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[54] **PRESSURE TRANSMISSION DEVICE**

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[52] **U.S. Cl.** ..... **128/2.05 D;** 73/392; 138/44

[51] **Int. Cl.²** **A61B 5/02**

[58] **Field of Search** ..... 128/2, 2 R, 2.05 D, 2.05 G, 128/2.05 R, 2.05 Q; 73/392, 395, 420; 138/44

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[57] **ABSTRACT**

Pressure transmission tube for medical or veterinary use, adapted to be filled with a liquid substance constituting the pressure transmission medium. Said tube comprises along at least one portion of its length a section having a smaller inner diameter differing from the inner diameter prevailing along the remaining section of its length, which ranges from 0.5 to 2.5 mm, the section of smaller diameter corresponding to a reduction in diameter of the order of 10 to 85 percent.

11 Claims, 6 Drawing Figures

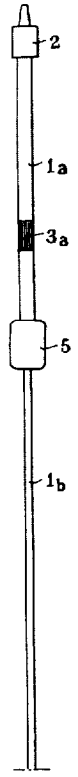


Fig.1

Fig. 2

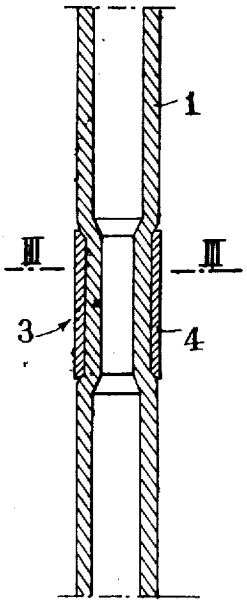


Fig.3

Fig.4

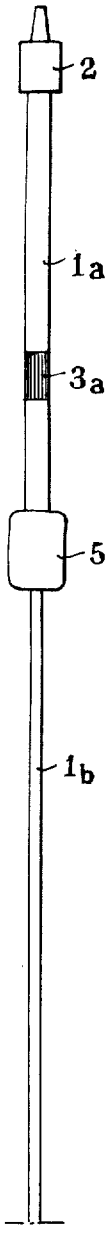


Fig.5

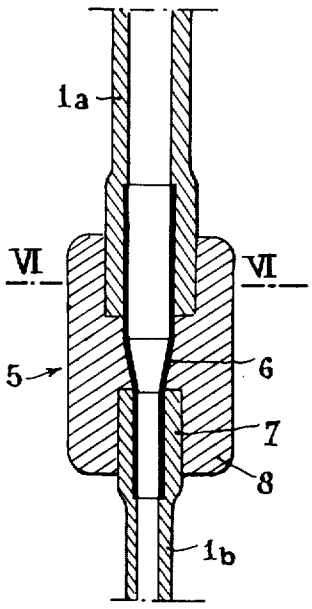
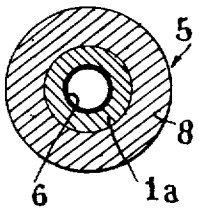


Fig.6



PRESSURE TRANSMISSION DEVICE

The present invention relates to a pressure transmission tube for medical or veterinary purposes, and also to all apparatus or instruments provided with such a tube.

The assessment of cardiovascular diseases relies more and more on intra-vascular, intra-cardiac, rachidial, renal and similar pressure measurements, apart from the usual clinical clues and the results of different analyses.

The blood pressure measurement method generally used consists in introducing a catheter into the cavity to be studied, the lumen of the catheter being previously filled with an isotonic solution: all variations in pressure, occuring at the catheter tip are completely transmitted by the incompressible liquid column filling the catheter lumen. Therefore, the measurement or the recording of the pressure variations transmitted to the external end of the catheter lumen will disclose the pressures occurring in the cavity under investigation. This is usually achieved by means of a so-called pressure transducer (of the Statham or another type), which provides an electric voltage proportional to the pressure variation.

However, it was found fortuitously that when two catheters of different diameters are introduced simultaneously into the same cavity, the pressure curves recorded through each of them, may differ significantly one from the other. In addition, the necessity of transmitting the pressure signals obtained by means of the catheter to a more or less distant electronic device led to interpose a pressure transmission tube between the catheter terminal and the pressure transducer. It was then observed that the distortions in the pressure signals was changed but did not subside.

A careful study of the phenomena led to the following conclusions: like any solid, fluid, or gazeous body, a catheter designed for transmitting pressure variations as well as the column of liquid filling same has its own resonance. This resonance arises whenever the hydraulic system, extending from the catheter lumen extremity to the transducer membrane, is stressed anywhere by a mechanical impulse or a pressure change. If no appropriate damping device is provided the pressure variations to be measured during their transmission to the transducer undergo significant distortions caused by the self-resonance phenomena occurring in the catheter and the pressure transmission tube. The self-resonance frequency of the most usual catheter lies between 15 and 60 Hz. If the frequency of the pressure signals to be measured nears these resonance frequencies, these signals, during their transmission, will undergo an erroneous amplification which may even exceed 400 percent. Even with pressure signal of much lower frequencies, like those occurring in the cardiovascular system, an erroneous amplification of course less significant, is still observed, but this constitute a cause of measurement errors far from negligible and impossible to estimate because appropriate calibration means are not available.

However, in the case of a cardiac catheterization, the mechanical impulses imposed to the catheter by the heat and its values, give rise to hydro-mechanical artefacts, often of high amplitude, which interfere with the pressure curves.

The pressure curves which can be recorded during a cardiac-catheterization are necessarily altered by the hydromechanical parasites as well as by the distortion which tends to widen erroneously the systolic pressure pulses.

It is the primary object of the present invention to avoid the inconveniences set forth hereinabove by providing an improved pressure transmission tube easy to use and manufacture, which is to be inserted between the catheter and the transducer.

This pressure transmission tube is characterized in that it comprises along at least one fraction of its length a section having a smaller inner diameter differring from the inner diameter prevailing along the remaining section of its length, which ranges from 0.5 to 2.5 mm, the section of smaller diameter corresponding to a reduction in diameter of the order of 10 to 85 percent.

Since its inner diameter is not uniform from end to end and comprises at least one dimensional variation, the tube of this invention has no inherent resonance and is therefore capable of efficiently filtering the pressure signals to be recorded while eliminating the greater part of the distortions to which these signals are exposed during their transmission. In fact, it is known that the flow of liquids, the propagation of a pressure and the production of resonance waves in tubes of relatively small diameter constitute complex phenomena according inter alia to the laws of Reynolds and Hagen-Poiseuille; therefore, the resonance or damping frequencies depend on the tube length and more particularly on the fourth power of the inner diameter of this tube. The characteristics of the catheter selected by a practicioner for a given investigation cannot be modified; therefore, the resonance frequencies should be eliminated in the pressure transmission tube by resorting to a sequence of pipe sections having mutually shifted resonance frequencies.

According to a first form of embodiment of the pressure transmission tube of this invention the tube has an inner diameter of constant value, except in a section of smaller inner diameter which consists of a neck having a relatively reduced length, within the range of 5 to 50mm, this neck being positioned in the first third of the total length of the pipe system, adjacent the end connected to the member or apparatus for detecting the pressure to be transmitted, for example a catheter.

In a modified form of embodiment the pressure transmission tube of this invention comprises the end to end assembly of at least two separate tube or pipe sections having inner diameters of different values, one section having an inner diameter within the range of 0.5 to 2.5 mm, the other section having a small inner diameter, the reduction in diameter corresponding to 10 to 85 percent of the inner diameter of said one section. Besides, the length of the pipe having the smaller inner diameter is equal to or less than the three-fourths of the total length of the tube assembly.

The attached drawing illustrates by way of example typical embodiments of the device of this invention. In the drawings:

FIG. 1 is a side elevational view of a first embodiment of a pressure transmission tube according to this invention;

FIG. 2 is a fragmentary axial section of this tube;

FIG. 3 is a cross-section taken along the line III—III of FIG. 2;

FIG. 4 is a side elevational view of another embodiment wherein the tube consists of a pair of pipe sections of different diameter, disposed end to end;

FIG. 5 is a fragmentary axial section of this tube, and

FIG. 6 is a cross-section taken along the line VI—VI of FIG. 5.

In the example illustrated in FIGS. 1–3 of the drawing the pressure transmission tube according to this invention comprises a single tube section 1 of a length of 50 to 300 cm. The inner diameter of this tube is within the range of 0.5 to 2.5 mm.

Advantageously, this tube consists of plastic material such as polyethylene, polyamide, P.V.C., E.V.A., etc. At one end, this tube carries a connector 2 for connecting the tube to a catheter adapted to be introduced into cavities of a patient or an animal for measuring pressures therein. At its opposite end this tube comprises another connector for connecting the tube to a transducer or a measuring instrument.

According to this invention, this tube comprises a neck or constricted portion 3 where at its inner diameter is reduced by about 10 to about 85 percent. If for instance the inner diameter of the tube is 1.5 mm, the inner diameter at this neck portion is reduced to 0.6 mm/. The length of this neck portion is extremely small and lies within the range of 5mm to 50mm. It will be noted that this neck portion is located in the first third of the length of tube 1, adjacent the connector 2 for connecting same to a catheter.

As illustrating in FIGS. 2 and 3, the neck portion 3 may advantageously be obtained by fitting an external tubular insert 4 to the tube 1 and shrinking this insert by means of a suitable shrinking machine. This tubular insert 4 may consist of stainless steel, copper or aluminium.

In the form of embodiment illustrated in FIGS. 4–6 the pressure transmission tube of this invention consists of a pair of pipe sections having different inner diameters, which are assembled to each other at one end, i.e. a first section 1*a* having an inner diameter within the range of 0.5 to 2.5 mm and a second section 1*b* having an inner diameter reduced by 10 to 85 percent with respect to the inner diameter of said first section 1*a*. At this end opposite to the second tube section 1*b* the first tube section 1*a* carries a connector 2 for connecting the tube to a catheter. On the other hand, the free end of the second tube section 1*b* carries another connector for connecting the assembly to a transducer or other measuring instrument. Possibly, the first section 1*a* may comprise a neck 3*a* similar to the neck 3 of the first embodiment shown in FIGS. 1–3.

The two tube sections 1*a* and 1*b* are assembled by means of a connector shown generally at 5.

This connector 5 comprises a metal tube 6 having an evolutive inner diameter corresponding exactly on the one hand to the inner diameter of tube section 1*a* and on the other hand to the inner diameter of tube section 1*b*, for it is essential in devices of this character to avoid any unevennesses likely to retain air bubbles, how small they are. This tube 6, like tube 4, may consist of stainless steel, aluminium or other suitable material. Finally, the reference numeral 8 designates a socket obtained by moulding a suitable elastomer over the ends of tubes 1*a* and 1*b*, on the one hand, and connecting tube 6, the function of this socket 6 consisting simply of reinforcing this joint between tube sections 1*a* and 1*b* of the pressure transmission tube and thus prevent any accidental rupture at this location.

First Application

The problem consisted in making a 130 cm long pressure transmission tube to be connected to a conventional catheter, a socalled "Cournand's catheter" No. 5, F-SW, having a length of 125 cm and an inner diameter of 0.66 mm. The pressure transmission tube having equal resonance frequencies, has been obtained by joining end to end, a first 100 cm long tube, having an inner diameter of 0.5 mm, with a second 30 cm long tube, having an inner diameter of 1.2 mm. These tube sections are connected as shown at 5, FIG. 5. However, it is not deemed necessary to describe in detail the connectors fitted to the ends of the connecting tube, since they are manufactured by conventional methods well known to all catheter manufacturers.

Second application

The problem consisted in making a 150 cm long pressure transmission tube, to be connected to a 125 cm long catheter "Flexo-Pulmocath" No. 13, having an inner diameter of 0.90 mm. The pressure transmission tube was according to the invention, comprised of two polyamide tube sections joined end to end: the first section was 100 cm long and had an inner diameter of 0.5 mm; the second section was 50 cm long, and had an inner diameter of 1.3 mm.

Third application

The problem consisted in making a 180 cm long pressure transmission tube, to be connected to a 125 cm long catheter "Flexo-Pulmocath No. 13, having an inner diameter of 0.90 mm.

The pressure transmission tube according to the invention consisted of two tube sections joined end to end: the first section was 90 cm long and had an inner diameter of 0.5 mm, the second section was 90 cm long and had an inner diameter of 1.2 mm.

In actual practice, with due regard for the resonance frequencies of the catheter in general use having an inner diameters of 0.5 to 2.0 mm, the tubes or tube sections constituting the pressure transmission tube according to the invention may have an inner diameter from 0.5 to 2.0 mm; however the inner diameters and lengths of these tube sections must be selected as a function of the catheters to be equipped with due consideration for the above mentioned laws.

The device according to this invention, can be used whenever it is contemplated, to observe or record a pressure existing in a cavity, for instance, the blood-pressure, the intra-cardiac pressure, the intra-vascular pressure, the intra-cerebral pressure, the renal pressure, the amniotic cavity pressure, the intra-rachidial pressure, the peritioneal cavity pressure, etc. This device can be used in the medical and the verterinary arts, as well as in all laboratories, for any kind of researches.

However, its specific application consists in recording the intra-vascular and the intra-cardiac blood pressure. Of course, the present invention also included all pressure transmission tubes, also referred to as connecting tubes, having different inner diameters, having or not constricted or widened sections which, when joined end to end, permit of obtaining a composite tube having a non-uniform inner diameter.

The present invention may also include pressure transmission tubes made of tube sections of which the cross-sectional contour is not a circle but any other configuration.

The present invention may also include a pressure transmission tube, made from a tubular element having a variable or evolutive inner diameter; this result can be obtained, during the actual manufacture, by using an extruder having movable punch and die members.

What we claim is:

1. In a device for use in measuring blood characteristics, particularly blood pressure or the like, having a catheter tube for insertion into the blood stream of a body and a transducer apparatus for picking up and converting pressure variations into proportional electrical voltage variations susceptible of measurement, a combination comprising a pressure transmission tube having two spaced end portions and adapted to be filled with a substantially immobile liquid pressure transmission medium, said end portions respectively communicating with said catheter tube and said transducer, and said pressure transmission tube defining an internal passage free of turbulence-producing projections and composed of at least two communicating main sections, one of said main sections having a constant inner diameter of between 0.5 and 2.5 mm and having a first self-resonant frequency, and the other of said main sections having a second self-resonant frequency and being of narrower diameter than said one main section and having a constant inner diameter of between 10 through 85 percent of said inner diameter of said one main section, whereby the self-resonant frequencies of said catheter tube and said pressure transmission tube are shifted away from the frequencies of the pressure variation signals to be measured so as to provide error-free measurement of the latter; and joining means forming a continuous internal channel located intermediate said sections of said pressure transmission tube and communicating with said internal passage so as to accommodate said liquid medium therein in a non-turbulent manner.

2. A device as defined in claim **1**, wherein said one main section is composed of at least two spaced portions and the other of said main sections is located intermediate said two portions.

3. A device as defined in claim **2**, wherein the other of said main sections is the first third of the total length of said pressure-transmission tube as measured from that one of said spaced end portions which communicates with said catheter.

4. A device as defined in claim **1**; and further comprising constriction means for contricting said pressure-transmission tube, said constriction means being a tubular sleeve located externally of said pressure-transmission tube and surrounding the same, said sleeve being of a shrinkable material and being shrunk to said tube, so as to thereby constrict the latter to attain said inner diameter of the other of said main sections.

5. A device as defined in claim **1**, wherein the other of said main sections adjoins said one main section.

6. A device as defined in claim **5**, wherein the other of said main sections has a length which is less than three-fourth of the total length of said pressure-transmission tube.

7. A device as defined in claim **5**, wherein the other of said main sections has a length which is equal to three-fourths of the total length of said pressure-transmission tube.

8. A device as defined in claim **5**, wherein the length of each of said main sections is between 30 cm and 150 cm; and wherein said inner diameter of one of said main sections is between 1.0 and 1.5 mm., and said inner diameter of the other of said main sections is between 0.3 and 0.8 mm.

9. A device as defined in claim **1**; and further comprising support means for supporting said joining means.

10. A device as defined in claim **9**, wherein said internal channel of said joining means evolutively communicates with said main sections of said pressure transmission tube.

11. A device as defined in claim **1**; and further comprising connector means located at each of said spaced end portions for respectively connecting said pressure-transmission tube to said catheter and said transducer.

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