Feb. 7, 1939. F. W. WALCH 2,146,100

JET PUMP

Filed April 25, 1938

Fig. 1

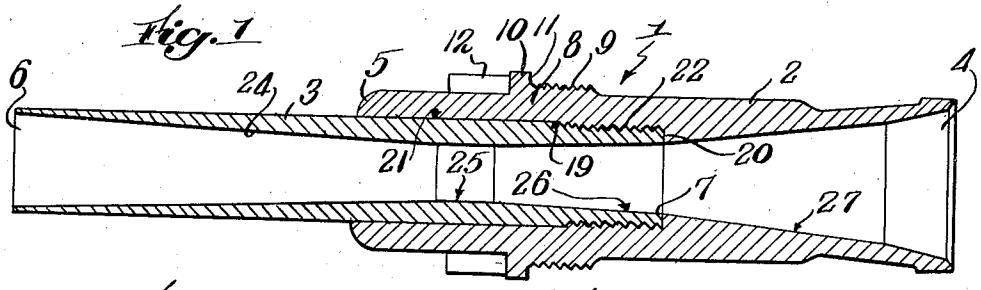


Fig. 2

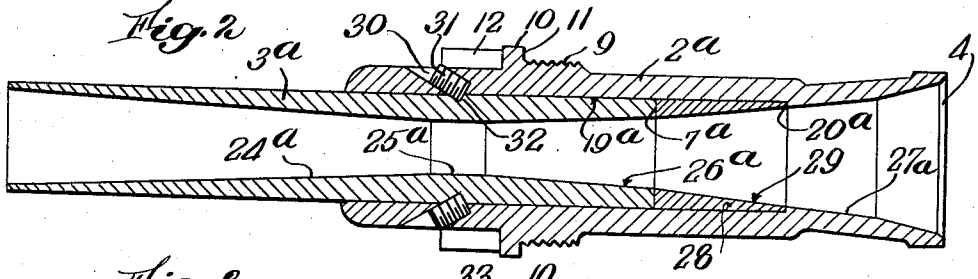


Fig. 3

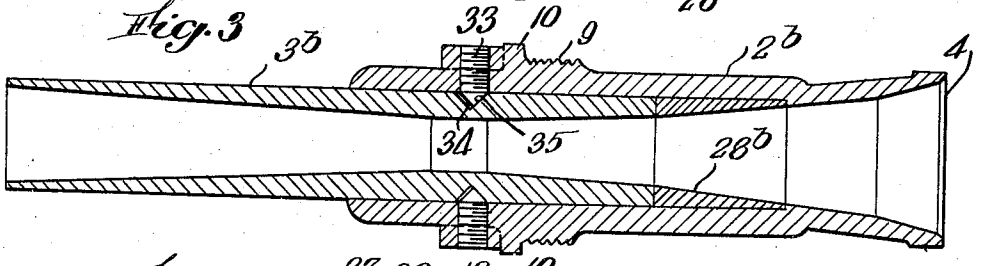


Fig. 4

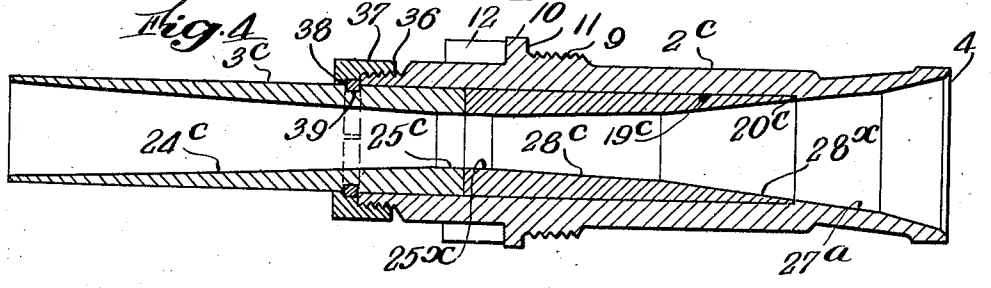
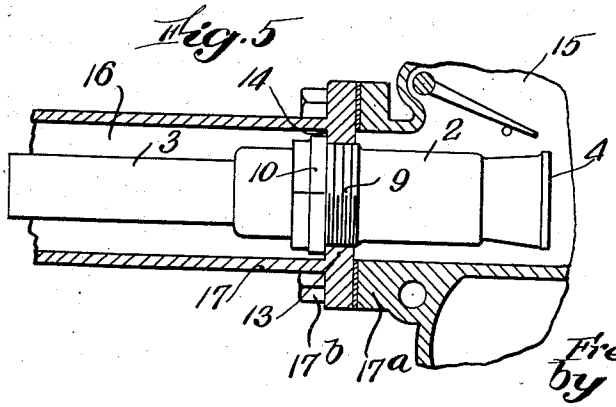


Fig. 5



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UNITED STATES PATENT OFFICE

2,146,100

JET PUMP

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Application April 25, 1938, Serial No. 204,023

14 Claims. (Cl. 103—277)

This invention pertains to steam pumps of the jet type, for example, inspirators or injectors, and relates more especially to a forcer tube structure for such a pump. The patents to Walsh No. 2,034,674, 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 bore or 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 forcer tube in the casing.

As pointed out in said patents, one of the principal difficulties encountered in the manufacture of pumps of this class is that of providing a forcer tube which will effectively resist the powerful erosive action of the water and entrained steam, such erosive action usually first showing itself at the region of the tube where the bore of the tube begins to increase in diameter, although eventually appearing wherever there is a marked change in the taper of the tube. Various expedients have been tried in the effort to increase the resistance of the tube to erosion and thereby to prolong its useful life; for example, by the use of a hard, wear-resistant lining at that part or parts of the tube where wear most frequently appears. Among the materials capable of resisting the peculiar wear conditions existing in such a tube structure, stainless steel seems to be one of the best, but stainless steel is hard and very difficult to machine.

If the wear-resistant sleeve be confined to that part of the tube at which the tube normally first begins to increase in diameter, the tube structure may resist wear at this point so long that the first wear will eventually appear at some other and unprotected point. It has been proposed to extend the wear-resistant sleeve or lining throughout a very substantial portion of the tube, for example throughout the entire length of the delivery section, or of the combining section, but to make and properly install such a long wear-resistant lining is troublesome and expensive. Accordingly it has been suggested that the entire tube structure, or at least the entire combining or the entire delivery tube section, might be made wholly of the wear-resistant material. However, as already noted, stainless steel and materials of similar characteristics are hard, brittle and very difficult to machine, and to make an entire tube section and properly to connect it with a complemental tube section in such a way as to ensure accurate alignment; the avoidance of leaks; and adequate resistance to breakage when the parts are subjected to prolonged and violent vibration, present a mechanical problem which has not heretofore been successfully solved.

In particular it has been noted that when the delivery section is made of hard metal and screwed into a threaded socket in the end of the combining tube section, the longitudinal stress set up in the threaded portion of the delivery section, when the parts are screwed up firmly enough to provide a leak-tight joint, so weakens the metal that the constant vibration to which the unsupported forward end of the delivery tube is subjected during use soon causes the delivery tube section to crack at its junction with the combining tube.

A principal object of the present invention is to provide a forcer tube in which a very substantial portion of the length of the bore of the tube has a surface of hard wear-resistant material. For instance, the entire delivery section may be made of this material but with provision for so uniting the parts of the tube as to minimize the effect of vibration as well as to provide a leakproof joint, all in a practical and commercially feasible construction.

A further object is to provide a forcer tube in which the wall of the throat portion, as well as the walls of the combining and delivery portions for substantial distances at opposite sides of the throat, are of wear-resistant material and continuous, that is to say, these several portions of the bore are formed in a single integral piece of wear-resistant metal.

A further object is to provide a forcer tube wherein the major portion of the length of the wall of the bore is of hard wear-resistant material, although that portion of the tube which engages the injector casing thereby to support the tube as a whole in operative position, is of a soft or at least readily workable material.

A further object is to provide means whereby a hard wear-resistant tube section or member may be securely connected in leakproof relation to the other tube section or part with a minimum amount of machining of the hard section or member. Other and further advantages of the invention will be made manifest in the following more detailed description and by reference to the accompanying drawing wherein:

Fig. 1 is a longitudinal section through a forcer tube made in accordance with a preferred embodiment of the invention;

Figs. 2, 3 and 4 are similar longitudinal sections illustrating modified constructions; and

Fig. 5 is a fragmentary vertical section through the casing of an injector or similar pump illustrating the manner of mounting a tube, such for example as illustrated in Fig. 1, in operative position within the casing.

Referring to the drawing, the numeral 1 designates the complete forcer tube structure comprising the combining tube section 2 and the delivery tube section 3. The combining tube has the wide or rear end 4 and the small or forward end 5, while the forward end of the delivery tube is indicated at 6 and its rear end at 7.

Near its forward end the combining tube is provided with a portion 8 of somewhat greater external diameter than the body of the tube, this portion 8 having external screw threads 9 for engagement with an internally screw-threaded support forming a part of the injector casing. The combining tube is also furnished with a peripheral flange 10 having a radial shoulder 11 which constitutes a stop for engagement with a part of the injector casing, thereby to limit movement of the tube structure as it is screwed into place, and to provide a leakproof joint with the surface of the casing with which it engages. To facilitate the mounting of the tube structure in the casing, the combining tube section 2 may be provided with angular faces 12 or the like, designed for engagement by a wrench or other suitable tool. It is contemplated that the combining tube section 2 will be made of some material which may be worked readily, for example, bronze, so that the screw threads 9, the shoulder 11, and the wrench-engaging surfaces 12 may be formed without too much difficulty or expense.

In Fig. 5 the improved forcer tube is shown, for example, as mounted in an injector casing, the latter having a transverse septum 13 having a radial surface 14 with which the shoulder 11 of the forcer tube engages when the tube is mounted in position. A septum 13 separates the inlet chamber 15 of the casing from the outlet chamber 16. As illustrated, the casing comprises separable parts 17 and 17^a, united by bolts 17^b, but the particular style of casing employed is immaterial so long as it is provided with an internally screw-threaded support having a stop surface with which the shoulder 11 may engage.

The smaller or forward end 5 of the combining tube is furnished with a substantially cylindrical bore 19 which provides an elongate socket for the reception of the rear end of the delivery tube section 3. This socket terminates at an abrupt radial shoulder 20 which constitutes a stop for the inner end of the delivery tube section, the latter being substantially cylindrical and fitting snugly within the socket 19. Adjacent to its inner or rear end the outer surface of the delivery tube section 3 is furnished with screw threads 22 which engage screw threads in the wall of the socket at the inner end of the latter, thereby to secure the delivery tube to the combining tube. Preferably the socket is of a depth of the order of one-half the entire length of the delivery tube and when the delivery tube is mounted in the socket with its rear end engaging the shoulder 20, the forwardly extending portion of the combining tube, beyond the screw threads 22, constitutes a supporting sleeve for the delivery tube section which prevents any possibility of breakage of the delivery tube adjacent to its screw-threaded portion. In this connection it may be noted that the smooth cylindrical outer surface of the delivery tube is designed to fit with a very snug fit into the long unthreaded portion of the socket so as to eliminate any possibility of relative transverse movement of the tube within the socket. Thus any stresses which may be set up in the delivery tube in forming the threads 22 or in screwing it into the combining tube will not be harmfully increased by vibration to which the tube structure may be subjected, and any tendency for the delivery tube to crack off near its inner end is avoided.

In accordance with the present invention it is proposed to make the entire delivery tube section 3 of some very hard wear-resistant material such as stainless steel, but as above noted, attempts to use such a material, which is quite brittle, have heretofore met with little success by reason of the tendency of the hard tube to break off at its connection with the combining tube. The present invention, by providing the delivery tube with a long tight-fitting supporting sleeve, avoids this difficulty.

As illustrated in Fig. 1, the bore of the delivery tube includes the entire divergent portion 24 of the passage through the tube structure, the cylindrical throat portion 25, and also a portion 26 of the convergent part of the passage,—the remainder 27 of the convergent part being formed in the combining tube 2. Thus the most pronounced changes in direction of flow take place within the material of the delivery tube which is hard and wear-resistant so that the life of the tube is greatly prolonged as compared with ordinary tube structures.

In Fig. 2 a modified construction is illustrated wherein the delivery tube 3^a is connected to the combining tube 2^a without requiring that the delivery tube be screw threaded. In this arrangement the combining tube is provided with a deep socket 19^a similar to that above described, but the socket is even deeper, extending throughout substantially three-fourths of the length of the combining tube and terminating at the shoulder 20^a. The delivery tube 3^a includes that portion 24^a of the passage which is divergent, the cylindrical throat portion 25^a and a portion 26^a of the convergent part of the passage. However, the delivery tube does not extend to the bottom of the socket but there is interposed between its inner end and the bottom of the socket a sleeve 28 also of wear-resistant material. This sleeve provides a second passage 29 of the convergent portion of the passage, while the remainder 27^a of this convergent portion is in the combining tube section itself. By this arrangement the wear-resistant material is extended even further than in the arrangement of Fig. 1, but by the use of the separate sleeve or liner 28 the operation of providing several of the successive tapers which usually make up the convergent portion of the passage, is made somewhat easier than though they were all to be formed in the delivery tube section itself.

The rear or inner end of the delivery tube section (Fig. 2) has the radial face 7^a which engages the forward end face of the sleeve 28, the latter forming a stop for the delivery tube. To hold the latter in place in its socket, the combining tube is provided with one or more bores 30 (of small diameter as compared with the tube itself) extending from its outer to its inner surface, such bore or bores being inclined inwardly and rearwardly and being internally screw threaded for the reception of set screws 31. The inner ends of these set screws seat in recesses 32

formed in the outer surface of the delivery tube. By this arrangement the outer surface of the delivery tube may be made cylindrical from end to end, with the exception of these slight recesses which may be formed by grinding, for example, and which do not substantially weaken the structure of the delivery tube. The arrangement of the set screws is such as to force the delivery tube rearwardly and thus to form tight joints at the points 7^a and 20^a.

In the arrangement shown in Fig. 3, which is in general quite similar to that of Fig. 2, the screw-threaded bores formed through the wall of the combining tube are radial and receive set screws 33 having conical tips 34 which engage conical recesses of somewhat larger diameter in the delivery tube section 3^b, the conical tips of the set screws engaging these recesses at their rear sides so as to force the delivery tube rearwardly.

In the arrangement shown in Fig. 4, the combining tube 2^c has the elongate socket 19^c terminating at the radial shoulder 20^c, the socket being of about the same depth as that shown in Fig. 2. In this instance the delivery tube 3^c is shorter than in the arrangements previously described and provides only the divergent portion 24^c of the passage and a part 25^c of the throat of the passage. The remainder $25^\times$ of the throat, as well as portions 23^c and $23^\times$ of the convergent part of the passage, are formed in a long wear-resistant liner sleeve 23^c having a radial face at its forward end against which the rear end of the delivery section abuts to make a tight joint. In this case the joint comes at about the middle of the throat where there is no outward pressure, so that possibility of leakage at this point is eliminated. For holding the delivery tube section in place, the extreme forward end of the combining tube is reduced in diameter at 36 and externally screw threaded for the reception of a clamping sleeve 37 having an internal radial flange 38 which is designed to engage a split ring 39 set into a peripheral groove in the delivery tube section 3^c. Such a groove may readily be formed even in such hard material as that of the delivery tube, and the ring 39 forms an abutment shoulder for engagement by the clamping sleeve 37 whereby the delivery tube section and the lining section 23^c maye be firmly clamped in position within the combining tube. This arrangement, like those shown in Figs. 2 and 3, provides a forcer tube structure having a hard wear-resistant lining extending throughout the greater part of its length, although that part of the tube structure which carries the elements (for example parts 8, 9, 10, 11 and 12) by which it is mounted in the injector casing may be of a softer and more easily workable material.

While certain desirable embodiments of the invention have been illustrated by way of example, it is to be understood that the invention is not necessarily limited to these precise embodiments or to the details disclosed, but is to be regarded as broadly inclusive of all equivalent constructions such as fall within the terms of the appended claims.

I claim:

1. A forcer tube comprising a combining section and a unitary delivery section, said sections, when assembled, forming a continuous convergent-divergent passage devoid of lateral outlets, the combining section being provided with means for mounting it in an injector casing, the delivery section being of substantially uniform external diameter from end to end and being socketed for approximately one-half its length within the substance of the combining tube, and means removably uniting the tube sections.

2. A forcer tube comprising a combining section and a delivery section, said sections when assembled forming a continuous convergent-divergent passage devoid of lateral outlets, the combining section being provided with means for mounting it in an injector casing, the rear end of the delivery tube fitting snugly within an axial socket in the combining tube to a depth of the order of one-half the entire length of the delivery tube, and means at the rear end portion of the delivery tube for connecting it to the combining tube section.

3. A forcer tube comprising a combining section and a unitary delivery section of a hard wear resistant material throughout, said sections, when assembled, forming a convergent-divergent passage, the combining tube section being of a material which is readily machined and being provided with means for mounting it in an injector casing, the bore of the combining tube section having an elongate substantially cylindrical portion of a length which is at least one-half the entire length of the combining tube section, said cylindrical portion of the bore constituting a socket for the reception of the rear end of the delivery tube section, said rear end of the delivery tube section being of such shape and dimensions as to fit snugly within said socket, and means removably securing the delivery tube section in associated relation with the combining tube section.

4. A forcer tube comprising a combining section and a unitary delivery section, said sections, when assembled, forming a continuous convergent-divergent passage devoid of lateral outlets, the combining section being provided with means for mounting it in an injector casing, the delivery section being of substantially uniform external diameter from end to end and being socketed for approximately one-half its length within the substance of the combining tube, the inner end portion only of the socket being screw threaded, said delivery section having external screw threads adjacent to its inner end only for engagement with the screw-threaded portion of the socket and having a smooth outer surface such as snugly to engage the unthreaded portion of the socket wall.

5. A forcer tube comprising a combining section and a delivery section, said sections, when assembled, forming a convergent-divergent passage, the combining tube section being provided with means for mounting it in an injector casing, the bore of the combining tube section having an elongate substantially cylindrical portion constituting a socket for the reception of the rear end of the delivery tube section, the latter section being substantially cylindrical from end to end and having its rear end portion fitting snugly within the socket, the inner end portion only of the socket being screw threaded and the inner portion only of the delivery tube section being screw threaded for engagement with the threaded part of the socket, the major portion of the length of the socket having a smooth wall and the delivery section having an unthreaded portion of substantial length which fits snugly in said smooth walled part of the socket.

6. A forcer tube comprising a combining section and a delivery section, said sections, when assembled, forming a continuous convergent-divergent passage devoid of lateral outlets, the combining section being provided with means for mounting

it in an injector casing, the bore of the combining tube section having a substantially cylindrical portion extending from the forward end of the section for a distance of the order of at least one-half the length of the tube toward its rear end, said cylindrical portion constituting a socket for the rear end of the delivery tube section, the delivery section being cylindrical and of substantially uniform external diameter from end to end and fitting snugly within said bore, means constituting a stop for limiting movement of the delivery section into the socket, and securing means operative to exert force tending to move the delivery section into engagement with said stop means.

7. A forcer tube comprising a combining section and a delivery section, said sections when assembled forming a continuous convergent-divergent passage devoid of lateral outlets, the combining section being provided with means for mounting it in an injector casing, the rear end of the delivery tube fitting snugly within an axial socket in the combining tube to the depth of the order of one-half the entire length of the delivery tube, the combining section having a screw-threaded bore of relatively small diameter leading from its outer surface into the socket, and a threaded clamping element engaging said bore, the smooth cylindrical part of the delivery section having a recess for engagement by the inner end of said clamping element.

8. A forcer tube comprising a combining section and a delivery section, said sections, when assembled, forming a continuous convergent-divergent passage devoid of lateral outlets, the combining section being provided with means for mounting it in an injector casing, the bore of the combining section having an elongate, substantially cylindrical portion constituting a socket for the reception of the rear end of the delivery section, the latter section fitting snugly within the socket, the delivery section comprising the entire divergent portion of the passage and also the smaller end portion of the convergent part of the passage, the combining section having a screw-threaded bore of relatively small diameter leading from its outer surface into the socket, the axis of said bore being inclined toward the bottom of the socket, and a set screw engaging said threaded bore, the cylindrical surface of the delivery section having a recess for engagement by the inner end of said set screw.

9. A forcer tube comprising a combining section and a unitary delivery section of a hard wear-resistant material throughout, said sections, when assembled, forming a convergent-divergent passage, the combining section being of a material which is readily machined and being provided with means for mounting it in an injector casing, the bore of the combining section having an elongate substantially cylindrical portion of a length which is at least one-half the entire length of the combining section, said cylindrical portion of the bore constituting a socket for the reception of the rear end of the delivery section, said rear end of the delivery section being of such shape and dimensions as to fit snugly within the socket, the forward end of the combining section being externally screw threaded, a threaded clamping ring engaging said threaded end portion of the combining section, and means carried by the delivery section for engagement by said clamping ring whereby rotation of the clamping ring, relative to the first section, draws the end portion of the delivery section axially into the socket.

10. A forcer tube comprising a combining section and a delivery section, said sections, when assembled, forming a continuous convergent-divergent passage devoid of lateral outlets, the combining section being provided with means for mounting it in an injector casing, the delivery tube section being of a hard wear-resistant but brittle material subject to breakage when exposed to vibration, and connecting means for uniting the combining and delivery tube sections, the combining tube section comprising means external to the delivery tube section for supporting the delivery tube section for a substantial part of the length of the latter forwardly of the location of the connecting means.

11. A forcer tube comprising a combining section and a delivery section, said sections, when assembled, forming a continuous convergent-divergent passage devoid of lateral outlets, the combining section being provided with means for mounting it in an injector casing, the delivery tube being of a wear-resistant material subject to breakage when exposed to vibration, and means connecting the inner end of the delivery tube to the combining tube, the combining tube comprising rigid means which externally engages the delivery tube at a point substantially spaced, in a forward direction, from the connecting means.

12. A forcer tube comprising a combining section and a delivery section, said sections, when assembled, forming a continuous convergent-divergent passage devoid of lateral outlets, the combining tube section being provided with means for mounting it in an injector casing, the bore of the combining tube section having an elongate, substantially cylindrical portion, constituting a socket for the reception of the rear end of the delivery tube section, the latter section fitting snugly within the socket, the delivery tube section comprising the entire divergent portion of the passage and also the smaller end portion of the convergent part of the passage, and means spaced rearwardly from the forward end of the combining tube for removably securing the delivery section within the socket.

13. A forcer tube comprising a combining section and a unitary delivery section of wear-resistant material and being of substantially uniform external diameter from end to end, said sections, when assembled, forming a convergent-divergent passage, the combining tube section being of a material which is readily machinable and being provided with means for mounting it in an injector casing, the bore of the combining tube section having an elongate substantially cylindrical portion constituting a socket for the reception of the rear end portion of the delivery tube section, the bore of the delivery tube section defining the entire divergent portion of the passage as well as the throat portion and also the smaller end of the convergent portion of the passage, the major part, at least of the length of the delivery tube which engages the socket having a substantially smooth exterior surface which fits snugly against the wall of the bore.

14. A forcer tube comprising a combining section and a one-piece delivery section of substantially uniform external diameter from end to end, said sections, when assembled, forming a convergent-divergent passage, the combining tube section being provided with means for mounting it in an injector casing, the bore of the combining tube section having an elongate substantially

cylindrical portion constituting a socket for the reception of the rear end portion of the delivery tube section, the bore of the delivery tube section defining the entire divergent portion of the passage as well as the throat portion and also the smaller end of the convergent portion of the passage, a wear-resistant lining fitting within the rear end of the socket and having an axial bore which provides another portion of the convergent part of the passage, and means for securing the delivery tube section in the socket.

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