Jan. 30, 1968 P. BAUER 3,366,143

INTERCONNECTION APPARATUS FOR FLUID SYSTEMS

Filed Jan. 3, 1966

FIG. 1

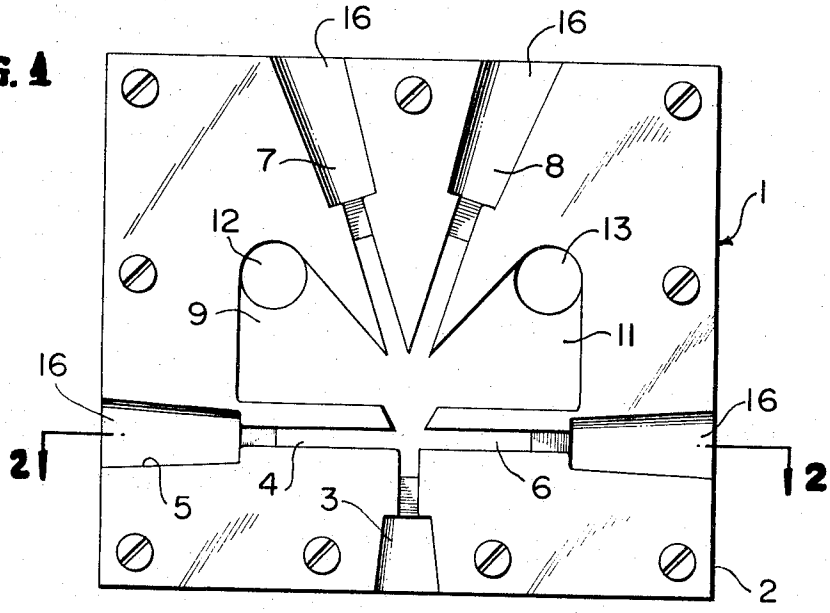


FIG. 2

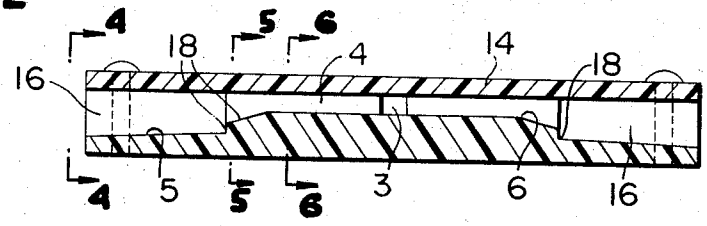


FIG. 3

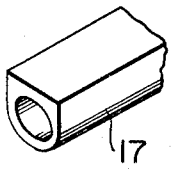


FIG. 4

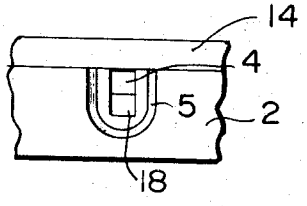


FIG. 5

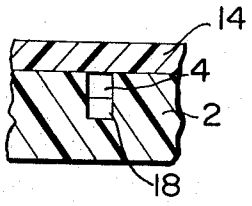


FIG. 6

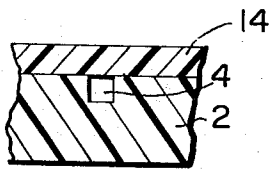
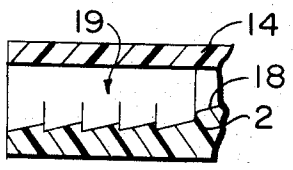


FIG. 7



INVENTOR
PETER BAUER

BY Hurwitz & Rose

ATTORNEYS

United States Patent Office 3,366,143 Patented Jan. 30, 1968

3,366,143

INTERCONNECTION APPARATUS FOR FLUID SYSTEMS

Peter Bauer, Germantown, Md., assignor to Bowles Engineering Corporation, Silver Spring, Md., a corporation of Maryland

Filed Jan. 3, 1966, Ser. No. 518,268
6 Claims. (Cl. 137—798)

The present invention relates to methods and apparatus for interconnecting pure fluid amplifiers and, more particularly, to an inexpensive, efficient and rapid technique for interconnecting pure fluid amplifiers by means of tubing.

Various methods and techniques are now known for the interconnection of fluid amplifier elements in order to interconnect the various elements to form larger circuits and systems. Perhaps the most widely employed system utilizes "Clippard" fittings. The fittings are threaded into the base of a fluid element and provide an outward tubular extension having a Christmas tree formed on the extension so as to receive and securely hold a plastic tube. These fittings are wholly satisfactory for their intended purpose; being expensive to attach, preventing stacking of elements and degrading signals due to the right angle bend. As to the additional cost, the base of the amplifier must be drilled and then threaded, which, of course, involves a certain additional cost plus the cost of the fittings, which at the time of this writing is about twelve cents each in quantity.

The Christmas tree fitting may be provided integrally with a molded fluid element, and the only difficulty with this type of arrangement is again cost since the cost of the molds for such an arrangement are materially greater than the cost of the mold for simply forming the channels in a flat plate.

An additional scheme which has been employed is to form a female Christmas tree type of fitting directly into the sides of the fluid element. Such a fitting is made up of two parts, one in the base member in which the fluid amplifier channels are formed and the other part of the female Christmas tree fitting is formed in the cover plate. In such an arrangement, difficulty arises since the cover plate must then be accurately aligned with the base member in assembly, and further in order to provide an accurate seal, extremely flat base and cover plates must be employed. The flatness requirements are true in all of the elements, but when the female Christmas tree fitting is provided the lapping required to obtain the flat surface often removes enough material in the region of the female fitting to provide an aperture which is too small for the tube and is not round. Therefore difficulties often arise in obtaining a good seal between a tube forced into the female fitting and the material surrounding the aperture.

It is an object of the present invention to provide an arrangement for connecting a piece of tubing to a fluid amplifier, which arrangement is inexpensive to manufacture, adding substantially no cost to the cost of manufacturing the element, and which additionally provides an effective fluid-tight seal between a length of tubing and the fluid amplifier.

It is another object of the present invention to provide a female fitting for fluid amplifiers which may be molded directly into the base of the amplifier and which does not require shaping of the material of the cover plate of the apparatus.

It is still another object of the present invention to provide a female receptacle for tubing to be connected to a fluid amplifier, which receptacle is formed in the base member of the fluid amplifier and wherein the sealing

plate applied to the amplifier is flat; that is, is uncontoured in the region opposed to the female receptacle in the base member.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of specific embodiments thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a top view of a fluid amplifier assembly employing a female receptacle for tubing in accordance with the present invention;

FIGURE 2 is a view taken along line 2—2 of FIGURE 1;

FIGURE 3 is a perspective view of the end of a length of tubing employed with the amplifier arrangement of the present invention;

FIGURE 4 is an enlarged view taken along line 4—4 of FIGURE 2;

FIGURE 5 is an enlarged sectional view taken along line 5—5 of FIGURE 2;

FIGURE 6 is an enlarged sectional view taken along line 6—6 of FIGURE 2; and

FIGURE 7 is a modification of the female receptacle for tubing also in accordance with a second embodiment of the present invention.

Referring specifically to FIGURE 1 of the accompanying drawings, a body including channels formed in one surface thereof to provide a pure fluid amplifier 1 is generally indicated by the reference numeral 2. The channels in the base plate or body 2 may provide in an exemplary device, a power nozzle 3, control nozzles 4 and 6, output passages 7 and 8, and enlarged vent areas 9 and 11. The vent areas 9 and 11 are vented to atmosphere or other source of reference pressure, via passages or apertures 12 and 13 which extend through the base plate 2. A cover plate 14 is positioned in contact with the channeled surface of the base plate 2 and is suitably secured thereto in order to seal the various channels in the member 2 from one another and provide communication therebetween only along the channels. The means for securing the cover plate 14 to the base member 2 may take any various suitable forms such as bonding by various adhesives or fusion, in case of glass and like materials, or by mechanical means such as screws which is the particular means illustrated in FIGURES 1 and 2.

Each of the various passages which are normally connectable or which normally may be desired to be connected to other than the surrounding atmosphere, such as passages 4, 6, 7, 8 and 3 are extended to the periphery of the base plate 2. Each of these passages terminates in an enlarged region 16 having a cross-sectional configuration conforming to the cross-sectional shape of a tube 17, one form of which is illustrated in FIGURE 3. The three sides of the region 16 provided by the base member 2 are all tapered inwardly from the outer periphery or edge of the base plate 2 by a relatively small amount, the taper being indicated by reference numeral 5. These tapers are greatly exaggerated in FIGURES 1 and 2 so that the taper becomes visible in the drawing. The taper is such that, as the tube 17 is inserted into aperture 16, a wedging action occurs between the sides of the tube and the sides of the region 16 so as to provide a tight and complete seal between the tube and the fluid amplifier. The cover plate 14 is not contoured adjacent the regions 16; wedging between the tube 17 and the cover plate 14 occurring as a result of the taper of the opposing surface of the channel 16 as illustrated more particularly in FIGURES 2 and 4 of the accompanying drawings.

It will be noted that the depth of the passage 16, where it intersects the edge of the block 2 is just about equal to the height, as illustrated in FIGURE 3, of the tube 17

so that only the upper surface of the tube **17** lies in the same plane as the upper surface of the member **2**, and as indicated above, is confined by the adjacent surface of the cover plate **14**.

A connection between a tube, such as tube **17**, and a fluid amplifier is made by simply inserting the end of the tube into the opening formed in the side of the member **2** and pushing the tube in sufficiently to produce wedging of the tube to produce a seal between the tube and the sidewalls defining the member **16**.

It is seen that such an arrangement is quite inexpensive since the only modification of the conventional pure fluid amplifier die or mold is the formation of the enlarged regions **16**. This is, of course, readily accomplished adding only a very small initial expense to the cost of the die, this expense being more than off-set by the costs of applying fittings to the prior art devices or attempting to provide a female receptacle which is formed in both the cover plate and the base plate. Further, inasmuch as the tube cross-section in the region of insertion is no longer circular, twisting of the tubing in use, does not tend to break the seal as so often occurs when circular tubing is employed. The flat surface of the tube **17** pressing against the adjacent flat surface of the cover plate **14** obviously prevents rotation of the tubing and therefore prevents breaking of the frictional engagement between the tubing and the base member.

It will be noted that, in FIGURE 2, the region **16** terminates in a straight shoulder **18**. This region may be curved to provide a smooth transition between the region **16** and the adjacent passage, for instance, the passage defining control nozzle **4**. Such an arrangement provides better impedance matching between the tube and the amplifier.

The tubing **17** has been illustrated as having a curved bottom and straight sides and top. A rectangular or square shape may also be employed; any shape which has a flat top being suitable although the curved bottom version is preferable.

The tubing may be of uniform cross-sectional shape or only the ends may be shaped to fit the regions **16**. In the latter case, a conventional round tubing is employed. When a connection is to be made, the tube is cut to length and the ends inserted in a heated mold to form the ends as desired. One such device employed looks much like a pair of pliers with the mold formed in opposed jaw surfaces. The device has a heated element in the jaws which is activated when the jaws are partially closed. The mold also has a center post in the recessed jaw; the post fitting into the hole in the tube to position the tube and prevent its collapse when clamped and heated. This latter feature is important since the hole area must remain constant. Also, retention of the hole shape permits interconnection between a connection of the type of the present invention and a standard male fitting, such as a "Clippard" fitting. Thus, the type of connection provided by the present invention is completely compatible with the prior art methods of interconnection and may be employed with devices employing such interconnection means.

Referring specifically to FIGURE 7, a slight modification of the invention is illustrated in which a Christmas tree type of arrangement, as generally designated by the reference numeral **19**, is provided. This type of arrangement does not have any effect upon the sealing arrangement provided by the apparatus, but does tend to hold more strongly the tubing in the amplifier, and thus provides a stronger physical interconnection between the two elements. Such arrangement does not add materially to the cost of the die or effect removal of the molded part from the die since the contoured surface is exposed and the die does not require removable parts such as thorns, cores, etc.

Although the interconnecting means of the present invention is described as applied to a particular element, it is equally applicable to a wide range of elements, subsystems, large and small systems or in any fluid interconnection between various types of elements, systems, etc.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. Interconnecting means for fluid systems comprising a base member having a fluid conveying channel formed in one surface thereof, a cover plate secured to said base member and having a first surface contacting said one surface of said base member, said channel extending to a periphery of said base member, said first surface of said cover plate being flat and planar at least in the region of said channel adjacent said periphery of said base member, a length of hollow tubing conforming to the shape of the region defined by said channel and said cover plate, the length of said channel adjacent said periphery having walls which taper outwardly from a region having smaller dimensions than said tubing to a region at said periphery which has dimensions at least as large as said tubing.

2. The combination according to claim **1** wherein the cross-sectional geometry of said length of said channel is such as to provide a curved bottom and straight sidewalls terminating in said flat surface of said cover plate.

3. The combination according to claim **1** wherein the cross-sectional geometry of said length of said channel is rectangular.

4. The combination according to claim **1** wherein said length of said channel has a serrated bottom wall.

5. The combination according to claim **1** wherein said channel includes impedance matching means disposed between said length of said channel and the remainder of said channel.

6. The combination according to claim **1** wherein said length of hollow tubing comprises an end portion of a longer length of hollow tubing.

No references cited.

M. CARY NELSON, *Primary Examiner.*

W. R. CLINE, *Assistant Examiner.*