MEANS FOR CONTROLLING FLUID FLOW

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ABSTRACT
A device for regulating fluid flow, especially of blood, saline drips and other medical fluids in hospital administration sets, is in the form of a clamp having jaws engaging a flattened portion of tube, and this flattened portion has a tapered groove or a tapered elongated member between its opposed walls. Movement of the point of action of the clamp along the flattened tube portion varies the rate of flow.

8 Claims, 8 Drawing Figures
MEANS FOR CONTROLLING FLUID FLOW

This invention relates to means for controlling the flow of a fluid (primarily a liquid, although the invention may also be used to control gas flow) by means of an adjustable clamp acting on the walls of a flexible-walled tube.

Such clamps are used in medical equipment to control the flow of blood or saline fluid or other medical fluid to the body of a patient from a container which is usually suspended above the patient to allow the flow to take place by gravity under the control of the adjustable clamp. It is necessary to be able to adjust the flow over a range of values, all small, of the order of 400 millilitres and hour down to as little as a millilitre per hour, under a head of about 75 cm. Such clamps are widely used, in the form of a ribbed roller movable along a channel-like guide that receives a flexible tube of plastics material, the opposing wall of the guide being inclined at an acute angle to the path of the roller, so that by moving the roller along the guide one can adjust the degree of flattening of the tube. Such a clamp forms the subject of U.S. Pat. specification No. 3,099,429. Another proposal on these lines is shown for example by U.S. Pat. specification No. 1,330,523 and a clamp employing a slide with an inclined surface but no roller is shown in U.S. Pat. specification No. 3,497,175. This last-mentioned specification discloses also a straightforward screw type of clamp, another example of which is shown by French Pat. specification No. 1,206,243.

However tests have shown that the roller type of clamp, although very widely used, is far from ideal as its adjustment is undesirably coarse, especially in the lower part of the flow range and, more seriously, the flow rate does not remain constant at the value to which it has been adjusted. In tests it has been found that the flow rate generally falls exponentially from the set value to a value which may, after some hours, be only about half that to which it was set. This is because of recovery in the plastics material of the tube walls. Consequently nursing staff have to check and re-adjust the clamp frequently, taking up valuable time.

The primary aim of the present invention is to overcome this drawback and to provide a tube clamp which can be adjusted in small steps and which moreover maintains the flow rate indefinitely at substantially the rate set.

According to the invention I now propose means for controlling fluid flow comprising a passageway having opposed flexible walls which are capable of being held in mutual contact throughout their cross-section except for a limited region, this region being of cross-section which varies along the general direction of flow through the passageway, with an externally applied clamp of which opposed jaws hold the walls in contact over a localised area of limited axial length, the jaws being movable along the direction of flow to other positions, along this direction of flow to alter the position, along this direction of flow, of the said area.

Preferably the region in which the walls are not in mutual contact is formed by a groove in one of the walls or, preferably, a mutually aligned groove in both walls that define a tapering passage of round or substantially round cross-section. In the area where the jaws of the clamp hold the walls in mutual contact only this round passage forms a path for the fluid, but upstream and downstream of this area the flexible nature of the walls allows the walls to move apart under even slight pressure, so that the cross-section for flow away from the selected area is large. Thus, by moving the clamp along the passageway one can alter that portion of the tapered passage which forms the flow-controlling orifice, and one can thus regulate the flow.

The walls are preferably formed by the opposed walls of an initially round tube of plastics material which has been permanently flattened by a heating and moulding operation.

Instead of providing a groove or grooves in the walls, I could leave the walls smooth but hold them positively apart in a localised region by means, for example, of a filament, preferably a tapering one, the behaviour being similar to that of the grooved version in that the fluid is only able to pass, in the area engaged by the jaws of the clamp, in the spaces formed immediately alongside the filament whereas upstream and downstream of this area the walls are able to move apart and allow ample cross-sectional area for flow.

The invention will now be further described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a general view of part of a medical fluid administration set, showing the manner in which the clamp according to the invention can be used;

FIG. 2 is a view, partly sectioned, of a length of tube to which the clamp is applied, but with the clamp omitted;

FIG. 3 is a view perpendicular to that of FIG. 2, showing the clamp in place;

FIG. 4 is a section through the clamp, to a larger scale;

FIG. 5 is a perspective view of one component of the clamp;

FIGS. 6 and 7 are respectively transverse and longitudinal cross-sections through a die suitable for moulding the tube to receive the clamp; and

FIG. 8 is a perspective view, partly broken away, of an alternative version of the tube shown in FIG. 2.

Referring first to FIG. 1 a typical medical administration set, for administering fluids such as blood or saline fluid to a patient in hospital, comprises a tube 1 carrying a hollow needle 2 at its upper end for inserting through a membrane in the cap or wall of an inverted reservoir or container (not shown) holding the fluid to be administered, an air venting branch 3, a filter bag 4, a transparent bag 5 for observing the rate of flow by counting the drops of fluid falling through it, and an outlet tube 6 leading to the patient. The clamp according to the invention, shown generally at 7, is applied to this outlet tube.

The tube 6 is made of flexible thermoplastic synthetic resin, such as polyvinyl chloride. To prepare it to receive the clamp, part of the length of such tubing is permanently flattened, for example by means of a die such as that shown in FIGS. 6 and 7. It will be seen that this die comprises two co-operating parts 8 and 9 which do not merely squash the tube flat, which would leave two ends of the oval cross-section still rounded, to leave a passageway of dumb-bell shape, but mould the tube to a rectangular profile with a passageway in the form of a plain slit which, in the rest condition, is of zero cross-sectional area. For this purpose the aperture in the die is only of exactly the same cross-sectional area as the material of the tube itself. The flattening is performed with the application of sufficient heat to allow the ma-
terial of the tube to flow and take a permanent set, with substantially no recovery, nearly in the shape shown in FIG. 6. However the degree of shaping is preferably such that in the free condition, i.e., with zero pressure difference across them, the walls do have a tendency to separate slightly.

Before the tube is placed in the die there is inserted in it a thin tapered metal wire or uniformly tapered wire, as indicated at 10 in FIG. 6. This wire or needle is removed after the moulding operation and leaves in the opposing inner surfaces of the two walls of the flattened portion 11 of the tube a pair of mutually aligned co-operating grooves 12 which taper from a maximum cross-section at one end of the flattened portion 11 down to zero before the other end is reached. In a typical example the tapered portion is 1½ inches (38 mm) long.

The needle or tapered wire 10 can be made by selective electrolytic etching of an initially uniform wire. As it is very fragile, it can be enclosed in a tube of stainless steel, which is inserted in the plastics tube 6 with the wire inside it. Then the stainless steel tube is carefully withdrawn, leaving the wire 10 inside the plastics tube, which is then placed in the die 8, 9.

The degree of heat and pressure applied in the die 8, 9 should be such that, in the finished tube 11 the opposed walls came into mutual contact throughout their area (except where the grooves 12 are) under negligible external pressure, but at the same time any even slight internal pressure will force them easily apart. It may even be such that, in the unstrained condition, the walls do bow slightly apart.

The clamp comprises a pair of co-operating lever members 13 having a mutual pivoting or rocking action so that jaw portions 14 of these lever members grip between them a localised area of the flattened tube 11 with an action not unlike that of a clothes peg. In the preferred embodiment illustrated, the lever members 13 are identical mouldings in synthetic resin, for example a silicon resin or polystyrene.

To locate the two members 13 with respect to each other they are provided with co-operating lugs 15 that form a rocking hinge. Additional lugs 16 limit the rocking movement so that the opposite ends of the members 13 from the jaw portions 14 cannot themselves close onto the tube and interfere with movement of the clamp along the tube. Flanges 17 help to locate the clamp on the tube portion 11 and lugs 18 on the jaw portions 14 keep these ends of the members 13 in alignment.

The jaw portions 14 of the members 13 are urged together by two resilient loops 19 encircling these portions and located in suitable grooves formed in the external faces of these portions. The loops are conveniently ordinary rubber bands and there are two of them so that failure of one will not result in total failure of the clamp.

The co-operating inner faces of the jaw portions 14 are flat and, to ensure that they engage the tube 11 squarely, i.e., so that they are truly parallel, the shape and position of the hinge lugs 15 are such that these lugs are out of mutual contact in the rest position of the clamp. They only come into engagement when the serrated finger-engaging ends 20 of the members 13 are manually squeezed together to open the clamp. Thus the jaws 14 are truly parallel, independently of slight variations in the thickness of the tube 11.

It will be understood that, with the clamp 7 engaged on the flattened portion 11 of the tube, the rate of flow through the tube is controlled by the smallest cross-sectional area of the grooves 12 in that area of the tube which is gripped by the jaw portions 14. Upstream and downstream of this area (subject to the comment below) the walls of the tube are free to move apart under the pressure of the fluid to provide a relatively large cross-sectional area. Thus by moving the clamp 7 along the flattened portion 11 to a region where the tapered passage formed by the grooves 12 is larger or smaller one can increase or decrease the rate of flow of the fluid, and by moving the clamp to the area beyond the small end of the grooves 12 one can cut off flow altogether. As will be seen in FIGS. 2 and 3 I can form a partially flattened portion 21 on the tube to provide clearance for the ends 20 of the clamp when the clamp is at this end of the portion 11.

In many situations it is immaterial whether the larger or the smaller ends of the grooves 12 are upstream as the behavior device is the same in each case. However, with a layout such as that shown in FIG. 1 it is possible for the fluid pressure downstream of the clamp to be below atmospheric pressure, and consequently the walls of the flattened portion tend to close up, and this could lead to a restriction or cut off of the flow regardless of the position of the clamp 7 if the flow were to be from the larger to the smaller end of the tapered grooves 12. Preferably, therefore, I arrange for the flow to be the other way, that is to say, from right to left in FIGS. 2 and 3. Similarly, the device works equally well with the clamp 7 facing either way but in practice, in a layout like that of FIG. 1, it is possible for twisting of the tube 6, such as can arise in use under hospital conditions, so the flattened portion 11 upstream of the clamp 7 can become twisted, which tends to close it up even against the fluid pressure inside. I therefore prefer to arrange the clamp 7 as shown in FIGS. 1 and 3, that is to say with the finger-engaging ends 20 upstream, as these ends, being close to the tube 11, prevent twisting of the tube.

The device according to the invention is preferably formed in a separate short length of tube, which can then be of slightly harder material than the normal polyvinyl chloride forming the remainder of the tube. It can be joined to the remainder by short internal sleeves as indicated at 6a in FIG. 2.

The flattened portion 11 may have markings on it, for example transverse lines, to enable the user to move the clamp rapidly to a known position to set the flow to a required value. The clamp may be held in place by adhesive tape binding one of the ends 20 to the tube. Where it is desired to allow maximum flow without the restriction imposed by the clamp 7, the clamp can be held open by a resilient sleeve which is slipped over the ends 20 to hold the jaws open. This sleeve can be permanently on the tube, normally just clear of the end position of the clamp 7. The ends 20 may have projections (not shown) to be engaged by the sleeve. An easier alternative for holding the clamp open, in place of such sleeve, is simply for the user to push the clamp along to a position where the jaw portions 14 engage the unflattened part of the tube 6, for example the region where the internal sleeve 6a is present, the internal sleeve preventing the tube collapsing.

In an alternative version, illustrated in FIG. 8, the grooves 12 are omitted altogether and in place of them
there is a longitudinally extending tapered wire or filament 22 placed between the walls of the flattened portion 11. Flow takes place in the roughly triangular spaces that are left between the walls immediately on each side of the filament. As before, the flow is controlled by moving the clamp longitudinally. This version is however less satisfactory as the rate of flow may be influenced by the pressure applied by the jaws, this pressure being a somewhat indeterminate quantity.

It will be understood that the form of the clamp may be different from that shown, the only essential thing being that it acts only on a area of the tube walls of limited longitudinal extent. For example, there could be a jaw formed by a flat stationary plate forming a backing or anvil lying on one side of the flattened portion and extending the full axial length. The other side of the flattened portion is engaged by a bar, forming the other jaw, which is slidably in guides associated with the anvil. Instead of a bar there could be a roller, not unlike that of U.S. Patent specification No. 3,099,429, except that its spacing from the anvil would remain constant, instead of varying, as it is moved longitudinally.

I claim:

1. Means for controlling fluid flow comprising a hollow tubular body, a longitudinally extending flattened portion in said body, said flattened portion having two opposed flexible walls capable of being brought into mutual contact, a clamp, said clamp having opposed jaws capable of engaging externally said walls over a longitudinally limited region thereof whereby to bring said walls forcibly into contact only over said region, the unclamped portions of said opposed walls being capable of flexing outwardly under fluid pressure to define between them a fluid duct of relatively large cross-sectional area if not already flexed outwardly by their own innate resilience to define such a duct, longitudinally extending tapered means disposed between said opposed walls to define a fluid passage therebetween even when said walls are in mutual contact, the cross-sectional area of said passage varying longitudinally by virtue of the taper of said tapered means, and the region of engagement of said jaws on said flattened portion being movable longitudinally of said flattened portion.

2. The means set forth in claim 1 wherein said tapered means comprise surfaces defining a longitudinally extending tapered groove in the inner surface of at least one said walls.

3. The means set forth in claim 1 wherein said tapered means comprise a tapered elongated member extending longitudinally between said walls and serving to keep said walls apart locally against the action of said clamp.

4. The means set forth in claim 1 wherein said tapered means do not extend the full longitudinal extent of said flattened portion.

5. The means set forth in claim 1 wherein said body is of thermoplastic synthetic resin.

6. The means set forth in claim 1 wherein said clamp comprises first and second lever members, said lever members lying on opposite sides of said flattened portion, means defining a rocking hinged connection between said lever members, and resilient means urging one pair of adjacent ends of said lever members together, said ends defining said jaws and clamping said flattened portion therebetween.

7. The means set forth in claim 6 wherein said resilient means comprise at least one elastic loop embracing said ends.

8. The means set forth in claim 6 wherein said jaws have mutually parallel faces and, in the rest condition of the lever member under the action of said resilient means, with said jaws engaging said flattened portion, said hinged-connection-defining means are out of mutual hinging engagement.