May 31, 1938. N. M. ELIAS 2,119,009

VACUUM JACKETED GLASS TUBE AND SHAPE

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Fig. 1.

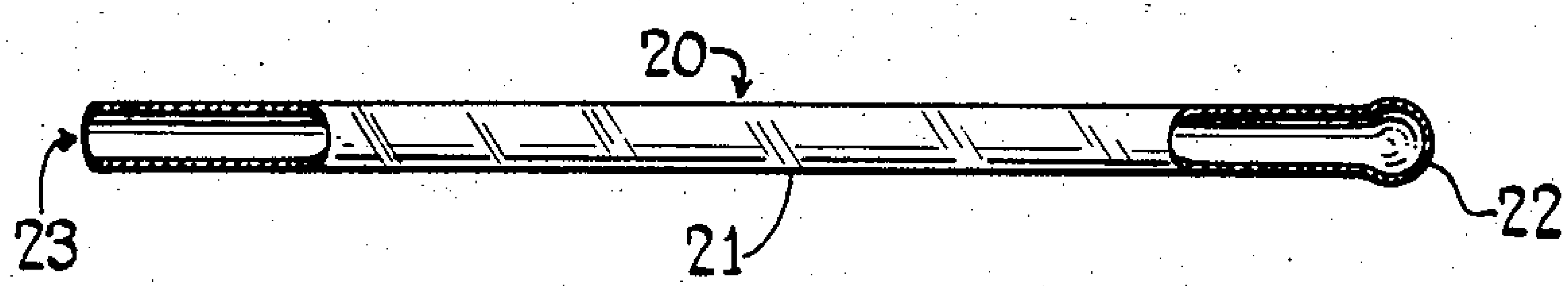

Fig. 2.

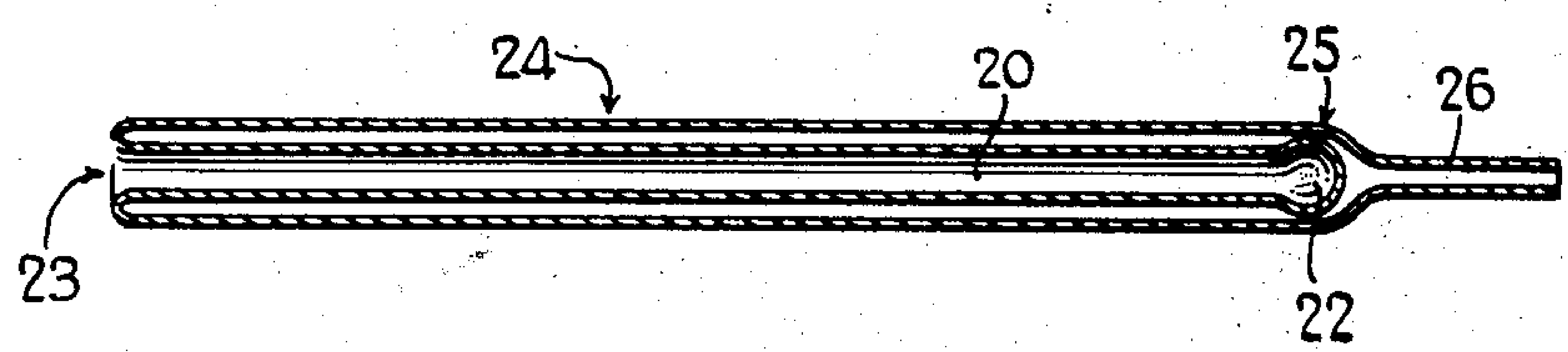

Fig. 3.

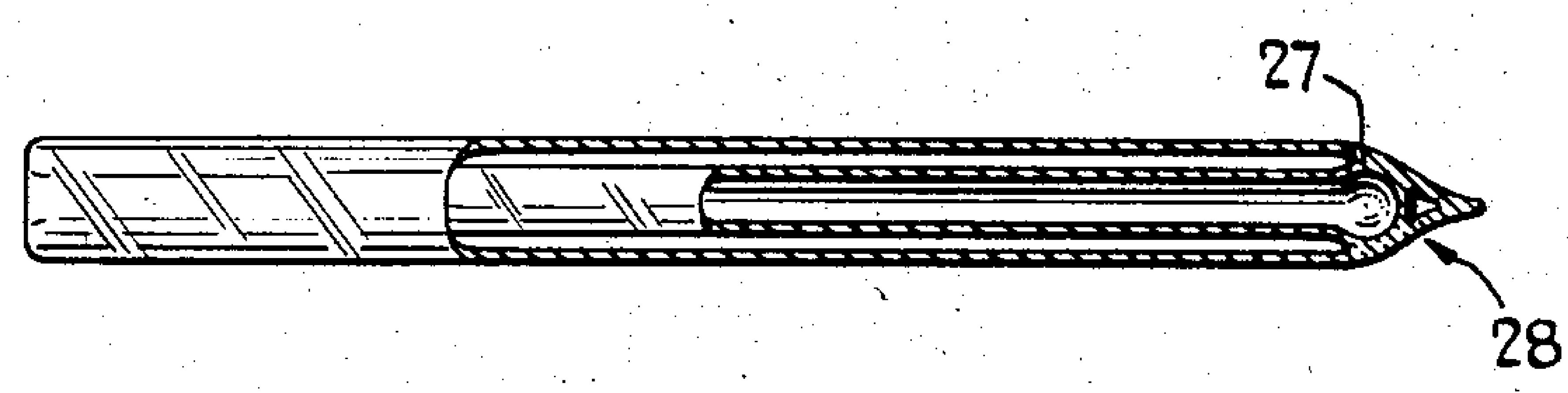

Fig. 4.

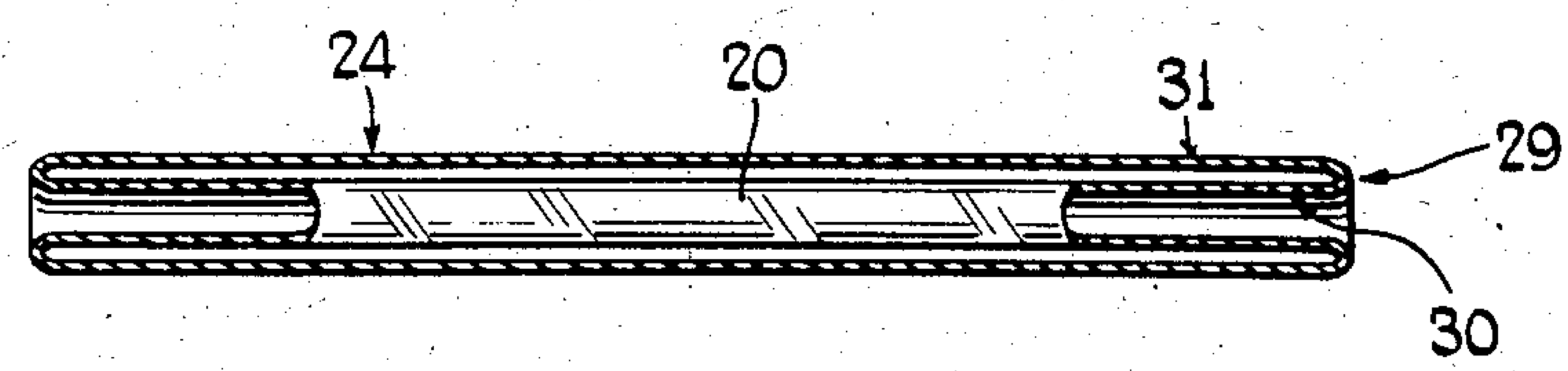

Fig. 5.

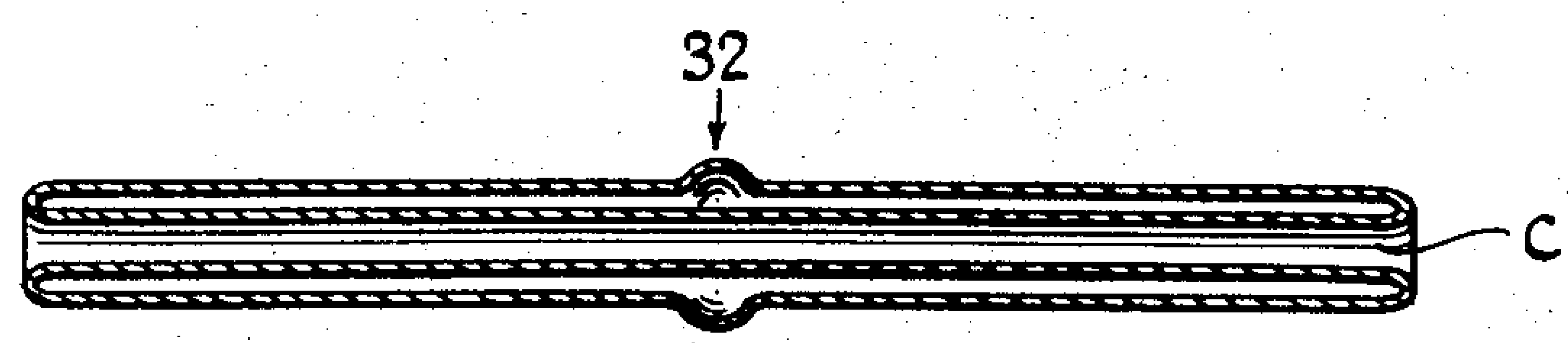

Fig. 6.

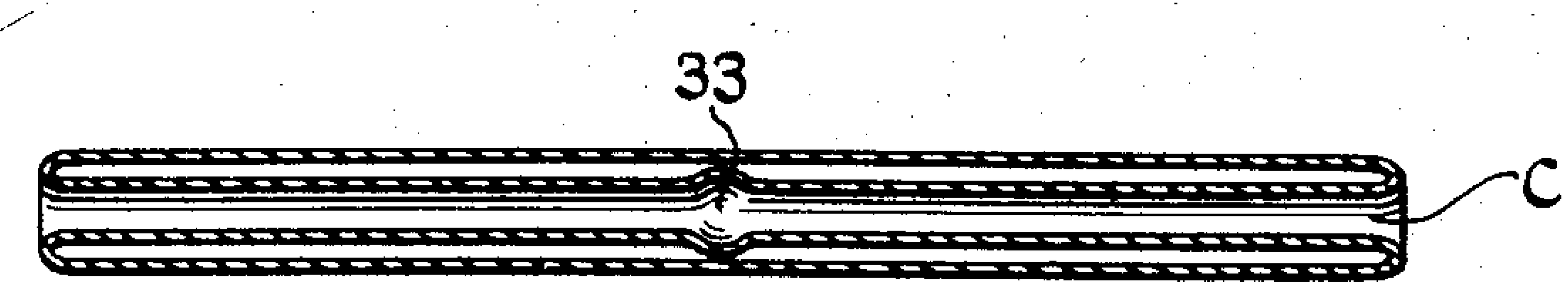

Fig. 7.

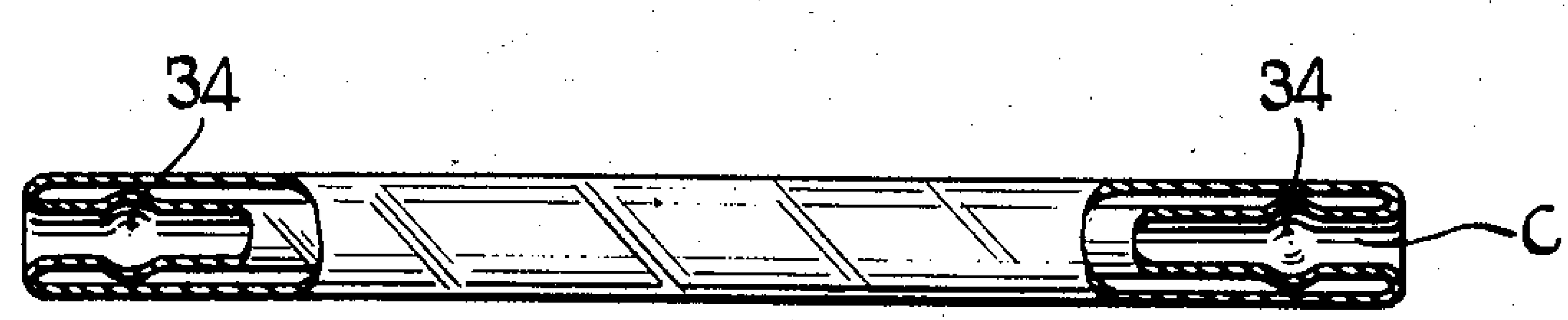

Fig. 8.

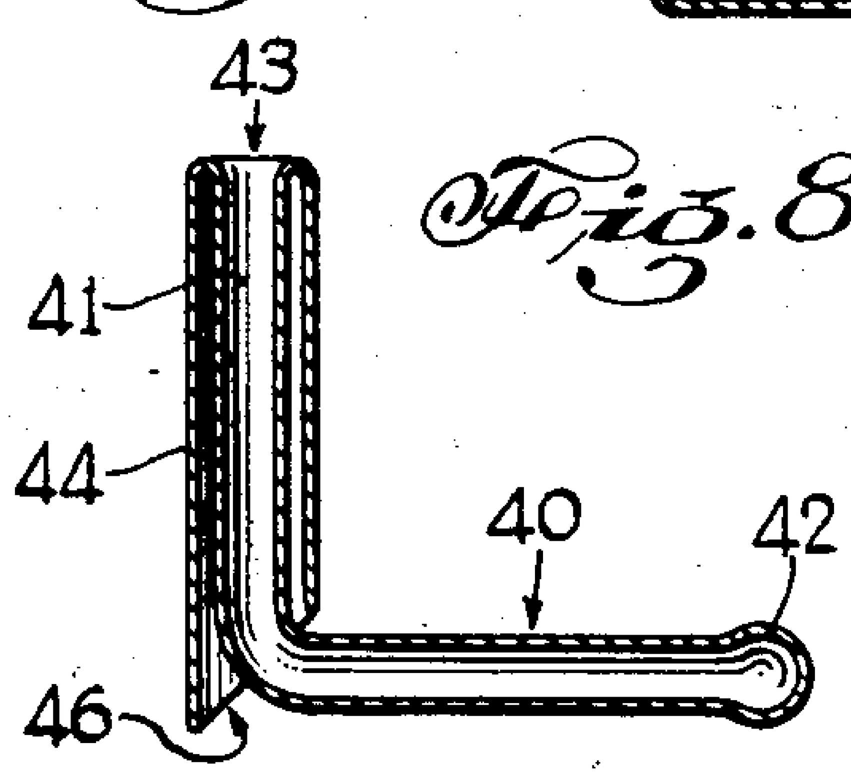

Fig. 9.

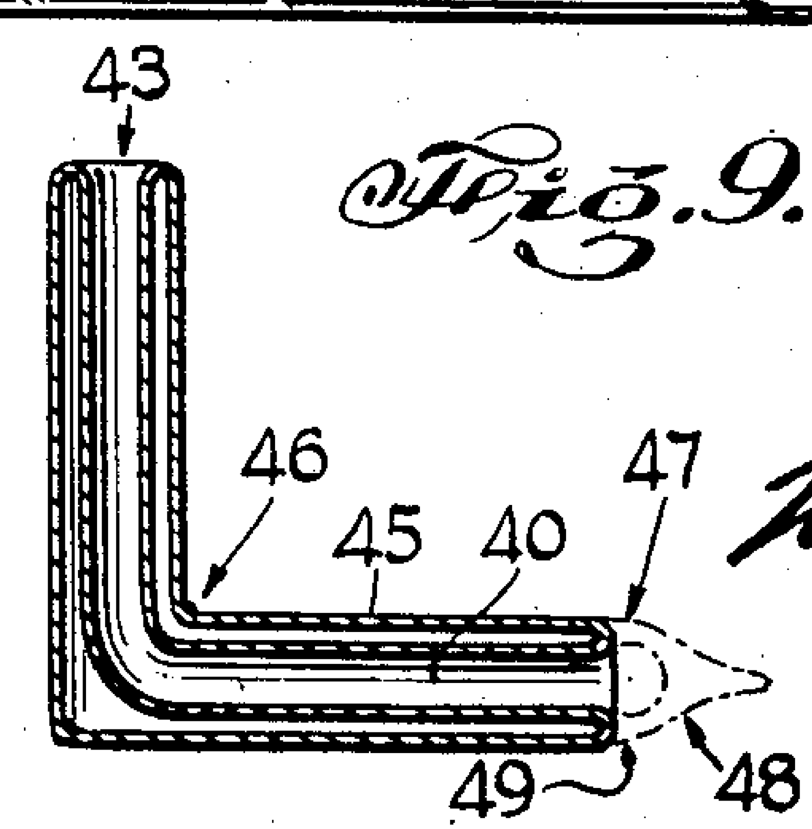

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Fig. 10.

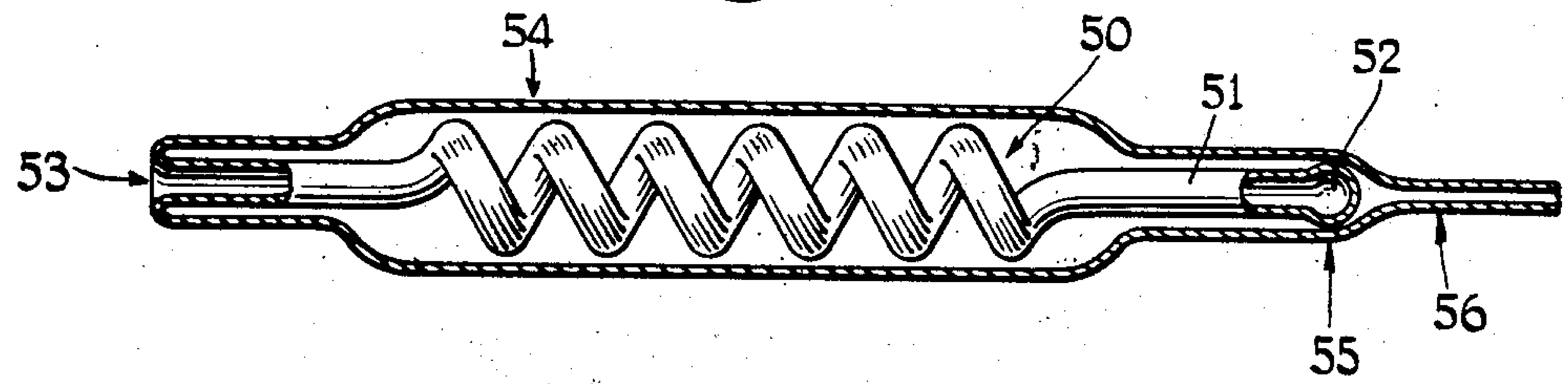


Fig. 11.

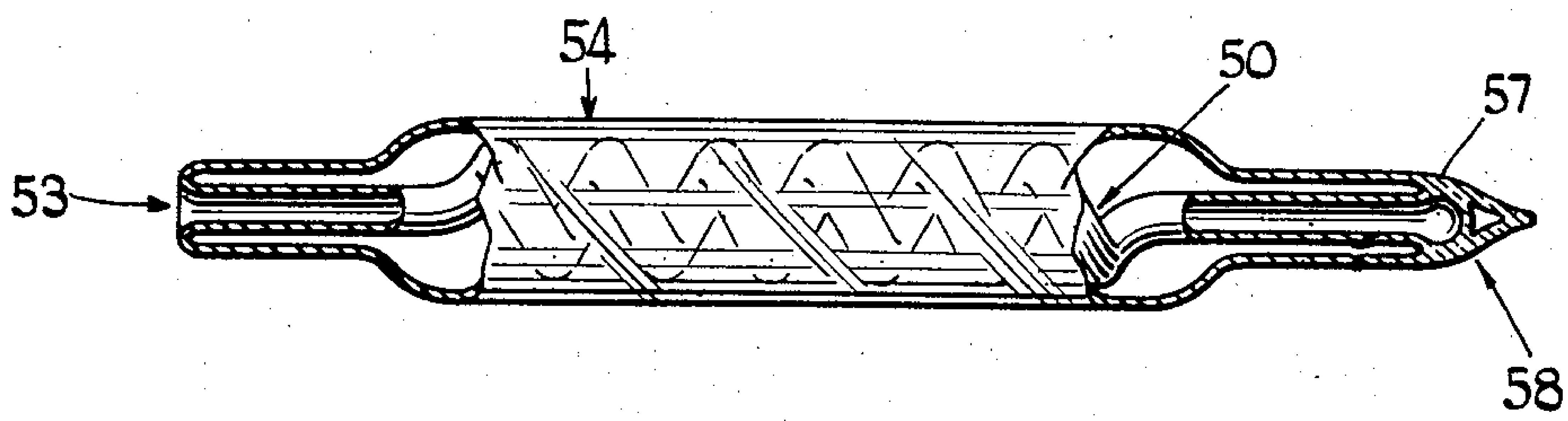


Fig. 12.

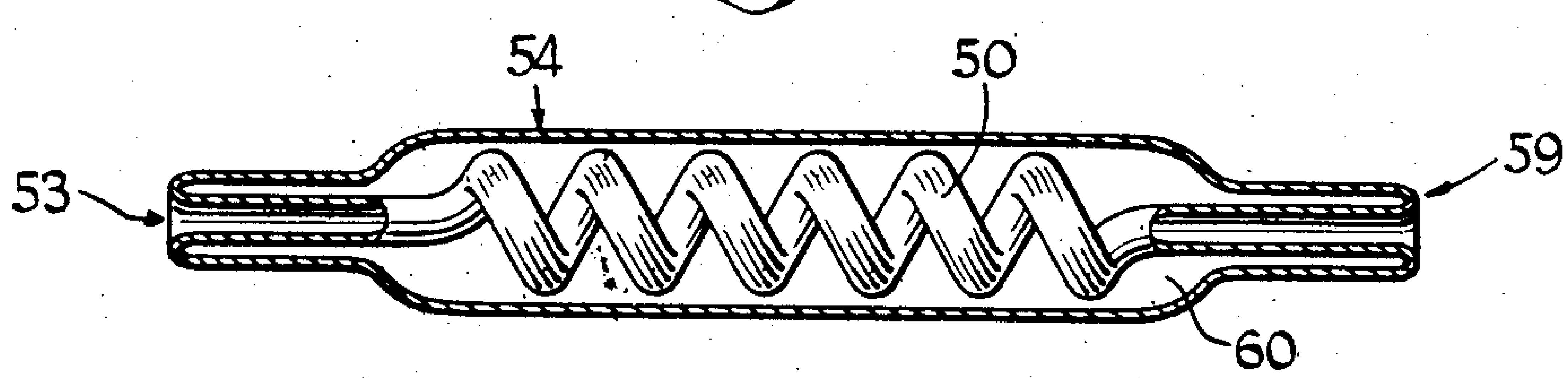
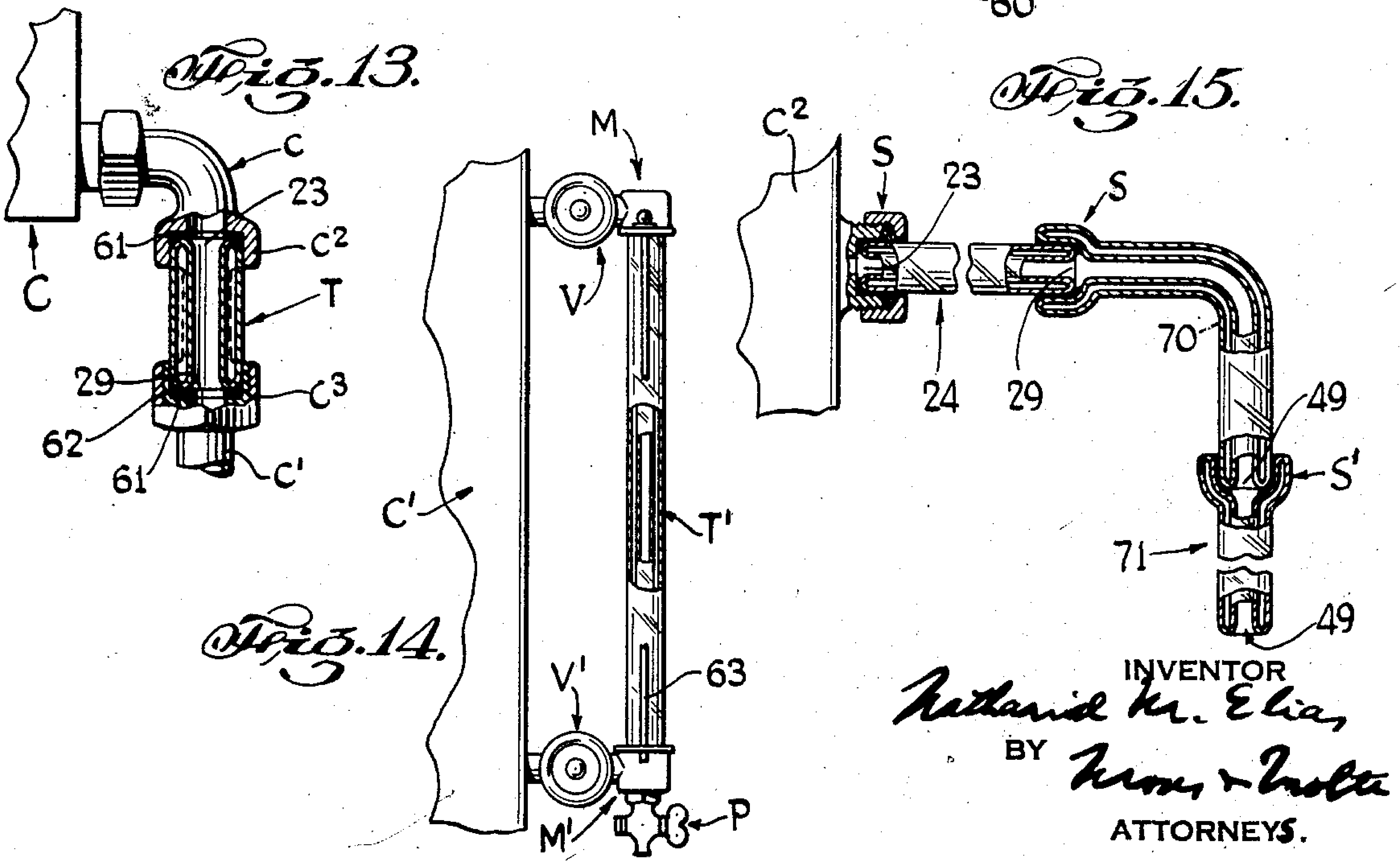


Fig. 13.

Fig. 14.

Fig. 15.



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UNITED STATES PATENT OFFICE

2,119,009

VACUUM JACKETED GLASS TUBE AND SHAPE

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Application June 27, 1935, Serial No. 28,633

9 Claims. (Cl. 49—82)

This invention relates to glass tubes, especially to the fabrication of double walled tubes and more particularly to the provision of such tubes in which the intramural space constitutes a jacket highly evacuated to reduce heat transfer therethrough, in order to produce a vacuum-insulated tube or tube-shape which is transparent.

One of the uses to which such tubing or shapes can be applied is in the transfer of liquids at very low temperatures, when some characteristic of the liquid is to be observed optically without too great absorption of heat by the liquid, or serious frosting of the outside of the tube because of deposition of moisture thereon from the atmosphere.

Another use therefor is as a gauge glass, particularly for low temperature liquids or liquefied gases. Even at temperatures as low as —50° C., serious frosting does not occur with the tube of the present invention. Use of such glasses for liquefied ammonia and other liquefied gases as well as for cold oil, refrigerating brine solution, cold creamery products, etc., has been found to be quite practicable.

While double-walled tubes have been known, their fabrication has been attended with numerous difficulties, among which has been experienced especially the difficulty in fabrication of such tubes by a method which can be practiced commercially to make tubing in which the vacuum jacket shall include substantially the whole length of the tube; another difficulty has been that the double-walled tube is usually left with a tip at the sealed-off end or if the tips have been removed the cost has been prohibitive; and still another difficulty is that there has been lacking a practical means for compensating for the unequal expansion between the inner and outer walls of the tube.

A principal object of the invention is to provide a method of making such double walled vacuum jacket tubes by which method the vacuum jacket is made co-extensive with the length of the tube, and to fabricate double-walled, vacuum jacketed tubes in which means are provided to compensate for unequal expansion and contraction, as between the walls, especially when long tubes are required. This provision is made, in the present invention, preferably by the inclusion of bulbs in either the inner or the outer tube wall or both, which bulbs act to give resilience to the glass and avoid breakage at the joints.

Another object is to provide a method of fabricating such glass tubes or shapes out of plural components without any sealed-off tip, and at moderate expense, this method including a novel mode of evacuation by which the vacuum itself, acting while the tube material is hot and soft, permits atmosphere pressure to become effective to cause a sealing contraction of the walls which makes unnecessary the retention of the conventional tip.

Another object of the invention is to provide a method of making such tubes not only in straight forms but with curved and other shapes.

Still another object of the invention is to provide for the fabrication of such vacuum jacketed glass shapes of widely diverse character, as for example, in L's, T's, curves, spirals, etc.; also as sight-glasses, gauge-glasses, and feed-tubes, etc., to be used in combination with systems for containing and/or transferring liquefied gases; liquids at temperatures below 10° C.; etc., as for example, systems containing brine, oil or liquid food products at such low temperatures.

Other objects and advantages will appear as the description of the particular physical embodiment selected to illustrate the invention progresses, and the novel features of the invention will be particularly pointed out in the appended claims.

In describing the invention in detail and the particular physical embodiment selected to illustrate the invention, reference will be had to the accompanying drawings, and the several views thereof, wherein like characters of reference designate corresponding parts, and in which:

Fig. 1 is a view of somewhat diagrammatic character illustrating the preliminary stage in the preferred method for fabrication of double walled, vacuum jacketed glass tubes in pursuance of the invention;

Fig. 2 is a similar view of the next stage in said method;

Fig. 3 illustrates a subsequent stage;

Fig. 4 shows the final product resulting from the fabrication of an illustrative tube; this figure being a view in side elevation, partly in section of a double-walled, vacuum jacketed glass tube in the construction of which my invention has been carried into effect;

Fig. 5 is a similar view of a modification;

Fig. 6 is a similar view showing another modification;

Fig. 7 shows still another modification;

Fig. 8 shows a preliminary step in carrying the invention into effect for the formation of an L-shaped tube;

Fig. 9 illustrates in dotted lines the final stage in making such a tube as that of Fig. 8; this figure being a view in longitudinal section of the completed L-shaped tube;

Fig. 10 illustrates a preliminary step in making a tube where the outer glass envelope does not correspond exactly in shape with the inner tube;

Fig. 11 illustrates an intermediate step in the fabrication of the tube, which is shown in Fig. 12, in its final shape;

Fig. 13 is a small-scale view of somewhat diagrammatic form illustrating a vacuum jacketed sight glass made according to my invention and assembled in combination with a condenser;

Fig. 14 illustrates the combination of a vacuum jacketed gauge glass with a storage tank containing liquids at temperatures below 10° C.;

Fig. 15 shows a series of vacuum jacketed transparent glass tubes of different shapes assembled in a system for conveying liquids at low temperatures.

The novel method of my invention may be illustrated and understood readily by reference to several steps thereof carried out in the fabrication of the tube shown in its final form in Fig. 4, and Figs. 1, 2 and 3 serve to illustrate stages or steps in said fabrication.

These figures show particularly the fabrication of a tube which in its final form lacks the conventional sealed-off tip which characterizes the ordinary tubes of such structure.

In making this new form of tipless jacketed tube, there is first prepared a tube **20** such as that shown in Fig. 1, which has a straight portion **21**, closed at one end by a bulb **22** and having its other end left open as at **23**. The tube is shown partially in section to reveal the inner wall structure.

The next step in the method consists in sealing to the tube **20** an outer tube, at the open end **23**, as shown in Fig. 2, this outer tube being designated generally **24**, its walls being substantially parallel with those of the tube **20** throughout the length of the tube, except at the region of the bulb **22**, where the walls, as at **25**, approach very closely to the periphery of the bulb **22**. Beyond that region, the extremity **26** of the outer tube may be drawn in to form a neck of convenient dimensions for attachment of a known or suitable evacuating means.

The next step in the fabrication of this form of tube involves a very important feature of the present invention, in that after a vacuum has been created by evacuation through the neck, and preferably after a preliminary sealing at the region designated **26**, the walls **25** of the outer tube are suitably heated so that the vacuum exercises a constrictive effect, or, to be more accurate, the inner support of the walls is so diminished that atmospheric pressure results in bringing the outer walls **25** into contact with the bulb **22**, and the inner and outer walls become fused together as shown very clearly at the annular region **27** in Fig. 3.

The final step consists in cutting off the surplus tip **28**, at a transverse plane so disposed that the thickness of the end wall at the region indicated at **29** in Fig. 4 is approximately that of the inner wall **30** and of the outer wall **31** of the tube in its completed shape as shown in Fig. 4. Some further fusing or molding may be necessary to give a good finish, as will be understood by those skilled in the art, the whole glass being preferably annealed very carefully to relieve internal tension in the material.

The product, as shown in Fig. 4, is a double-walled glass tube, vacuum jacketed, and having no sealed-off tip at either end, so that the vacuum jacket is substantially co-extensive in length with the length of the tube.

In experimenting with tubes of this novel structure, I have found that for many purposes the annular space between the two tube walls may be less than one-quarter of an inch, and still be effective for the purpose described. Such a dimension is not however necessary, and the annular space may be either greater or less according to the exigencies of particular embodiments. The dimension just mentioned is of course that between the walls **30** and **31**.

When tubes containing expansion bulbs are to be made, the method comprises substantially the same steps as those above-described, except that the expansion bulb or bulbs are first blown into the tubing, either in the outer tube as shown at **32** in Fig. 5, or in the inner tube as shown at **33** in Fig. 6, or in both tubes, as will be readily understood without further need for specific illustration. Fig. 7 illustrates a similar tube in which the inner tube has two bulbs spaced apart, being disposed near the ends of the double walled tube. It will be readily understood that by such a structure provision is made for compensatory adjustments to relieve internal tensions set up in one or the other tube, or in both, as the result of differences in temperature within the channel C as against the atmospheric temperature to which the outer tube is subjected.

Any suitable glass may be used in carrying the above method into practice, for which purpose a borosilicate glass has been found satisfactory.

The invention may be utilized not only for making straight jacketed tubes, but also may be embodied in many other shapes, of which a few examples will now be described.

In Figs. 8 and 9 is illustrated an adaptation of the method as employed in making L-shaped jacketed tubes, or "L's" as they are sometimes termed. A satisfactory procedure is to make the inner L-shaped tube designated by the reference character **40**, having one end, as **42**, formed with a closed bulb, while the end of the branch **41** of the L is open, just as in the case of the open end **23** of the straight tube shown in Fig. 1. Indeed the parts **40**, **41**, **42**, and **43** of the L-shaped tube shown in Fig. 8 may be considered as illustrative of the parts numbered **20**, **21**, **22**, and **23** in Fig. 1.

Furthermore, as in Fig. 2 the numeral **23** designates the closed end of the tube after an outer tube **24** has been secured thereto in the manner described above, so in Fig. 8 the numeral **43** designates the closed end common to the inner tube **41** and the outer tube **44**.

In order to complete the jacketing of the L along the stretch designated **40** in Fig. 8, a separately formed outer tube section designated **45** in Fig. 9 is superimposed upon the part **40** of the tube shown in Fig. 8 and a beveled fused joint is first formed at **46** between suitably beveled edges at the meeting ends of the outer tube sections **44** and **45**; then, just as shown in Figs. 2 and 3, a joint **47** is made between the outer ends of tubes **40** and **45**. This end joint is finished off by removal of the superfluous tip **48** and the end **49** of the resultant product resembles that indicated at **29** in Fig. 4.

This method of making the L-shaped tube, illustrated in Figs. 8 and 9, has the common characteristic with respect to the method of making the straight tube shown in Fig. 4, that one end of the double walls by which the jacket is formed can be finished off prior to evacuation, and that another joint, spaced at any desired and suitable distance from the first joint, can be made during or after evacuation of the intra-mural space, this final joint being made by means of the contractile effect resulting from the circumambient atmospheric pressure, which becomes effective when the glass of the adjacent wall portions is heated sufficiently to promote fusion at the annular contiguous ends. Thus the L-shaped member is provided with a vacuum jacket, coextensive with its length, and regardless of its shape.

By a further adaptation of the same principle, numerous other shapes can be made, and it is not always necessary for the outer jacket tube to correspond exactly in shape with the inner one. For example, an inner spiral tube may be made with a straight outer jacket, as illustrated in Figs. 10, 11, and 12. In Fig. 10 the spiral inner tube designated 50 is first made, having at one end a portion 51 closed by a bulb 52, the latter corresponding to the bulb 22 at the end of the straight portion 21 in the tube of Fig. 1. During this first stage, the other end of the spiral has a straight open portion 53 corresponding to the straight open end 23 of the tube shown in Fig. 1. During the next stage, a tube 54 of suitable diameter is slipped over the spiral portion of the inner tube 50 and a joint is made at the end 53 corresponding to the similar joint at 23 between the tubes 20 and 24 of Fig. 2. Then the other end of tube 54 is drawn down as at 55 into proximity with the bulb 52, and is drawn down still further at 56 to receive a rubber or other evacuating means or coupling (not shown).

The remaining stages in the formation of a shape of this kind consist in completing the annular fused joint at 57 by a softening of the adjacent double walls at that region and so permitting atmospheric pressure to force the walls together, after which the superfluous tip parts 58 are removed, according to usual glass-blower's practice and the end 59 is finished up if necessary by further fusion and smoothing to be symmetrical with the end 53.

It will be seen from the foregoing that the final product in each of the examples above described presents a very practical, sturdy, inexpensive and efficient embodiment of my invention, and that these examples, which are merely illustrative, serve to teach the novel application of a natural principle in practice of the improved method of forming jacketed double walled tubes or other shapes herein disclosed. As already indicated, the examples given are merely illustrative and are not intended to exclude similar adaptations in as many other forms or shapes as may embody the idea of means constituting the generic feature of the present invention.

For example, as already indicated briefly at an earlier point in this disclosure, I have found in practice that it is not only possible, but often desirable, to make a seal of a preliminary nature at the region indicated by the reference character 26 in Fig. 2, and by 56 in Fig. 10, thus leaving this end of the tube ready for the sealing of the annular ring at the region indicated by the reference character 25 in Fig. 2, and by 55 in Fig. 10.

There is a vacuum in the annular space at the region 25, or 55 as the case may be, or in any equivalent embodiment of the novel structure represented by these illustrative examples, and by properly heating around the designated regions 25 or 55, the existing vacuum tends to collapse the two tubes together at that region.

This last-described method is the now-preferred method, in that the tube can be manipulated more readily during the difficult step of completing the annular seal if the tube is not attached to a pump, and the presence of the preliminary seal at the region 26 permits detachment of the tube from the pump while preserving the tube in a state in which the vacuum-engendered contractile bias is effective at the annular region where the final seal is to be made, viz., at 25, 55 or the like.

It is noteworthy that the tube illustrated in Fig. 3 represents not only a tube constituting an incomplete product, when regarded from the aspect of the fianl product which constitutes the objective of the entire method, carried through to the stage illustrated in Fig. 4, etc., but the tube of Fig. 3 constitutes an entity having distinctive characteristics which are desirable for particular uses; for example, if a vacuum-jacketed tube is required which is closed at one end.

Similarly, the tube of Fig. 2, when the preliminary seal at region 26 has been made, as already described, and when the tube, in this condition, has been removed from the evacuator means, clearly constitutes an entity which in itself is a new article of manufacture, viz., an integral blank or intermediate product, of which any desired number may be made and accumulated preparatory to the performance of the final step or steps which result in the product of Fig. 3 and then of Fig. 4, or any suitable modification thereof.

Such blanks will also be found susceptible of usual employment otherwise, so that the invention lends itself to mass production of such tubes in which the earlier steps of the method yield an intermediate product which is not essentially limited to completion by the remaining steps of the preferred method if a final product is required for other uses than the principal intended uses herein exemplified.

A few embodiments of the novel jacketed tubes in combination with apparatus of a nature especially requiring the use of such tubes are shown in Figs. 13, 14 and 15.

In Fig. 13, a tube, identical in formation with that of Fig. 4, but somewhat shorter, is illustrated for use as a vacuum jacketed sight glass at the outlet of a condenser C, the latter being shown in diagrammatic, fragmentary form, as are also the elbow c and the conduit c′ leading from the condenser. The tube embodying the invention is designated in this instance by the reference character T, and its ends 23 and 29 are embraced between cup-shaped seats c^2, and c^3, provided in the elbow c and the conduit c′, respectively. The reference characters 61 and 62 designate packing means of known form.

In Fig. 14 is shown a tube T1, which may be regarded as in all respects identical with the tube shown in Fig. 4. It is mounted as a gauge glass for a storage tank C′ containing liquids distilled to temperatures below 10° C. The mountings M and M′ are of usual structure, embodying valves V and V′, and the reference character 63 designates the usual strengthening rods connecting the mountings M and M′. The reference character P designates a pet cock.

In Fig. 15 is illustrated a series of vacuum jacketed, transparent glass tubes each embodying my invention and combined in a system for conveying fluids. If liquids of low temperatures are to be conducted through the system, the different components are respectively adapted to permit the contents to remain visible by preventing frosting due to the accumulation of moisture deposited from the atmosphere. In this figure the reference character C2 designates a storage tank having a suitable stuffing box S of ordinary structure, which does not require description, and in which is seated one end, as 28, of a tube identical in construction and shape with that of the tube 24 in Fig. 4, being designated therefore by that reference character.

The other end 29 of this tube is seated within a spigot *s* formed at one end of an L-shaped member 70 which is identical in construction with the L-shaped member shown in Fig. 9, except that in Fig. 15 the L-shaped member is formed with the said spigot by the exact method of procedure described in full with reference to the L-shaped member shown in Figs. 8 and 9. The remaining component of the series shown in Fig. 15 is a member 71 having a spigot *s'* with reference to which the remarks above as to the spigot *s* apply in every respect.

It will be readily understood, that the series of tubes shown in Fig. 15, or any equivalent assembly of similar components embodying my invention, can be extended indefinitely, and every such extension, with all possible implications as to variations in form, and adaptations to meet the needs of particular installations, falls within the purview of the present invention.

Although I have particularly described a specific embodiment of my invention and explained the principle, construction, and mode of operation thereof, nevertheless, I desire to have it understood that the form selected is merely illustrative and does not exhaust the possible physical embodiments of the idea of means underlying my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of fabricating a vacuum-jacketed glass shape, said method comprising the step of assembling an outer glass wall with an inner glass wall; the step of fusing said walls together at a selected region and so forming there a sealed joint; the step of heating the outer wall and drawing it into proximity to the inner wall at a region spaced from said first-named joint; the step of evacuating the jacket space enclosed between said walls intermediate said regions; and the step of fusing said walls together at said last-named region, utilizing the contractile force produced by said vacuum to make a sealed joint at said last-named region.

2. The method of fabricating a vacuum-jacketed glass tube; said method comprising the step of assembling an outer glass tube with an inner glass tube; the step of fusing together adjacent walls of said tubes at a selected region to make a sealed joint of substantially annular shape; the step of evacuating the jacket space between said walls and concurrently fusing together said walls at a region spaced from said first-named joint, utilizing the vacuum in said jacket space to produce a contractile sealing effect at the locus of the last-named joint.

3. The method of fabricating vacuum-jacketed double-walled glass shapes which comprises the step of forming out of fusible material, such as glass, a shape adapted to serve as the inner wall of a vessel, conduit or vehicle for the storage or transfer of fluids, the step of forming out of similar fusible material a shape adapted to confine at least a portion of said inner wall, and thereby to serve as the outer wall of the jacketed final shape; the step of fusing together said walls at a suitable region; the step of bringing together at a remote region other portions of said inner and outer walls, and forming a hollow evacuation tip at said latter region; the step of evacuating the intramural jacket space; and the step of heating said adjacent wall-portions to the fusion point, whereby atmospheric pressure is permitted to become effective to exert a contractile force on said adjacent wall portions, bringing them into fused, sealing contact.

4. The method of fabricating vacuum-jacketed double-walled glass shapes which comprises the step of forming out of fusible material, such as glass, a shape adapted to serve as the inner wall of a vessel, conduit or vehicle for the storage or transfer of fluids, the step of forming out of similar fusible material a shape adapted to confine at least a portion of said inner wall, and thereby to serve as the outer wall of the jacketed final shape; the step of fusing together said walls at a suitable region; the step of bringing together at a remote region other portions of said inner and outer walls, and forming a hollow evacuation tip at said latter region; the step of evacuating the intramural jacket space; and the step of heating said adjacent wall-portions to the fusion point, whereby atmospheric pressure is permitted to become effective to exert a contractile force on said adjacent wall portions, bringing them into fused, sealing contact and the step of removing said tip from said last-named joint formed after evacuation.

5. The method of fabricating vacuum-jacketed double-walled glass shapes which comprises the step of forming out of fusible material, such as glass, a shape adapted to serve as the inner wall of a vessel, conduit or vehicle for the storage or transfer of fluids, the step of forming out of similar fusible material a shape adapted to confine at least a portion of said inner wall, and thereby to serve as the outer wall of the jacketed final shape; the step of fusing together said walls at a suitable region; the step of bringing together at a remote region other portions of said inner and outer walls, and forming a hollow evacuation tip at said latter region; the step of evacuating the intramural jacket space; and the step of heating said adjacent wall-portions to the fusion point, whereby atmospheric pressure is permitted to become effective to exert a contractile force on said adjacent wall portions, bringing them into fused, sealing contact and the step of removing said tip from said last-named joint formed after evacuation; and the step of finishing said last-named joint into a tipless form symmetrical with the joint formed before evacuation.

6. As a new article of manufacture, vacuum-jacketed, glass tubing comprising an inner wall and an outer wall, said inner wall surrounding an extended channel and being formed with one or more bulbous enlargements intermediate the length of the channel to permit compensation for unequal expansion as between said walls, while preserving the channel undiminished in diameter.

7. As a new article of manufacture, a generally straight vacuum-jacketed glass tubing unit comprising an inner wall and a parallel outer wall, one of said walls being formed with one or more bulbous enlargements to permit compensation for unequal expansion as between said walls, while

preserving a straight channel of undiminished diameter through the axial space defined by said inner wall.

8. The method of fabricating a vacuum-jacketed glass shape, said method comprising the step of assembling an outer glass wall with an inner glass wall; the step of fusing said walls together at a selected region and so forming there a sealed joint; the step of heating the outer wall and drawing it into proximtiy to the inner wall at a region spaced from said first-named joint; the step of evacuating the jacket space enclosed between said walls intermediate said regions; the step of making a preliminary seal in said outer tube between said second-named region and the evacuating means, and removing said tube structure from said evacuating means; and the step of fusing said walls together at said second-named region, utilizing the contractile force produced by said vacuum to make a sealed joint at said second-named region.

9. As a new article of manufacture, a generally straight vacuum jacketed glass tube unit, comprising an inner wall formed by an open ended straight wall inner glass tube and a substantially parallel outer wall formed by an outer glass tube, the adjacent ends of the walls of the tubes being joined and integral with each other, thereby forming a straight open ended channel of undiminished diameter throughout the axial space defined by said inner tube, and a vacuum jacket surrounding said channel and formed by both said tubes, said vacuum jacketed glass tube also having means serving to compensate for unequal expansion as between said walls.

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