PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : F16J 15/32 — A1

(11) International Publication Number: WO 94/28337

(43) International Publication Date: 8 December 1994 (08.12.94)

(21) International Application Number: PCT/US94/06171

(22) International Filing Date: 2 June 1994 (02.06.94)

(30) Priority Data:
08/071,162 2 June 1993 (02.06.93) US

(71) Applicant: CHOMERICS, INC. [US/US]; 77 Dragon Court, Woburn, MA 01888 (US).

(72) Inventors: GENOVA, Anthony, T.; 51 Stoney Brook Road, Westford, MA 01886 (US). KROHTO, Eric; Apartment 4, 1 Sawin Street, Natick, MA 01760 (US). SACCUZZO, Ron; 8 Muse Terrace, Salem, NH 03079 (US).

(74) Agents: HUBBARD, John, D. et al.; W.R. Grace & Co.-Conn., Patent Dept., 55 Hayden Avenue, Lexington, MA 02173 (US).

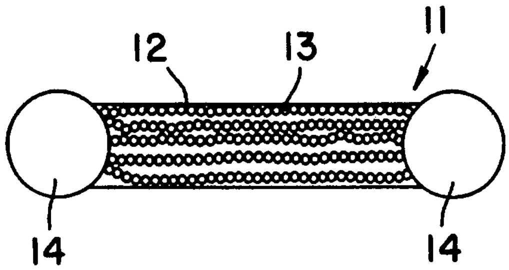
(81) Designated States: CA, JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: CONDUCTIVE/SEALING GASKET

(57) Abstract

An EMI shielding/environmental gasket formed of an inner conductive area (11) and an outer, non-conductive sealing area (14). The inner area (11) is formed of one or more layers of electrically conductive mesh (12) embedded into a fluoroelastomer (13) such as a fluorosilicone. The outer layer (14) is formed of a non-conductive fluoroelastomer and is of a height equal or greater than that of the inner area so that it forms a good environmental seal around the perimeter of the conductive area when placed between two adjoining substrates.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgystan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo			SE	Sweden
CH	Switzerland	KR	Republic of Korea	SI	Slovenia
CI	Côte d'Ivoire	KZ	Kazakhstan	SK	Slovakia
CM	Cameroon	LI	Liechtenstein	SN	Senegal
CN	China	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TG	Togo
CZ	Czech Republic	LV	Latvia	TJ	Tajikistan
DE	Germany	MC	Monaco	TT	Trinidad and Tobago
DK	Denmark	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	US	United States of America
FI	Finland	ML	Mali	UZ	Uzbekistan
FR	France	MN	Mongolia	VN	Viet Nam
GA	Gabon				

Conductive/Sealing Gasket

The present invention relates to a gasket which is electrically conductive so as to provide lightning proection, EMI shielding, and grounding and which provides a good environmental seal. Moreover, it relates to a fluorosilicone/wire mesh composite gasket having good EMI/RFI shielding and lightning protection capabilities as well as environmental sealing properties.

Background of the Invention

EMI shielding is for providing protection against interference from electromagnetic energy, including radio frequency interference (RFI). The shielding may protect an electronic device from external EMI and RFI or may prevent EMI or RFI from escaping from an electrical device, or both. Grounding is the ability to properly terminate a panel or panels as to eliminate the threat of EMI to or from the equipment. Lightning protection is for the ability of the gasket to carry the full current of a direct lightning strike in the vicinity of the gasket. Environmental sealing is for protection against moisture, corrosion, dust, insects and similar environmental contamination encountered by electrical or electronic devices when in service.

EMI gaskets and seals have been made from the combination of rubber or elastomeric materials and metal wires or metal filaments. These gaskets are intended to function by the metal contacting the surfaces between which the gasket is assembled to provide the EMI shielding and the rubber or elastomeric material is intended to provide the environmental seal when compressed between the intended surfaces.

Other EMI gaskets have been provided in the form of an elastomeric binder containing electrically conductive particles, such as copper, iron, aluminum or nickel, coated with silver.

EMI gaskets have also been provided with a flexible foam rubber core having a wire exterior cover on the foam core such as a knitted or braided or otherwise woven wire fabric cover. The foam rubber core is intended to provide resilience to assure that the wire cover makes good electrical contact when compressed between the intended surfaces and is also intended to provide an environmental seal between the intended surfaces.

A further form has been to impregnate a wire fabric with a gel which encapulates the mesh keeping it from corroding.

It has been found that the above gaskets exhibit a number of problems in actual use, including corrosion or rusting of the metallic or wire portion and failure of the plastic, rubber, elastomer foam or gel to provide the desired environmental seal. In an attempt to eliminate corrosion and rusting, some gaskets have been made of noble metal wires, such as silver, which adds significantly to the cost of the gasket and does not always solve the corrosion and oxidation problems. In some of the above gaskets, a moisture leak path exists where the wires contact the surfaces because the rubber, elastomer foam or gel material does not adequately seal around and between the wires or metallic structures and the surfaces to prevent migration of moisture into or through the gasket area. Any migration of moisture into or through the gasket area frequently causes corrosion of the metal in the gasket and the adjoining substrate as well as other problems in the electrical or electronic device being protected by the gasket.

It has been recognized in the art that the above gaskets do not fulfill all the desired functions at once. Frequently when the gaskets provide satisfactory an EMI shield, they do not provide the desired environmental sealing, and/or lightning protection, and/or grounding and/or the gasket itself has or causes corrosion problems. Alternatively when the gaskets provide adequate environmental sealing, they frequently do not provide the desired EMI shielding, lightning protection and grounding. Consequently, it has also been recognized in the art that in many cases it has been necessary to separate the two functions and have an exterior conventional non conductive environmental gasket, such as an elastomeric or rubber gasket, and a separate interior EMI gasket, such as one of those mentioned above. This arrangement is undesirable, however, because it takes extra space, requires extra design, engineering and machining and increases installation difficulties, costs and risks of improper installation.

In view of the above, it is an object of this invention to provide an EMI gasket which provides electrical shielding and provides environmental sealing for not only the space between two surfaces but also for the conductive components which provide the EMI shielding in the gasket. Another object of this invention is to provide a corrosion resistant gasket which need not be made of noble metal components. Another object of this invention is to provide a method of EMI shielding, lightning protection, and grounding and environmentally sealing electrical or electronic components using such a gasket. Another objection on this invention is to provide lightning protection for the device(s) to which it is applied.

Summary of the Invention

In one aspect, this invention provides an EMI gasket for electrically shielding, lightning protection, grounding and environmentally sealing the space between two surfaces comprising:

(a) an electrically conductive deformable structure adapted for forming electrical contact with said surfaces and/or providing EMI shielding, lightning protection, grounding in the space between said surfaces; and

(b) a nonconductive, soft, resilient fluoroelastomer rim attached to the outer (and where present, inner) peripheral edges of the conductive structure so as to provide an environmental seal.

In a further aspect, this invention produces an EMI/environmental gasket comprising an inner, substantially planar conductive layer formed of one or more layers of conductive mesh selected from the group consisting of metal mesh and metal plated plastic mesh; and a fluoroelastomer binder impregnating the mesh; and an outer nonconductive environmental seal area bonded to an outer periphery of the inner conductive area, the seal area being of a thickness greater than that of the inner layer and being formed of a fluoroelastomer.

In another aspect, this invention provides the above gasket wherein at least a portion of the conductive structure is positioned in a fluoroelastomer material and the nonconductive rim is positioned so as to deform into sealing contact with the surfaces around the metallic structure to seal the conductive structure from the environment when the gasket is compressed between the surfaces.

In another aspect, this invention provides a method of providing EMI shielding, lightning protection, grounding and environmental sealing the space between two surfaces by positioning a gasket as defined above between the two surfaces and compressing said gasket between said surfaces to deform the conductive material and establish electrical contact of the metallic structure with the surfaces.

In the Drawings

Figure 1 shows a planar view of a gasket according to the present invention.

Figure 2 shows a cross sectional view of the portion of the gasket of Figure 1 taken along lines I-I.

Figure 3 shows a cross sectional view of the gasket of Figure 1 in use between two substrates.

Figure 4 shows the graphical presentation of the shielding effectiveness of the preferred embodiment of the present invention.

Figure 5 shows the amount of corrosion in the samples of Example 2 after 168 hours of salt fog testing.

Figure 6 shows the volume resistivity of the samples of Example 2.

Detailed Description

The present invention relates to an EMI shield/environmental, lightning and grounding gasket. It is formed of a conductive area and a nonconductive, environmental seal area which is formed along the periphery of the conductive area regardless of whether the periphery is formed on the outer and/or inner portions of the gasket.

Figure 1 shows a preferred embodiment of the present invention. It can be used to seal a panel to an enclosure, such as an access panel on an electrical box or computer, or as an antenna seal on aircraft, such as an access panel on an aircraft fuel panel or other such equipment.

The gasket 1, as shown, has a substantially planar conductive area 2 and in this instance, inner and outer environmental seal areas 3A and 3B formed on the inner and outer peripheral areas of the conductive area. A number of attachment holes 4 are also shown although other attachment means, such as conductive adhesives, channels, groups, etc. can be used.

Figure 2 shows the gasket of Figure 1 in cross section. The conductive area 11 is formed of one or more layers of conductive mesh 12 embedded in a fluoroelastomer 13. The fluoroelastomer may contain conductive filler, although it is not preferred, nor typically necessary. The environmental seal area 14 is shown as being rounded, although other crosssectional shapes can be used (square, rectangular, oval, etc.) The environmental seal area has a thickness substantially the same as that of the conductive area 11 or preferably greater than that of the conductive area so that upon application of a compressive force, as caused by the attachment of one substrate to the other, with gasket between, a complete environmental seal is established.

Figure 3 shows the crosssection of Figure 2 in such an application. The seal area 24 is slightly compressed or flattened by the force applied to seal the two substrates 21, 22 together. The conductive area 23 is thereby effectively protected from the outside elements, such as rain, jet fuel, solvents, dust, etc.

The mesh of the present invention may be formed of metal or a conductive plastic, such silver plated nylon yarn or fabrics. Preferably, it is formed of a metal fiber, such as steel, aluminum, copper or nickel or non-noble metal plated metal such as tin plated steel (FERREX mesh, available from Chomerics, Inc.), tin plated aluminum, tin plated copper, nickel, or aluminum; various alloys such as MONEL (a nickel copper alloy) or a noble metal plated non-noble metal such as silver plated nickel, copper, aluminum or steel mesh.

The conductive mesh may be formed as a woven fabric, a braid or a knit or as a nonwoven fabric, especially when a silver plated nylon is used. Alternatively, the mesh may be an expanded metal grid formed of any of the metals described above.

One or more layers of the mesh may be used and they may, when multiple layers are used, be of the same or different materials. For example, with multiple layers, it may be desirable to have the most corrosion resistant mesh, such as a FERREX mesh at the outer surfaces with less corrosion resistant, but more conductive mesh layers, such as MONEL or silver plated aluminum mesh in between. The mesh may extend above the surface of the fluoroelastomer so as to establish complete contact with the adjacent substrate.

Alternatively, it may be equal with or slightly embedded into the fluoroelastomer provided that sufficient compressive force is applied so as to provide the necessary mating with the adjoining substrates.

The fluoroelastomer may be any natural or synthetic fluoro-containing elastomer or rubber. Preferably, it is either a fluoroolefin, such as polytetrafluoroethyelene (PTFE) or a fluorosilicone rubber. The more preferred material is a fluorosilicone due to its softness, ease of compounding, good physical properties (moisture resistant, solvent resistant, etc.) and cost. One such fluorosilicone is available from Dow Corning as LS 2840 type silicone.

The seal area has a Shore A hardness of from about 40 to about 60 when cured, making it a very resilent, easily deflectable/compressible material. This reduces the amount of force required to obtain a good seal and contact between the gasket and the adjoining substrates.

The seal area may be foamed or unfoamed. Preferably, it is unfoamed. If foamed, it is preferred that the foam be closed celled.

A number of processes can be used to form the present invention, depending upon the final configuration desired.

A preferred method of forming the gasket is to take one or more layers of conductive mesh and embed or impregnate the mesh with a fluoroelastomer, which may or may not contain conductive fillers and form it into a sheet. The sheet is then cut to the desired configuration and the outer environmental seal is then bonded to the outer edges (and where applicable the inner edges of the gasket). A preferred method of bonding the outer environmental seal to the conductive area is by molding. The conductive area is placed into a mold which has a groove, channel or other design around the edges of the conductive area. A fluoroelastomer, such as fluorosilicone is then added to the mold, filling the groove or channel and touching the edges of the conductive area. The environmental seal is then cured so as to be bonded to the edge of the conductive area.

An alternative is to form a mold that has the desired gasket configuration, place the conductive mesh into the region of the mold which will form the conductive area and then add the fluoroelastomer to the mold in an amount so that it encompasses both the conductive area as well as the outer environmental seal area.

A further method is to form the conductive area, such as in a roll mill and separately form the environmental seal and then bond the two together along their edges via a separate bonding material.

Example I

A gasket, according to the present invention, was formed by taking 8 layers of tin plated steel conductive mesh stockings and flattening each of the layers. The flattened layers were then laid on top of each other and impregnated with a nonconductive fluorosilicone rubber dissolved in a solvent. The sheet was dried and then die cut to the desired shape. The die cut gasket was placed into a mold and nonconductive fluorosilicone was applied to the outer edges of the sheet. The entire sheet was then vulcanized and bonded into a unitary structure. The gasket was then tested according to Military Standard Test 285, EMI Shielding, by placing the gasket around an opening, such as a shielded room, so as to be between the outer wall of the room and a coverplate which effectively sealed the room from the outside. A transmitter was placed outside the room about one meter from the center of the opening and a receiver was placed inside the room, in line with the transmitter. Values of the signal received were measured at a range of frequencies from 1 Mhz to 18,000 Mhz for both the shielded and un-shielded opening. The difference between the values at the same frequency represent the attenuation or shielding effectiveness obtained with the material. Figure 4 shows the results of such testing. As can be clearly seen, the present invention provided excellent shielding over a wide range of frequencies.

Example II

In order to test for corrosion resistance, six samples (A-F) were prepared in a manner similar to Example I with the following differences:

A. - Mesh was formed of aluminum wire with no outer non-conductive layer.

B. - Silicone material filled with conductive silverplated aluminum particles, with no outer non-conductive layer.

C. - Same as B, except resin material was a fluorosilicone.

D. - Same as A, except FERREX wire was used instead of aluminum.

E. - Same as D, except that a non-conductive silicone layer was formed at the outer edge of the conductive layer.

F. - Same as A, however, a non-conductive fluorosilicone layer was formed at the outer edge of the conductive layer.

All of the samples were placed between two plastic blocks, such that the top surface of the gasket touched the lower surface of the upper plastic block, the bottom surface of the gasket touched the upper surface of an aluminum wafer, the bottom surface of the aluminum wafer touched the top of a non-conductive rubber gasket, the bottom which touched the top surface of the bottom block. Each assembled gasket sample was then placed in a salt fog chamber and subjected to a saturated salt fog for 168 hours. The blocked samples were then removed and disassembled. The aluminum wafer was then weighed and compared to its presalt fog exposure weight. The reduction in weight was an indication of the level of corrosion found. Values below .5 milligrams are considered to be acceptable. The gasket samples were tested for volume resistivity and compared with their pre-exposure value. Changes of less than 20%, more preferrably 10%, were considered acceptable. Little, if any, changes in volume resistivity was found in examples E and F as compared to the examples A and D without the outer non-conductive layer. Only those samples made according to the present invention provided the desired combination of corrosion resistance and volume resistivty.

Figure 5 shows the corrosion values obtained for the samples.

Figure 6 shows the volume resistivity of the gaskets measured before and after salt fog exposure.

The tests clearly show that those samples, according to the present invention, had good corrosion resistance.

While the present invention has been described in relation to the preferred embodiments, other embodiments, variations, and equivalents would be obivous to one skilled in the art which is meant in the appended claims to cover all such embodiments, variations, and equivalents as those that fall within the true scope of the claims.

What is claim:

1.) A gasket comprising a conductive area formed of one or more layers of electrically conductive mesh; the one or more layers of mesh having a fluoroelastomer embedded therein; the conductive area having a continuous nonconductive environmental seal of a height the same as or greater than that of the conductive area, bonded to an outer peripheral edge of the conductive area.

2.) The gasket of Claim 1 wherein the gasket has sufficient electrical conductivity so as to provide EMI shielding properties and wherein the environmental seal is formed of a fluoroelastomer having a shore A hardness of from about 40 to about 60.

3.) The gasket of Claim 1 wherein the mesh is selected from the group consisting of woven, knit, braided and nonwoven materials and wherein the mesh is formed of a material selected from the group consisting of metal, metal plated metals, metal alloys and metal plated plastic.

4.) The gasket of Claim 1 wherein the conductive area is substantially planar.

5.) An EMI shielded structure comprising a first electrically conductive substrate formed of metal and metal coated composites, a second electrically conductive substrate selected from the group consisting of metal and metal coated composites, and an EMI shielding/environmental gasket between the first and second substrates, the gasket having an inner EMI shielding conductive area formed of one or more layers of electrically conductive mesh and a fluoroelastomer binder and an outer sealing area formed of a nonconductive fluoroelastomer bonded to the entire outer periphery of the inner conductive area and being of a height that is equal to or greater than that of the inner layer such that upon insertion between the first and second substrates, the outer area is slightly deflected so as to form and environmental seal.

6.) The EMI shielded structure of Claim 5 wherein the conductive mesh is selected from metal and metal plated plastic mesh.

7.) The structure of Claim 5 wherein the fluoroelastomer is selected from the group consisting of fluorolefins and fluorosilicones.

8.) The structure of Claim 5 wherein the fluoroelastomer is a fluorosilicone, the conductive mesh is a tin plated steel knitted mesh.

9.) The structure of Claim 5 wherein sealing area has a diameter of from 40 to 60 Shore A hardness.

10.) The structure of Claim 5 wherein the sealing area is circular in crosssection and of a height greater than that of the inner conductive layer.

11.) An EMI/environmental gasket comprising an inner, substantially planar conductive layer formed of one or more layers of conductive mesh selected from the group consisting of metal mesh and metal plated plastic mesh; and a fluoroelastomer binder impregnating the mesh; and an outer nonconductive environmental seal area bonded to an outer periphery of the inner conductive area, the seal area being of a thickness greater than that of the inner layer and being formed of a fluoroelastomer.

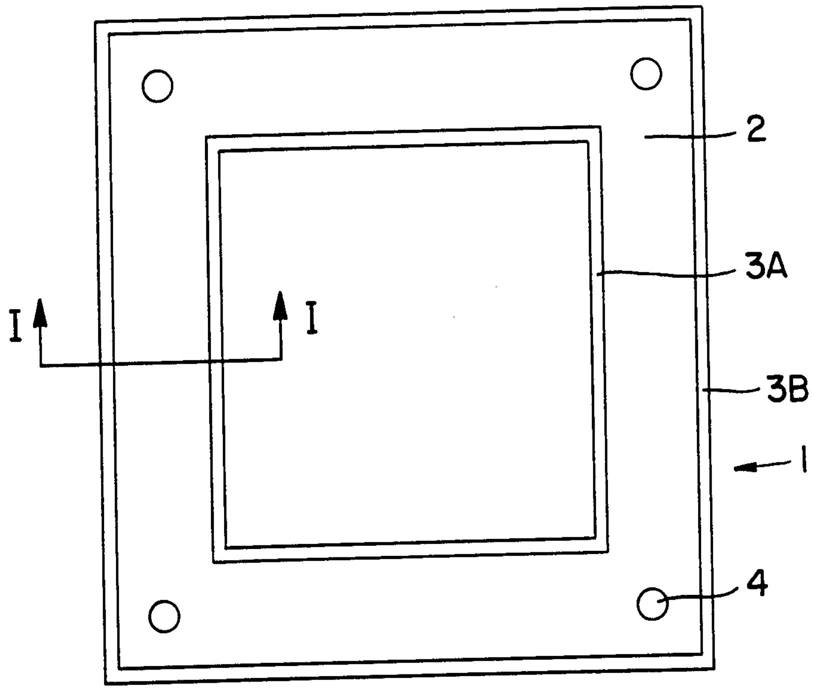


FIG. 1

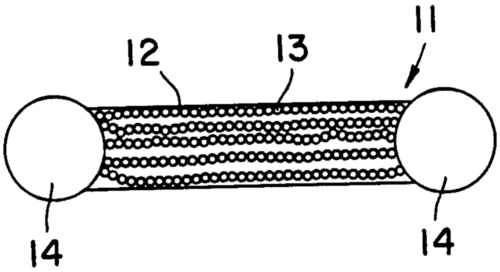


FIG. 2

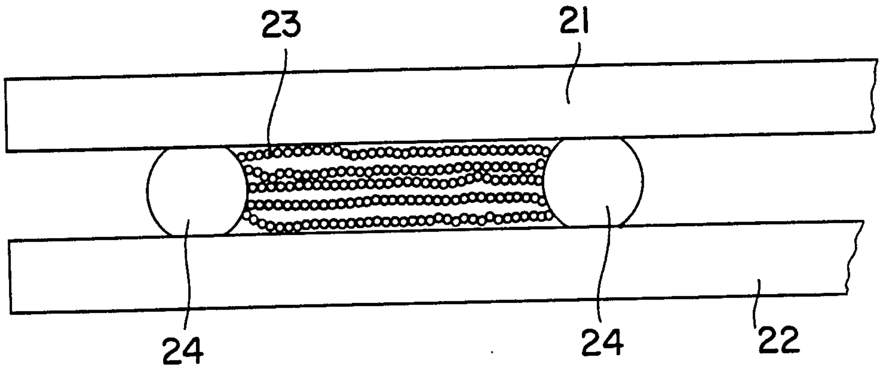


FIG. 3

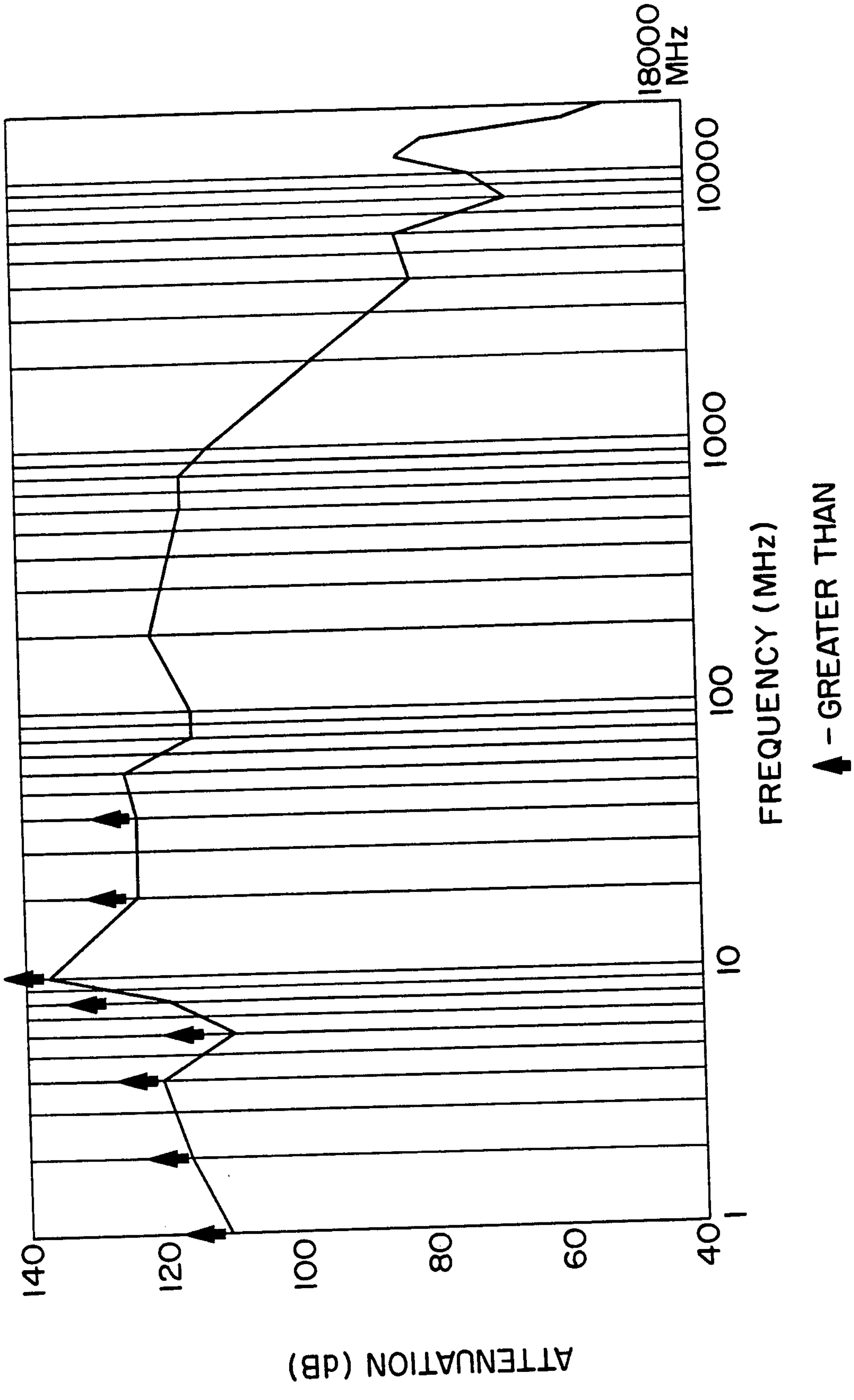

18000
MHz
10000
1000
100
10
1
140
120
100
80
60
40
FREQUENCY (MHz)
ATTENUATION (dB)
- GREATER THAN

FIG. 4

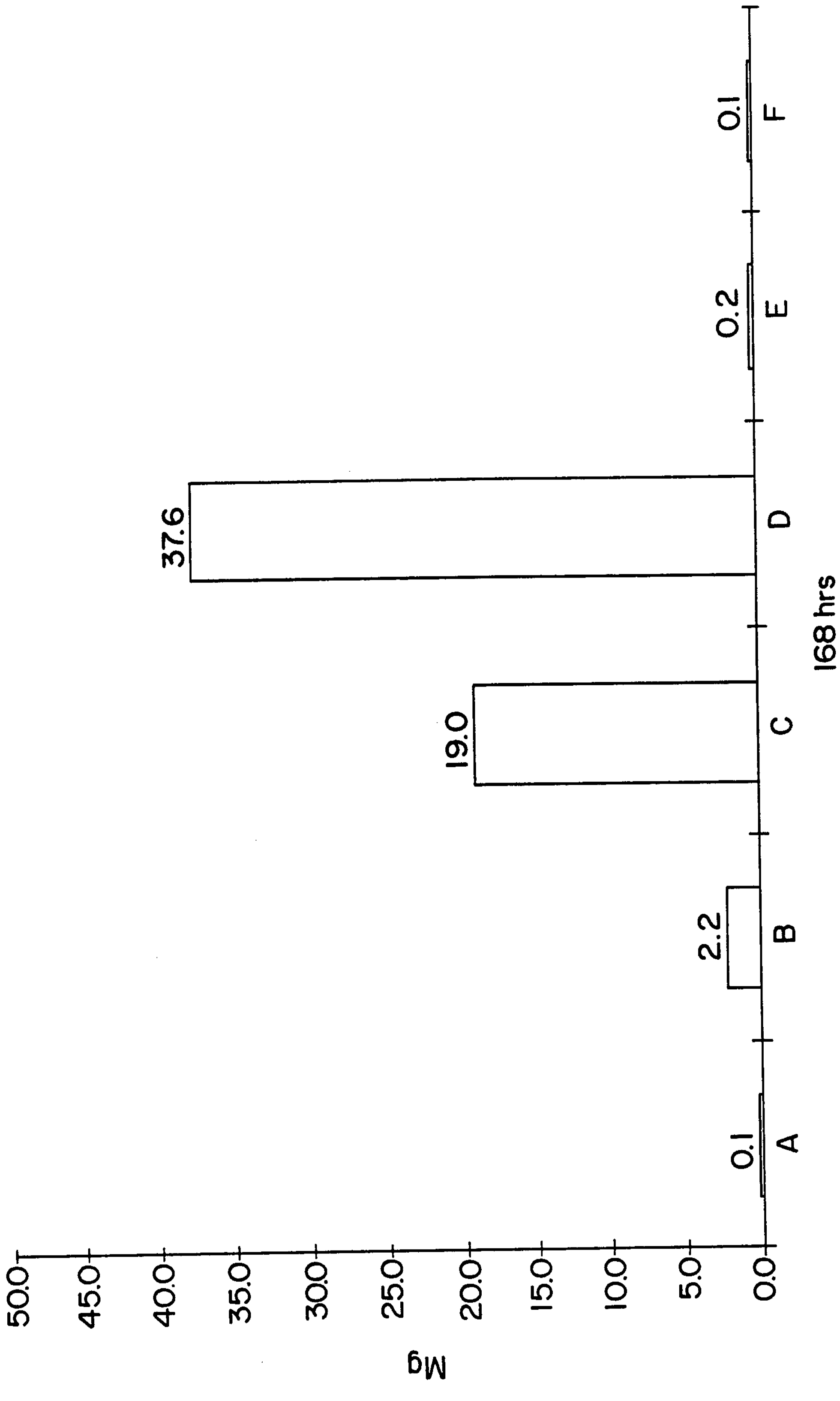

Mg
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0.1
2.2
19.0
37.6
0.2
0.1
A
B
C
D
E
F
168 hrs

FIG. 5

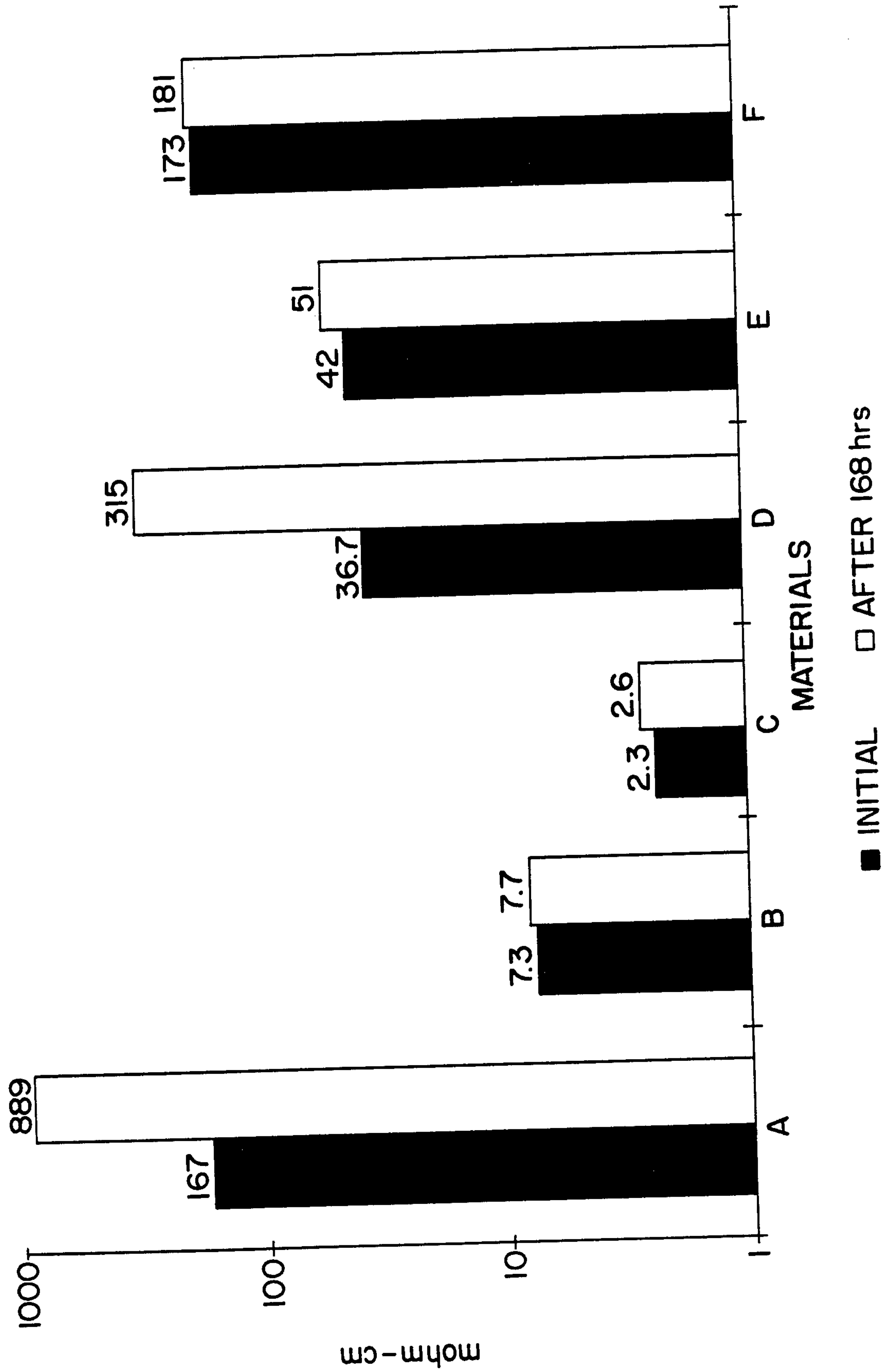

mohm-cm
1000
100
10
1
167
889
7.3
7.7
2.3
2.6
36.7
315
42
51
173
181
A
B
C
D
E
F
MATERIALS
■ INITIAL
□ AFTER 168 hrs

FIG.6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/06171

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :F16J 15/32
US CL :277/227, 901
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 277/227, 901; 174/35GC

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS search terms: gasket, tin, steel, mesh, elastomer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 3,140,342 (EHRREICH ET AL.) 07 July 1964, figures 6 and 7.	1-11
Y	US, A, 4,037,009 (SEVERINSEN) 19 July 1977, figure 1, column 2, lines 1 and 24.	1, 3-6, 10 and 11
Y	US, A, 5,294,270 (FENICAL) 15 March 1994, column 1, line 35 and column 8, line 49.	2,7,8 and 9

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

24 JULY 1994

Date of mailing of the international search report

AUG 05 1994

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
for DANIEL G. DEPUMPO
Sheila H. Veney
Paralegal Specialist
Group 2400
Telephone No. (703) 308-0771