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SEALING AND CONDUCTING GASKET MATERIAL

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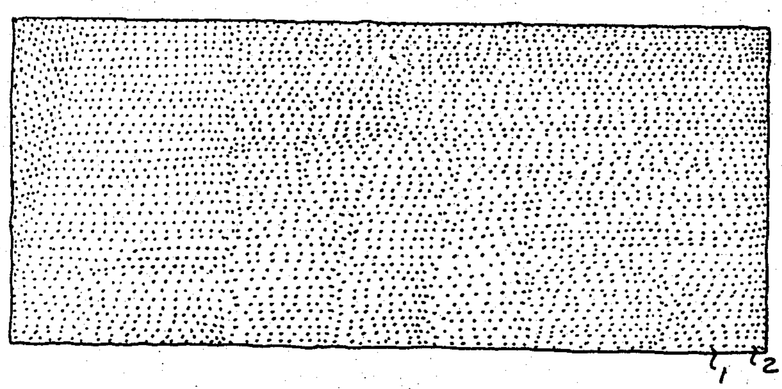

Fig-1

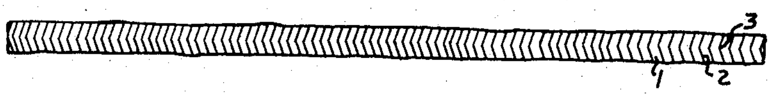

Fig-2

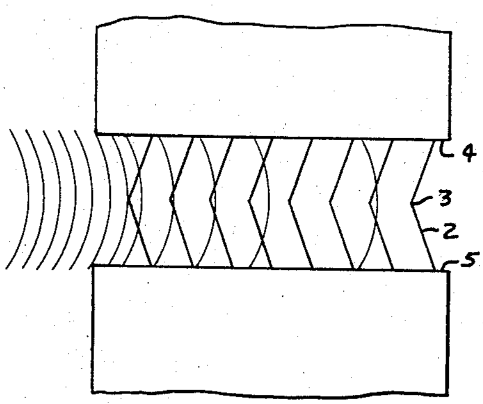

Fig-3

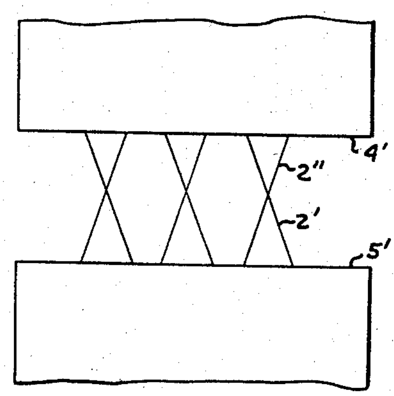

Fig 4

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SEALING AND CONDUCTING GASKET MATERIAL

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3 Claims. (Cl. 174—35)

This invention relates to gasket materials and more particularly to a gasket material which will both provide a gas tight seal at a joint and will prevent electrical energy of radio frequencies from escaping at joints in closed containers and to a method for making the gasket material.

As a background for insuring a sufficient understanding of the present invention as claimed, the transmission of electromagnetic energy along and its confinement by the metal walls of a wave guide of the like, includes propagation in angular and in radial modes with lines of force which emerge perpendicularly from the guide wall, which turn and travel parallel to the guide axis and then bend back into the guide. Both electrical and magnetic modes may be directed to be transverse to the axis of the wave guide in their propagation therealong.

When an electromagnetic wave is incident to a conducting metal surface, such as the inside of a metal container, electrical and magnetic energy currents are set up in the metal. If the metal were a perfect conductor it might be assumed that a field equal and opposite to the exciting field would be set up at the metal surface in a vanishingly small skin depth. Incident energy would be partly reflected and would be partly retained in the metal container. Since the metal has finite conductivity, there is current flow in the metal and a portion of the incident energy is retained within the container. The current flow in the metal increases its temperature and part of the current passes through the metal and is radiated. Therefore, of the energy incident on a metal surface, part is reflected, part is attenuated within the metal and part of the energy escapes as radiation. Energy attenuation is a function of the permeability of the metal.

Energy of very high radio frequencies, above a million cycles per second, incident to good conductors is very nearly all reflected and very little is attenuated or is radiated. It follows, therefore, that the mechanism of the shielding of energy at frequencies above a million cycles per second is principally one of reflection. The conduction of electromagnetic energy of frequencies above a million cycles per second and past a joint or other discontinuity between abuting ends of two sections of a wave guide without loss, is a problem with which the present invention is concerned. Two pipe flanges abutted together comprise opposed flange surfaces which act as a radial wave guide in transmitting radio frequency energy to the outside of the pipe from which it is radiated.

A smoothly soldered or welded junction between the abutting ends of two wave guide sections is in effect a continuous metal wall and minimizes losses in electromagnetic energy at the junction. Flanged pipe ends may be smooth faced and clamped together with bolts. It might be assumed that such a joint would function with negligible loss of radio frequency energy if the flanged surfaces were substantially smooth and free from irregularities or projections on opposed pairs of surfaces so bolted together.

Irregularities on finely turned copper are about 5×10^{-4}

cm. high. Irregularities on optically polished aluminum are between 100 and 1,000 angstroms in height. Irregularities on steel surfaces lapped with 150 grade carborundum paper are about 5×10^{-5} cm. high and steel surfaces polished with 600 grade carborundum paper are about 10^{-5} cm. high. In practical application flange surfaces are far more irregular than polished surfaces and touch at but few points with open gaps at most of the joint. The irregularities, as energy radiators, objectionably dissipate the energy conducted by the wave guide and objectionably raise the interference level in the operation of adjacent other sensitive electronic equipment. Continuously forming oxide films on flange surfaces further reduce radio frequency conductivity. Very high pressures capable of penetrating oxide films are not practical on abutting flange surfaces.

In an effort to minimize electromagnetic energy losses at wave guide junctions and the like, and further to provide a gas-tight seal thereat, a number of available gaskets and sealing arrangements have been tested at constant energy levels of 3 and 3.5 amperes over a frequency range of from 150 kilocycles to 150 megacycles and with flange pressures of from 50 to 200 pounds per square inch. Shielding and sealing materials consisting of metal screen, wire cloth and the like, imbedded in rubber or in paste, were tested experimentally and information gained from the investigation was used in arriving at the present invention. Conductors extending parallel to the flange surfaces act as antennae to conduct radio frequency electrical energy to outside of the container. Metal conductors subjected to insufficient pressure to make electrical contact with the flange surfaces are ineffectual. In the presence of an excessive number of conductors the pressure between the conductor ends and the flange surfaces may be insufficient to provide adequate contact.

In this experimentation of radio frequency shielding and sealing gaskets it was determined that flange pressure is a first order factor and that the impedance of a gasket is without meaning unless it is accompanied by the pressure at which the impedance is measured. The clamping pressure on bolt secured flanges may range from a ton per square inch under the bolts to 100 pounds per square inch between the bolts. The variation in pressure between bolts is large with ordinary gaskets. Low pressure points in ordinary gaskets originate interference in neighboring electronic equipment. Gasket material shielding satisfactorily at low clamping pressures is highly desirable.

A general statement of the nature and of the substance of the present invention, as claimed herein, comprises in nature a gasket shielding electromagnetically and pressure sealing joints in hollow conductors and in substance a compressible gasket comprising an electromagnetically shielding resilient multiplicity of unconnected wires supported by a pressure sealing resilient body and to a method for making the gasket. The word "unconnected," as used herein, has its usual dictionary definition of separate or not joined or linked together.

A general statement object of the present invention, as claimed, is to provide previously unobtainable improved gasket material which will prevent radio frequency current from escaping at joints in closed containers or to provide an electromagnetically shielding and pressure sealing gasket applicable to joints in wave guides and the like, and to a method for its production, with the gasket serving to minimize interference in neighboring sensitive electronic equipment.

Other objects are to provide a gasket material which supplies a multiplicity of electrically conducting paths between the surfaces of opposed metal flanges; a gasket material providing an adequate density of mutually unconnected metal conductors with their ends exposed to make adequate break-through contacts with the flange metal to carry a predetermined current and the gasket material also providing a gas impervious seal which is effective at a particular pressure; to provide a preformed gasket having a radio frequency impedance which is lower than that of any previously available gasket material; a gasket material providing a desired density of or number per unit area of radio frequency conduction paths evenly distributed over the gasket and maintaining uniformly distributed high local pressure points evenly spaced over the engaged flange surface with the pressure at each contact point adequately high to break through any surface film of oxides or the like on the flange surfaces; to provide a joint sealing and electromagnetically screening gasket which is gas and weather tight applicable to an installation subjected to varying weather conditions during its use through the agency of a rubber or similar material which under pressure flows easily to fill gaps and to seal under low clamping pressures, the pressure being shared between the contacts and the sealing agents in a delicate balance; to provide a gas sealing gasket insoluble in and of unimpaired service in the presence of gasoline, oil and water and that bonds well to metal over a temperature range of from about −65° F. to 400° F. in which range aircraft engines are operated; to provide a shielding and a sealing gasket having appreciable functional improvements over previously available comparable gaskets made of woven wire, screen wire, and the like in neoprene rubber, matted copper fiber in cements, chromium granules, copper fiber and the like; to provide a shielding and a sealing gasket having a peak impedance curve at about 170 conductors per square inch and a minimum impedance value at about 375 conductor paths per square inch at a pressure of about 200 pounds per square inch using a frequency in the range of from 0.15 to 15 megacycles per second; and to provide a shielding and a sealing gasket comprising silicone rubber and unconnected metal fibers running at an angle from one surface to the other surface of the rubber to provide a gas tight seal between flange surfaces under conditions of high temperature; and to the method of making the gasket.

An illustrative embodiment of the present invention is represented in the accompanying drawing wherein:

Fig. 1 is a plan view of the surface of a gasket material which embodies the present invention;

Fig. 2 is an edge elevational view of the gasket in Fig. 1 showing unattached wires slightly bent between their ends and embedded in silicone rubber;

Fig. 3 is an enlarged schematic diagram of the gasket wires or metal fibers in thrust between opposed flange faces, with the flange rubber not shown in section for purposes of clarity, and with curved lines indicating electromagnetic radiation energy radiated from the left of the joint from inside a hollow conductor and of reduced density toward the right, from the action of the flange bridging wires or metal fibers, to no radiation loss at the flange outside to the right of the hollow conductor; and

Fig. 4 is an enlarged schematic diagram of gasket having as conductors straight wires or metal fibers making angles from one side of the gasket to the other in a crisscross pattern in the gasket rubber body portion, which again is not shown in section for purposes of clarity.

The gasket material embodying the present invention and represented in the accompanying drawing, comprises a resilient material, such as rubber material 1 or the like, in which are embedded a multiplicity of electrically conducting metal fibers or wires 2 which are embedded within and which are inclined to the planes of opposite sides of the resilient material 1. The wires 2 illustratively may be of stainless steel or the like, and the resilient material 1 illustratively may be of silicone rubber or an equivalent material. The density of the wire distribution in the rubber preferably is about from 250 to 500 wires

per square inch, although the invention functions experimentally outside of this range.

With the gasket material positioned between a pair of opposed flange faces in a wave guide, the wires 2 are maintained yieldingly in thrust so that they are curved somewhat between their ends, represented in the drawing as the curve 3. The wires 2 are of a diameter or a gage and of a composition which are commensurate with the pressure to which the gasket is to be subjected and to the service to which the gasket is to be put. The wires 2 may, as a primed modification illustrated in Fig. 4, be straight wires making angles from one side of the gasket to the other in a crisscross pattern in the rubber within which they are embedded.

Optimum radio frequency shielding effects are accomplished when an adequate number of direct electrical conducting paths are provided between and in direct contact with opposed metal flange faces 4 and 5 between which the gasket material is positioned.

In making the gasket material, the gasket rubber body portion is calendered in usual manner between rolls and then a multiplicity of steel wires is thrust through it at regularly spaced intervals, so that each wire completely penetrates the body or base material and projects slightly from the opposite surfaces thereof. The preferred slight bend between the ends of each wire imparts to it a spring action under compression rather than a stiff strut action. The wire ends on opposite faces of the gasket rubber portion are then clipped to uniform length. The sheets of gasket material so made may then be cut to desired figurations and dimensions in the making of manufactured, standardized gaskets. The slight bend in each wire, or the angle at which the wires are positioned in the base material or both impart a spring action to the wire by which good contact is secured between the wire ends and the flange surfaces under normal clamping pressures to which the gasket is subjected.

It has been determined experimentally that commercially available card cloth used in processing cotton fibers may be modified for its application and use as one form of the gasket contemplated hereby. Card cloth used in processing cotton has a heavy fabric backing of canvas or the like on one side of a rubber base material with illustratively from 250 to 500 steel staples driven through the base material at regularly spaced intervals so that the points of the staples project at an angle from the surface of the card cloth not covered with canvas.

In adapting commercially available card cloth to one form of the present invention, the canvas back and a portion of the staples may be removed by grinding or by a similar operation, to provide a sheet of rubber base material for the multiplicity of unconnected small steel wires extending through the base material and presenting exposed wire ends from both of the opposite sides therof.

Following the above described method of making gasket material from available card cloth, the exposed wire staple ends are cut to a uniform length closely adjacent to the surface of the rubber by which they are supported. The gasket material is then cut to desired shapes to fit joints with which it is to be used in sealing the joints against both gas pressure and the loss therethrough of radio frequency electromagnetic energy.

Satisfactorily operating gaskets embodying the present invention were ⅛" thick and had about 500 bridging wires per square inch with each wire .005" in diameter. A second gasket was ¼" thick and also had about 500 bridging wires per square inch, but with each wire 0.020" in diameter. The wire density or the number of wires per square inch may be varied over a wide range depending upon the degree of shielding which it is desired to accomplish and the magnitude of clamping pressure which is required for a particular installation.

A preferred method of making gasket material embodying the present invention is the passing of a rubber sheet of the required thickness through a stapling machine where a desired multiplicity of wires are inserted into and left in the rubber sheet and then passing the stapled metal sheet between two grinding wheels which reduced the wires exposed on both sides of the sheet to a uniform length.

An excellent gasket material may be made in sheet form from card cloth by moulding, spraying or dipping the card cloth in rubber and then cutting away excess canvas wire or rubber to make a gasket material which is substantially that represented in Figs. 1 and 2 of the accompanying drawing.

The shielding effectiveness of the described gasket material is determined by measuring its impedance at various clamping pressures. Experimental impedance values of the described gasket material at a frequency of 2.6 megacycles was 10^{-7} ohms. This impedance is a four magnitude improvement by the gasket material which embodies the present invention, as compared with the best commercially available gasket material upon which experiments were made which measured an impedance at the frequency of 2.6 mc. as 10^{-3} ohms.

A gasket to seal at a relatively low clamping pressure may be made of a soft rubber measuring about 40 to 50 on a durometer. Gaskets preferably are as thin as possible with optimum performance of shielding and sealing. Constant energy level tests indicate that shielding is more difficult in the frequency region of 1.5 megacycles than at adjacent upper and lower frequencies.

The characteristics of a satisfactory shielding and sealing gasket embodying the present invention are: that the conduction paths across the joint occupied by the gasket should not be connected with each other; that the radio frequency conducting wires should be substantially evenly distributed within the gasket material; the wires should be good conductors of electrical energy and should be chemically inert to any material in the gasket; the wires should be sufficiently hard tempered so that their tips may break through or penetrate any surface coat on the opposed flange surfaces to make firm electrical contact therewith when the junction is under pressure; and when under pressure the wires should uniformly yieldingly oppose that pressure; and the sealing body of the gasket should provide a gas tight and a permanently weather tight seal at the joint.

The number of electrically conducting paths per square inch is a factor in controlling local contact pressures to which the gasket is subjected. There is an optimum number of conductors per square inch for each combination of gasket design for conducting material and the mechanical properties of the electrical conducting metal elements and of the gasket body sealing agent under an established clamping pressure are such as to establish and to maintain satisfactory electrical conducting paths simultaneously with the gasket body portion providing an adequate gas seal at the same clamping pressures.

It has been established experimentally that gaskets embodying the present invention and mounted between flanges made of alumium or of magnesium perform nearly as well as when between flanges made of brass. This experimentation indicates that aluminum and magnesium also may serve as shielding materials, when joined with gaskets embodying the present invention.

It is to be understood that the composition of the gasket body and the composition, the distribution and the characteristics of the wires supported by the gasket body may be modified and substitutions may be made therein within the scope of the present invention without departing from the functional advantages thereof.

We claim:

1. A method for making gasket material, comprising the steps of forming a resilient material into a sheet of gasket body portion, inserting into the gasket body portion a plurality in the order of about 250 to 500 wires per square inch of isolated and unconnected slightly bent wires to extend transversely therethrough and to establish substantially uniform length of wires with wire ends exposed from opposite sides of the gasket body portion to assume a predetermined related mechanical compression resistance between the wires and the gasket body portion.

2. An electrically conducting gasket for minimizing the electrical impedance between joint mating surfaces of a hollow electrical shield housing a radio frequency energy conductor, the gasket comprising a resilient gasket material to be interposed between the joint mating surfaces to provide pressure and moisture sealing engagement therewith, and a plurality of electrically conductive wires supported by the resilient gasket material with each wire electrically and mechanically isolated from all other wires in the structure for the purpose of maintaining a plurality of separate and discrete low impedance electrical paths between the joint mating surfaces of the hollow electrical shield and for preventing the conduction of radio frequency energy from the interior of the hollow electrical shield to the exterior of the gasketed joint.

3. The gasket defined in the above claim 2 wherein each wire has a slight bend between its ends for imparting spring action to the wire in delivering high unit contact pressure between the wire ends and the flange surfaces of the joint mating members.

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