alignment, and to enable closure of the panels against one another against the repulsive force generated by the magnets **56**, **58**, the pitch of the threads is shallow and the screws are inserted nearly synchronously, or in alternating partial turns. An oblong or elongated slot **60** is visible through block **44** into which hinge bar **54** has been inserted. When panel **22** is fully pressed against diaphragm **26** and back panel **24**, hinge bar **54** is pressed against the "upper" end of the elongated slot **60**. It will be understood that bar **54** corresponds almost exactly in diameter to slot **55** through blocks **46**. The direction of elongation is parallel to the front to back direction of the panel in the assembled transducer **18**.

With removal of threaded set-screws **58** front panel **22** moves away from back panel **24**, as is shown by the gap between diaphragm **26** and front panel **22**, and by the illustration of hinge bar **54** being located at the bottom of elongated slot **60** as shown in FIG. 7. It is desirable for assembly and disassembly that C-clamps or similar devices are used as restraints while the set screws are inserted and removed do to the powerful repulsive forces generated by the opposed magnets. As illustrated in FIG. 8, this allows top panel **22** to be pivoted away from back panel **24**.

The invention provides a field serviceable push-pull magnetic-planar transducer which allows field replacement of diaphragms.

While the invention is shown in only one of its forms, it is not thus limited but is susceptible to various changes and modifications without departing from the spirit and scope of the invention.

What is claimed is:

1. A push-pull, planar-magnetic acoustic transducer, comprising:
 - a front panel incorporating an array of magnets;
 - a back panel including an array of magnets;
 - a hinge structure connecting the back panel to the front panel along a major edge of each;
 - the hinge structure including a pivot bar coupling the front and back panels to one another and a plurality of sections which depend in alternating order from the front and back panels and which interlace upon assembly, with the sections which depend from one of either the front or back panel incorporating an oblong slot for admitting the pivot bar, the oblong slot being elongated in the front to back direction of the push-pull, planar-magnetic acoustic transducer which allows the front and back panels to be moved relative to one another while held face to face; and
 - set-screws holding the front and back panels together in facing, parallel assembly.
2. A push-pull, planar-magnetic acoustic transducer as described in claim 1, further comprising:
 - the front and back panels having central apertures connecting the major surfaces of the front and back panels and in which the arrays of magnets are placed;
 - a plurality of threaded bore holes distributed around the central apertures in each of the front and back panels into which the set-screws are inserted for holding the front and back panels in proximate, facing position, the set screws being long enough to extend through the front panel into engagement with the back panel up to the maximum spacing allowed between the back and front panels by the hinge structure when the front panel and back panel are facing one another and parallel.
3. A push-pull, planar-magnetic acoustic transducer as described in claim 2, further comprising:
 - a diaphragm for insertion between the front and back panels, the diaphragm having a plurality of alignment holes for alignment on the threaded bore holes of the back panel.
4. A push-pull, magnetic-planar acoustic transducer with a replaceable diaphragm, comprising:
 - front and back panels incorporating arrays of magnets;
 - an edge hinge coupling the front and back panels along a major edge of the panels on which the panels can be pivoted to bring the panels into facing opposition and opened to allow replacement of the diaphragm from between the panels; and
 - the edge hinge including interlaced blocks also allowing front to back and back to front translation of the front and back panels with the panels remaining in a flat, parallel and facing orientation with respect to one another and without pivoting of the panels with respect to one another on the edge hinge.
5. A push-pull, magnetic-planar acoustic transducer with a replaceable diaphragm as described in claim 4, further comprising:
 - a plurality of distributed, incrementally adjustable clamping elements for drawing the front and back panels toward one another and holding the panels in close proximity to one another with a diaphragm pinched between the panels from the location of maximum spacing of the front and back panels when facing and parallel to one another.

5

6. A push-pull, magnetic-planar acoustic transducer with a replaceable diaphragm as described in claim 5, further comprising:

physical modifications of the back panel for guiding alignment of a replacement diaphragm on the back panel; and

6

a plurality of set screws to be fitted around the perimeter of the panels allowing essentially flat closure of the panels on one another to a working spacing engaging the diaphragm.

* * * * *