

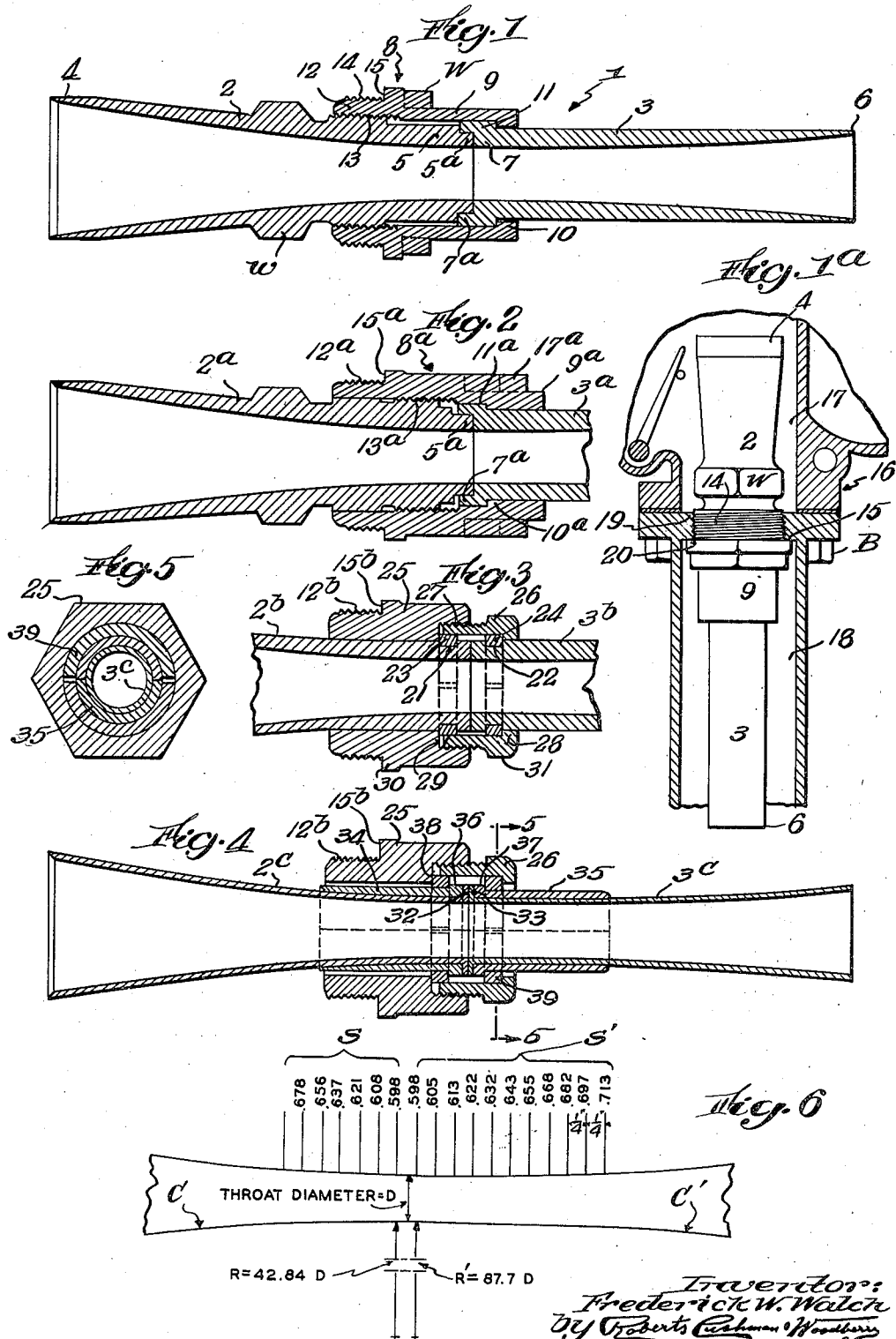
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FORGER TUBE

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FORCER TUBE

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This invention pertains to jet pumps, for example to pumps of the kind known as injectors or inspirators commonly employed to force feed water into steam boilers, and relates more particularly to an improved forcer tube for such a pump.

The patents to Walch No. 2,032,674, dated March 3, 1936, and No. 2,046,887, dated July 7, 1936, describe highly desirable forms of forcer tube. As disclosed in said patents the forcer tube comprises a receiving or combining section and a discharge or delivery section, said sections collectively defining a substantially straight, convergent-divergent passage devoid of lateral outlets from one end to the other, the sections being provided with complemental parts for securing them rigidly together at their smaller ends and with means for removably supporting the tube in the pump casing. As pointed out in said patents the high velocity fluid which flows through the forcer tube tends to erode the inner surface, particularly at any point at which the taper of the tube abruptly changes, and said patents describe means designed to prolong the useful life of the tube, for example, a wear-resistant liner at a certain point in the tube.

Wear-resistant material, for example, stainless steel, is quite difficult to machine, and the possibility, as a practical matter, of making the entire tube of such a wear-resistant substance has been seriously questioned in view of the difficulty involved in providing for the union of the tube sections and in providing a suitable mounting whereby the tube may be positioned within the pump casing. Previous methods of uniting the tube sections have also substantially precluded the use of a thin-walled tube, although, when using such an expensive material as stainless steel, a decrease in wall thickness would be desirable in order to reduce the cost of manufacture.

The present invention has for one of its objects the provision of an improved forcer tube (useful in either the axial flow or the non-axial flow type of injector) having provision for uniting its two sections and for supporting the tube as a whole, such that a minimum of machine work is required to be performed upon the tube sections themselves. Thus, if desired, a hard wear-resistant material may be used in making both tube sections, and if desired the sections may have thin walls, even including walls of drawn tube or sheet material shaped, for example, by a spinning operation.

As above noted, the wear at the inner surface of the usual forcer tube commonly first appears adjacent to a point at which the taper of the pas-

sage changes abruptly. It has commonly been the practice to bore the tube section with a series of straight tapers for convenience in machining, but where two such tapers converge, rapid wear takes place. A further object of the present invention is to provide a forcer tube having an inner surface of such contour, to wit, a substantially continuous streamline taper as to eliminate those flow conditions which appear to be responsible for localized wear, and thus greatly to prolong the life of the tube, whether or not it is made in whole or in part of wear-resistant material.

Other objects and advantages of the invention will be pointed out in the following more detailed description and by reference to the accompanying drawing wherein

Fig. 1 is a longitudinal diametrical section showing a forcer tube constructed in accordance with one desirable embodiment of the present invention;

Fig. 1^a is a fragmentary section illustrating the mounting of the tube in an injector casing;

Fig. 2 is a longitudinal section illustrating a modified construction;

Fig. 3 is a fragmentary section similar to Fig. 1, but showing a further modification;

Fig. 4 is a longitudinal diametrical section, showing a construction generally similar to that of Fig. 3, but in which the walls of the tube sections are of thin material, for example, sheet metal;

Fig. 5 is a transverse section substantially on the line 5—5 of Fig. 4; and

Fig. 6 is a diagram illustrating, merely by way of example, one desirable curvature for the bore of the tube such as to avoid the formation of eddies or other breaks in the continuity of the flowing stream which are apparently responsible for rapid localized wear.

Referring to the drawings and particularly to Figs. 1 and 1^a, the improved forcer tube 1 is shown as comprising the combining portion 2 and a delivery portion 3 which are arranged in end-to-end axial alignment thereby to provide a substantially straight passage devoid of lateral outlets from one end to the other. The combining tube 2 has a large receiving end 4 and a small end 5, while the delivery tube section has a large discharge end 6 and a small receiving end 7. The small ends 5 and 7 of the respective tube sections are provided with telescoping parts 5^a and 7^a respectively, whose meeting surfaces are preferably finished smoothly, as for example by grinding so that the smaller ends of the tubes snugly inter-

fit and so that no appreciable crack or crevice occurs at the joint between them.

For holding the tube sections 2 and 3 in proper relative position and for supporting the tube as a whole in the injector casing, there is provided a sleeve device 8, shown in Fig. 1 as comprising a substantially cylindrical portion 9 which embraces the smaller ends of the tube sections and which is provided at its right-hand end as shown in Fig. 1 with an inwardly directed flange 10 having a substantially radial abutment face which normally engages a complementary radial abutment face on a peripheral shoulder 11 of the tube section 3.

The sleeve device 8 also comprises the cylindrical portion 12 which is internally screw threaded for engagement with exterior screw threads formed on an integral part 13 of the tube section 2. The member 12 of the sleeve device is also externally screw-threaded at 14, such screw-threaded portion terminating at a shoulder having a substantially radial abutment surface 15. Preferably the sleeve device is also furnished with wrench-receiving parts W for engagement by an appropriate wrench device whereby the tube as a whole may be mounted in or removed from the injector casing.

As illustrated in Fig. 1^a, the injector casing 16, which may consist of several parts secured together, for example by bolts B, comprises the inlet chamber 17 and the outlet chamber 18 separated by an annular diaphragm member or abutment shoulder 19 which is internally screw-threaded for the reception of the screw-threaded portion 12 of the tube-supporting sleeve device. This diaphragm is provided with a radial stop surface 20 against which the radial face 15 of the sleeve device abuts when the sleeve device is in operative position in the casing. When thus mounted in the casing, the combining tube section 2 is disposed within the chamber 17 and the delivery tube section 3 is disposed within the chamber 18 of the casing. As more fully described in the patent to Walch above referred to, the casing is furnished with a removable check valve housing (not here shown) at the end of the chamber 18, and by removing this check valve housing the improved tube with its parts assembled may be introduced as a whole into the casing or removed therefrom.

The external diameter of the tube section 3 is preferably substantially uniform from its end 6 to the radial abutment face 11, and the sleeve device 8 may be slipped on to the tube section 3 at the right-hand end of the latter and moved to the left, as viewed in Fig. 1, until its flange 10 abuts the part 11. The smaller end of the tube section 2 may now be introduced into the sleeve device and by relative rotation of the section 2 and the sleeve device, the tube section 2 may be screwed into the sleeve device until its smaller end firmly abuts the smaller end of the tube section 3. For convenience in such relative rotation of the tube section 2 and the sleeve device, tube section 2 may be provided with wrench-receiving elements w.

It may be noted that very little machine work is required to be done on the tube sections 2 and 3. These sections may, for example, be die castings or drop forgings and the necessary machine work for finishing them requires little more than the proper grinding of the abutment face on shoulder 11; the grinding of the abutting surfaces of the smaller ends of the tube sections; and the formation of the screw threads

upon the part 13. It is thus possible to make both tube sections, if desired, of some hard, wear-resistant material difficult to machine, such for example as stainless steel, while on the other hand the sleeve device, which is of irregular contour including the wrench-receiving members W, may be made of some relatively soft and easily workable material, as for example cast iron, brass, or bronze.

It may further be noted that with this arrangement the entire tube structure may be removed as a unit from the injector casing and that either tube section 2 or 3 may be renewed without renewing the other, in accordance with the amount of wear shown by the respective sections.

In Fig. 2, a slight modification is illustrated wherein the tube sections 2^a and 3^a have the interengaging, telescoping portions 5^a and 7^a at their smaller abutting ends, as in the arrangement previously described. In this instance the sleeve device 8^a is somewhat longer than the sleeve device 8 of Fig. 1, and the part 9^a of this sleeve device overlaps the tube section 3^a to a greater extent, thus assuring a very rigid construction. The part 9^a of the sleeve device is furnished with the radial inwardly projecting flange portion 10^a having an abutment face for contact with the complementary abutment shoulder 11^a of the tube section 3^a. The tube section 2^a is furnished with the externally screw-threaded portion 13^a for engagement with the internal screw thread provided in the sleeve device but in this arrangement the externally screw-threaded portion 12^a of the sleeve device is spaced axially from the screw threads 13^a. The sleeve device has a shoulder or abutment face 15^a and when the sleeve device is screwed into the injector casing this abutment face 15^a constitutes a limiting stop to determine the operative position of the forced tube.

In Fig. 3, a further modification is illustrated wherein the tube sections 2^b and 3^b have their smaller ends in abutting relation but do not telescope one over the other. The smaller end portions of the tube sections are furnished with peripheral grooves 21 and 22 respectively, and these grooves receive split flange rings 23 and 24, respectively. The connecting sleeve device comprises the parts 25 and 26 which are so united that they may be moved axially with respect to each other, thus changing the effective length of the sleeve device, as for example by having interengaging screw-threaded portions, as shown at 27. The member 26 of the sleeve device is furnished with a substantially radial face at the inner side of its end flange 28 which engages the radial surface of the annulus 24, while the sleeve member 25 is furnished with a radial face 29 which engages the radial face of the annulus 23. The member 25 of the sleeve device is also provided with external screw threads at 12^b and with an abutment face 15^b for mounting it in the injector casing.

In assembling the parts of the device of Fig. 3, the members 25 and 26 being separated are first slid onto the smaller ends of the tube sections 2^b and 3^b, respectively, and then the split rings 23 and 24 are disposed in the grooves 21 and 22 thereby providing abutment shoulders. The sleeve members 25 and 26 are then brought into engagement and by relative rotation are drawn toward each other thereby forcing the rings 23 and 24 toward each other and so clamping the tube section 2^b and 3^b very firmly together in axial alignment. Preferably the parts 25 and 26

of the sleeve device are furnished with wrench-engaging elements 30 and 31 to facilitate their relative rotation and also to assist in mounting the forcer tube in the injector casing.

5 In Figs. 4 and 5 a further modification is illustrated. In these figures the tube sections 2^c and 3^c are of relatively thin material. For example, these tube sections may be made of drawn seam-
10 less tubing or, alternatively, of sheet material formed up into a tube and welded along the longitudinal joint. Since these tube sections are of thin material their exteriors taper substantially in the same way as their interiors. Such taper of these tube sections may for example be pro-
15 duced by the metal working operation known as spinning or by pressure within suitable dies or the like. If formed from drawn steel tubing the internal grain structure of these tube sections will be characteristic of drawn tubing with the fiber running longitudinally.

20 However these tube sections may be formed, they are preferably provided at their smaller ends with integral out-turned flanges 32 and 33, respectively, whose abutting radial faces may be faced off true and smooth, for example by grinding, so that there will be no appreciable crevice where the tubes join.

30 In order that the tube structure may be stiff enough and properly supported in the casing, it is contemplated that the smaller ends of the tube sections may be embraced by substantially rigid sleeve members 34 and 35, respectively, which may be as long as desired, in fact, they may extend to the ends of members 2^c and 3^c so that the latter in effect become linings. Preferably the adjacent ends of these sleeve members are furnished with radial flanges 36 and 37, respectively, between which the abutting flanges 32 and 33 of the tube sections are interposed. Preferably split annuli 38 and 39 are arranged to embrace the reinforce members 34 and 35 adjacent to the flanges 36 and 37, and these split annuli 38 and 39 are forced toward each other in assembling the tube parts by the action of a sleeve device similar to that of Fig. 3 comprising the relatively movable members 25 and 26, which have screw-threaded engagement with each other. The parts 38 and 39 constitute rigid forcer members for transmitting pressure from the parts 25 and 26 to the flanges 36 and 37, thereby to clamp the flanges 32 and 33 firmly together.

50 The reinforce sleeves 34 and 35 are split so as to facilitate their mounting upon the tube sections 2^c and 3^c after the latter have been flanged, but under some conditions it is contemplated that the reinforce members 34 and 35 might each be an integral tubular element which would be slipped over the end of its corresponding tube section before the latter was flanged.

60 In assembling the tube sections 2^c and 3^c, the flanges 32 and 33 are placed in contact, the separated members 25 and 26 are slipped over the flanged ends of the sections, the split reinforce members 34 and 35 are then put in place, the split annulae 38 and 39 are disposed over the reinforce members 34 and 35, and the sleeve members 25 and 26 are then screwed together, thus holding the parts rigidly in assembled relation and in readiness for mounting in the injector casing, it being noted that the member 25 is furnished with external screw threads at 12^b and with a shoulder at 15^b, as described with reference to the structure of Fig. 3. It is contemplated that either or both of the tube sections 2^c and 3^c may be made of some hard, wear-resistant ma-

terial, for example stainless steel or the like, while on the other hand the various parts including the reinforcing members 34 and 35 of the sleeve device may be made of some other softer and easily workable material such as brass or cast iron.

5 In the several figures of the drawing, the tube structure is illustrated as having a convergent, divergent bore, the convergent, divergent portions in longitudinal section being shown as smoothly curved from end to end, as distinguished from the series of tapers universally used heretofore as an approximation to such curvature. These smooth curves may be produced in any desired manner, as for example by a boring, reaming, or grinding operation or, in the case of the tube structure of Fig. 4, the desired curve may be produced as above suggested by spinning, or by pressure within a suitable die.

20 Merely as illustrative of the characteristics of a desired curvature but without any intent to limit the scope of the invention thereby, an approximation to a theoretically proper curvature is diagrammatically illustrated in Fig. 6. In this view C represents a portion of the inner surface of the combining tube section, and C' the inner surface of the delivery tube section. These surfaces merge at their smaller ends to form the throat which, by reason of the flatness of the curvature at this point, is approximately cylindrical. The length of this cylindrical throat portion preferably approximates $\frac{1}{40}$ the total length of the bore of the tube.

35 The proper curvature may be defined, for example, as follows, assuming that the throat diameter is D inches. Taking the radius R as the radius of curvature of the combining section, then $R=42.84D$ where the center of curvature is in a plane perpendicular to the axis of the tube at the junction of the combining tube with the throat, while the radius of curvature of the delivery tube is represented by the formula $R'=87.7D$,—the center of curvature being in a plane perpendicular to the axis of the tube and through the junction of the throat with the delivery tube.

45 As a specific example of a proper curvature arrived at in another way, and assuming a throat diameter of 0.598" and a throat length of $\frac{1}{4}$ ", then, if intervals of $\frac{1}{4}$ " be laid off along the axis of the tube, the internal diameter of the tube at such successive intervals will approximate the values indicated by the series S for the combining tube and by the series S' for the delivery tube, at least at the central part of the bore where exactitude of curvature is of great importance.

55 Such a curvature provides smooth, substantially unbroken flow devoid of eddies which for convenience may be termed "streamline" flow. As above noted, such a curve avoids localization of wear and a tube thus curved has a useful life far in excess of any tube heretofore made in which the bore consists of a plurality of distinct substantially straight tapers when following the other.

65 While certain desirable embodiments of the invention have been illustrated and described by way of example, it is to be understood that the invention is not necessarily limited to these precise embodiments, but is to be regarded as particularly inclusive of all equivalent construction, such as fall within the terms of the appended claims.

I claim:

75 1. A forcer tube for use in an injector casing of the kind which has an annular abutment

shoulder for centering and positioning the tube, the shoulder having a substantially radial stop surface, said tube comprising a convergent combining section and a divergent delivery section independent of the combining section, the smaller ends of said sections having accurately finished abutting surfaces, the sections collectively forming a continuous passage devoid of lateral outlets, and a tube-supporting sleeve device independent of but embracing the tube sections at their smaller end portions and bridging the joint between them, the sleeve device having an external shoulder constructed and arranged to engage the annular abutment shoulder of the casing, said external shoulder of the sleeve device having an abutment surface which is complementary to the stop surface of said internal shoulder with which it engages.

2. A forcer tube for use in an injector casing of the kind which has an annular abutment shoulder for positioning the tube axially, said tube comprising a convergent combining section and a divergent delivery section, said sections being coaxially arranged and collectively providing a passage devoid of lateral outlets, a supporting sleeve device independent of but concentric with at least one of said sections, the sleeve device having an external peripheral shoulder constructed and arranged to engage the abutment shoulder of the casing, said external shoulder of the sleeve device having an abutment surface which is complementary to the surface of the internal shoulder of the casing with which it engages, the sleeve device also having an element constructed and arranged to engage a cooperating part of the casing thereby to retain the sleeve and tube in place, the sleeve device also comprising parts operative to apply clamping force to the respective tube sections thereby forcibly to draw them toward each other.

3. A forcer tube for use in an injector casing of the kind which has an annular abutment shoulder for positioning the tube axially, said tube comprising a combining section and a delivery section independent of the combining section but arranged coaxially with the latter, a tube-supporting sleeve device concentric with the smaller ends of the tube sections and bridging the joint between them, said sleeve device including an inwardly directed element and one of the tube sections having a substantially radial surface with which said element of the sleeve device engages, and means reacting between the sleeve device and the other tube section to draw the tube sections axially toward one another, the sleeve device having an external shoulder provided with a substantially radial face constructed and arranged to engage a complementary stop surface of the positioning shoulder of the casing, the sleeve also having an external screw-threaded portion constructed and arranged to engage an internally screw-threaded portion of the casing, and wrench-receiving elements upon the exterior of the sleeve device.

4. A forcer tube for use in an injector casing of the kind which has an internal annular internally screw-threaded abutment shoulder having a stop surface for positioning the tube axially, said tube comprising convergent and divergent tube sections having their smaller ends telescoped one within the other and having accurately finished engaging surfaces thereby collectively to provide a passage devoid of crevices or lateral outlets, and a sleeve device independent of the tube sections and embracing the small ends

of the tube sections and having parts cooperative with the tube sections to draw the latter forcibly toward one another, the sleeve device having external screw threads adjacent to that end which overlaps the combining tube section and engageable with the internal screw threads of the abutment shoulder, the sleeve device also having an abutment surface at the forward end of said external screw threads operative to engage the stop surface of the abutment shoulder of the casing, the sleeve device also having external wrench-receiving elements.

5. A forcer tube for use in an injector casing of the kind which has an annular internally screw-threaded abutment shoulder for centering and positioning the tube, said tube comprising combining and delivery sections coaxially arranged, a tube-supporting sleeve device embracing the tube sections at their smaller ends and bridging the joint between them, said sleeve device including an inwardly directed gripper element, one of the tube sections having a substantially radial face for engagement by said gripper element, said sleeve device having an internally screw-threaded portion and the other tube section having a complementary externally screw-threaded portion engageable therewith whereby rotation of the sleeve device draws the two sections toward each other, the sleeve device having external screw threads adjacent to one of its ends for engagement with the internal screw threads of the abutment shoulder of the casing, the sleeve also having an abrupt abutment surface at the inner end of said external screw threads operative to engage the stop surface of the annular abutment shoulder of the casing, the sleeve device also having external wrench-receiving elements.

6. A forcer tube having a bore comprising a convergent combining portion and a divergent delivery portion and having a substantially cylindrical portion approximately midway its length, said cylindrical portion being approximately one-fortieth of the length of the tube, the inner surface of the convergent and divergent portions respectively of the tube each being smoothly curved in longitudinal section substantially from end to end, the curvature of the divergent portion being of greater radius than that of the convergent portion.

7. A forcer tube having a bore comprising a convergent combining portion, a divergent delivery portion, and a throat connecting the smaller ends of the combining and delivery portions, the longitudinal curvature of the inner wall of the combining and delivery portions, respectively approximating circular arcs struck on centers located in planes perpendicular to the axis of the tube at the smaller ends of the combining and delivery sections, respectively, the radius R of curvature of the combining tube being represented by the formula $R=42.84D$ where D is the diameter of the throat, and the radius R' of curvature of the delivery tube section being represented by the formula $R'=87.7D$.

8. A forcer tube having a bore comprising a convergent combining portion and a divergent delivery portion, the inner surface of each of said portions in longitudinal section being a smoothly continuous curve substantially from end to end, the radius of curvature of the delivery section being of the order of twice as great as that of the combining section.

9. A forcer tube for use in an injector casing of the kind which has an annular abutment

shoulder for positioning the tube axially, said tube comprising a combining section and a delivery section coaxially arranged, a tube-supporting sleeve device embracing the tube sections at their smaller ends and bridging the joint between them, said sleeve device having an external shoulder constructed and arranged to engage the annular abutment shoulder of the casing and comprising two relatively movable parts having screw-threaded engagement with one another whereby relative rotation of said parts varies the effective length of the sleeve device, each of said parts of the sleeve device having a substantially radial interior face, and each of the tube sections having a flange abutting the respective radial interior faces of the sleeve device.

10. A forcer tube for use in an injector casing of the kind which has an annular abutment shoulder for positioning the tube axially, said forcer tube comprising a combining section and a delivery section coaxially arranged and disposed with their smaller ends in abutting relation, a tube-supporting sleeve device embracing the tube sections at their smaller ends and bridging the joint between them, said sleeve device having an external shoulder constructed and arranged to engage the annular abutment shoulder of the casing and comprising two relatively movable parts having screw-threaded engagement with one another whereby relative rotation of said parts varies the effective length of the sleeve device, each of said parts of the sleeve device having a substantially radial interior face, and each of the two tube sections having a peripheral groove and a radially projecting flange

member seated in such groove, said flange members abutting the respective radial interior faces of the sleeve device.

11. A forcer tube for use in an injector casing of the kind which has an annular abutment shoulder for positioning the tube axially, said tube comprising a combining section and a delivery section, each of said sections having an integral radial flange at its smaller end, and tube-supporting means comprising parts operative to draw the end faces of said flanges forcibly into contact, said supporting means including an external shoulder constructed and arranged to engage the annular abutment shoulder of the casing for positioning the tube axially in the latter and an element cooperable with a corresponding element of the injector casing thereby to support the tube in operative position.

12. A forcer tube for use in an injector casing of the kind which has an annular abutment shoulder for positioning the tube axially, said tube comprising a combining section and a delivery section, each of said sections being of seamless sheet metal of substantially uniform thickness throughout and having their smaller ends juxtaposed and tube supporting means comprising a sleeve device coaxial with said tube sections at their smaller ends and including an external shoulder constructed and arranged to engage the annular abutment shoulder of the casing for positioning the tube axially of the casing and an element cooperable with a corresponding element of the injector casing thereby to secure the tube in operative position.

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