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BY A. P. C.

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PIPE LINE SYSTEMS

Filed June 9, 1939

Serial No.

278,373

2 Sheets-Sheet 1

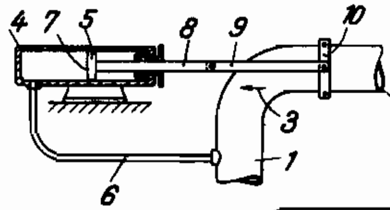

Fig. 1

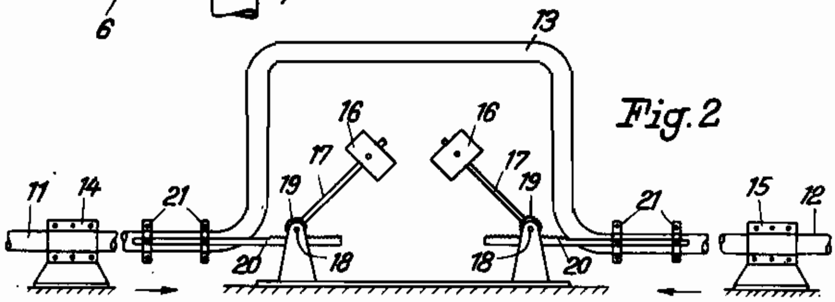

Fig. 2

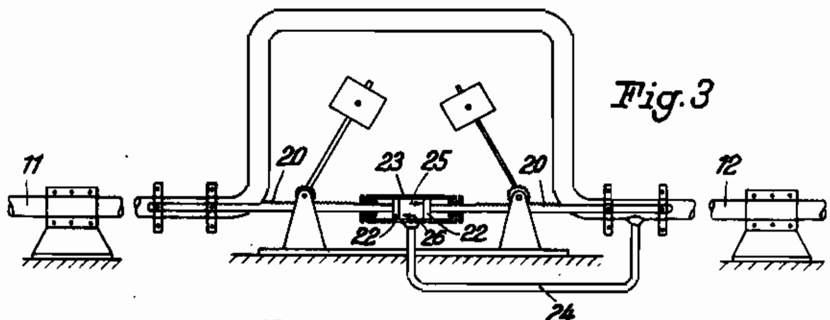

Fig. 3

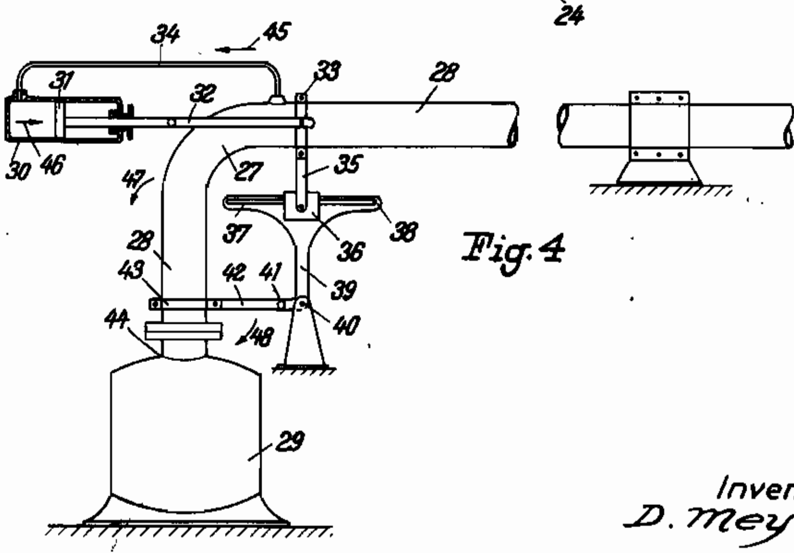

Fig. 4

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Fig. 5

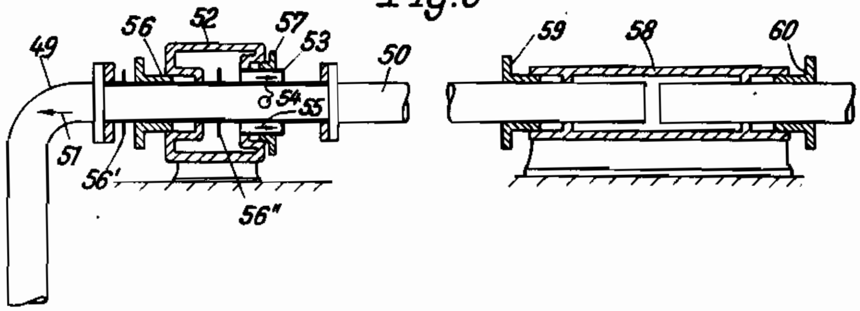


Fig. 6

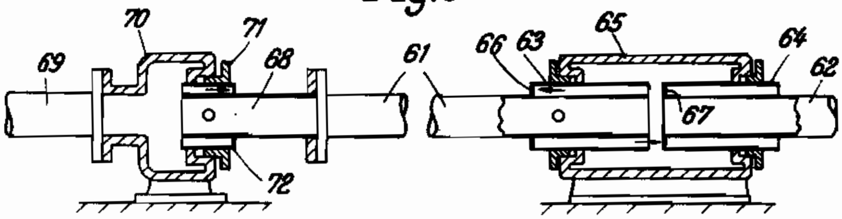


Fig. 7

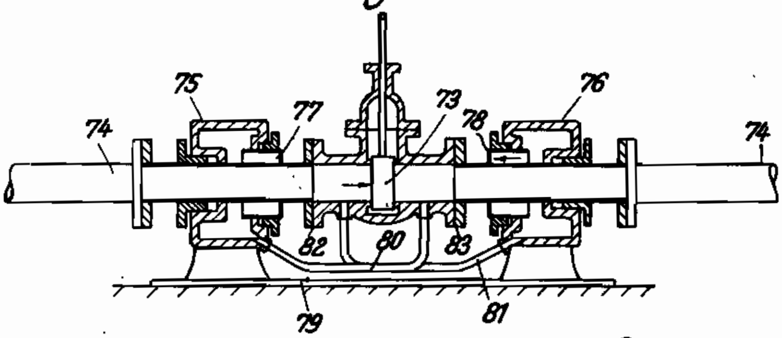


Fig. 8

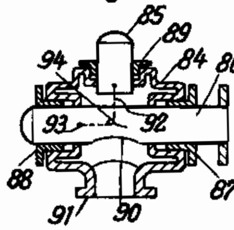
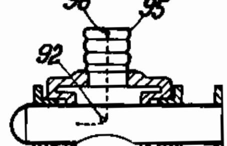


Fig. 9



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PIPE LINE SYSTEMS

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This invention relates to hollow bodies, such as, tube, pipe lines, containers and the like for conducting and/or receiving etc. fluids under pressure or heated fluids.

In such structures some components, and more particularly the joints which, for instance, in pipe lines, may be flange-, sleeve- or welded joints, also bends, compensators and the like, represent weak points of the structure. The joints must be made so that a reliable packing is ensured in operation and under any conditions. Particular difficulties arise with fluids under high pressure, e. g., in the conducting of very high pressure steam or the like and also where larger pipe diameters are in question. High temperatures which frequently occur at the same time also influence the strength etc. of the material in an unfavourable manner and cause displacements and expansions at the same time.

The difficulties are the more important, since the joints not only serve to provide a packing between the hollow bodies or pipe lines but they serve also to transfer axial forces occurring in the pipes. This is due to the fact that the forces occurring at various points of the pipe lines, e. g. the pressure forces acting upon sluice valves or upon the bends mostly are taken up only at a large distance from the points where they arise, by corresponding reaction forces, e. g., at fixed points. For example, stuffing box compensators with balance are known for the compensation of heat elongations, in which the forces produced by the balancing device have to be conducted for a long distance through the pipe lines proper, since the primary forces which have to be compensated generally arise at a substantial distance from the heat elongation compensators. The matter is similar with respect to bend compensators etc.

The difficulties become very large where the pipe lines, or tubes, in order to prevent their sagging, are additionally held under tensile strain over a large or their entire length. This requires extremely large forces which act upon the whole pipe.

It has been attempted to meet the aforementioned large difficulties, occuring, for instance, with respect to the joints, the flange connections or the like, by a particular construction of the components, such as the flanges, packings, bolts and nuts, and by a particular reinforcement of the welded seams by fish-plates, sleeves and the like; however, the success was small or even the disadvantages of the expensive and inconvenient special constructions preponderated or prevented their application.

The invention is substantially characterised by the feature that means for taking up the axial forces, bending moments and the like are provided immediately at or near the respective points of attack of the forces, so that the hollow body (i. e., for instance, the pipe line) over the greatest part of its length shows no tensions due to these forces or bending moments, and that the components of the pipe, such as joints etc. do not have to take up and to transfer such forces. The above mentioned forces or bending moments may be due to the pressure of the fluid under pressure, for instance, at bending or shut-off points or may be caused by heat effects, e. g., expansions. According to the invention all these forces as far as possible are compensated at the point where they are produced or they are counter-acted at this point. To this end, there may be provided such devices that the axial forces or bending moments due to the pressure and due to the temperature are compensated or balanced by a force or moment which is equal to the resultant of the two forces or bending moments.

It will be understood that due to the said provisions the design of all parts of the pipe line including the joints is substantially facilitated with respect to the stresses to be taken up. In the case of flange joints, the danger of overstressing is substantially reduced and it is possible to use less screw bolts or bolts of a smaller cross section for the same cross sectional stress as in the known cases. Where the joints are made by welding, the stress in the welds is reduced and the danger of the production of cracks and the like is decreased. Safety devices for welded seams are no more required. The stress on flanges is reduced or the same may be made smaller; leakages and disturbances of service are eliminated.

According to a further feature of the invention, points of attack or pressure forces which are not required to be slidable are made as fixed points. On the other hand, points of attack which must be movable are provided with mechanical devices for the positive transfer of counter-forces. Where the primary stresses are due to the pressure of the working fluid, the counter-forces to be produced may be made dependent on the working fluid by direct action of the working fluid or through the agency of another matter, or the working fluid may be used as a control agent.

The balancing forces may be produced as forces of a predetermined magnitude, e. g., in the moment where the loading force has reached a predetermined magnitude, or they may be made variable, to increase and decrease with the loading forces. For certain purposes it may be advantageous that an advance or lagging or a difference of the magnitude of the balancing forces with respect to the loading forces is provided, so that, for instance, a tension of a desired amount remains in the pipe line which may serve to counter-act frictional forces or the like.

Annular pistons or plungers or tubular pistons or lentiform members or bellows, as known per se may be provided as means for the balance of the forces produced by the working fluid.

Particular balancing means may be preferably provided on bends if the same are to be yielding, or on resilient compensators for heat expansion. In such compensators the resilient reaction forces and, in the case of the construction of these compensators in a U-shape or lyre-shape, the pressure forces produced at the ends of the compensators can be balanced.

Where the various possible loading forces are taken up at their points of attack, in accordance with the invention, by making such points of attack as fixed points or by the provision of special balancing devices, simple stuffing box type compensators without any balancing device may be used to compensate heat expansions. Such simple stuffing box compensators have the advantage over the so-called balanced compensators that the number of the stuffing boxes is less and partly also they are smaller and, as a result, the frictional forces occurring due to the sliding motion of the inner pipe in the outer pipe of such stuffing box compensators are smaller.

It will thus be clear from the foregoing that it is an important object of the present invention to relieve or balance the pipe line, the various pipe parts and more particularly their joints with respect to stresses, more particularly, tensile stresses. A further object of the invention is to make the relieving or counter-forces larger than the original or primary forces so that an excess of pressure forces is produced in the pipe line. These excessive pressure forces render it possible to make the pipe parts and the joints with still further reduced dimensions of their parts. Advantageously also in this case the counter-forces are made dependent on the primary forces, both as to their magnitude and as to their temporal relation.

Of course, where additional pressure forces are applied, care must be taken that the pipe line is sufficiently safe against buckling. In many instances the free bearing points and the bearing points which are required anyhow are sufficient for this purpose.

Where the application of additional pressure forces, i. e., an over-compensation is desired, it will be advantageous, generally, to provide special balancing devices for the production of over-dimensioned counter-forces in dependence on the primary forces, also at the points of attack of pressure forces which according to the preceding statements are made as fixed points. Thus, for instance, in sluice valves a device for the application of the counter-force may be provided on either side. Such a device preferably consists of a stationary casing surrounding the pipe line and an annular piston which is slidable therein and secured to the pipe line and has a larger cross-section than the interior cross-section of the pipe. In order to prevent the production of any tensile forces also between the balancing devices on both sides, the device on the left hand side of the shut-off valve may be connected to the right hand pipe and the device on the right hand side may be connected to the left hand pipe. Similar devices may also be desirable at the fixed points of systems operating with a simple balance and without over-balance. In this case, the cross-section of the annular piston will be made equal to the inner cross section of the pipe line.

In case of over-compensation the stuffing box compensators, if any, are so formed that the inner pipes are provided with annular pistons and enter into the compensator casing.

The invention will be better understood by reference to the following detailed description in connection with the accompanying drawing showing by way of example and purely schematically some embodiments of the invention, viz—

Fig. 1 is a side elevation, partly in an axial section, of a quarter bend or elbow pipe including an associated balancing device for the positive transmission of a balancing or relieving force.

Fig. 2 is a side elevation of a U-shaped bow including means for the compensation of the reaction forces due to heat expansion.

Fig. 3 is a side elevation, partly in an axial section, of a compenasting device similar to Fig. 2, including an additional device for compensating the pressure forces occurring on the ends of the bow.

Fig. 4 is a side elevation and partial axial section of a quarter bend connected to a vessel and including devices for the compensation of axial forces and bending moments.

Fig. 5 is a fragmentary axial section of a pipe line provided with a bend and a stuffing box compensator and including a device for balancing the pressure force occurring on the bend.

Fig. 6 is a fragmentary axial section of a pipe line including two different types of compensators for heat elongation and means associated therewith for applying additional compressive forces.

Fig. 7 is an axial section of a sluice valve including devices on both sides for the application of balancing or over-balancing forces.

Fig. 8 is an axial section of a bend or angle piece including balancing plungers and

Fig. 9 is a section of a modification of Fig. 8.

Similar reference numerals denote similar parts in the different views.

Referring now to the drawings in greater detail, and first to Fig. 1, it will be seen that the pipe line **2** is acted upon, the direction indicated by the arrow **3**, by a force which is produced by the fluid under pressure in the pipe, due to the bend **1** provided in the pipe. A cylinder **4** and piston **5** slidable therein are provided for compensating or balancing this force. The cylinder **4** is mounted stationarily and its rear end is connected, through a pipe **6**, with the pipe line, so that the fluid under pressure acts upon the rear face **7** of the piston **5**. The latter is connected, through a rod system **8**, **9** which may have a slide bar if desired, with a clamping member **10** secured to the upper side of the bend **1**.

The cross section of the cylinder corresponds to the interior cross section of the pipe so that the piston **7** is acted upon by the fluid under pressure with a balancing force of the same magnitude as that of the primary force or stress acting upon the inside of the bend in an opposite direction. Hence, said primary force is prevented from producing stresses of the pipe line **2** outside the region defined by the arrow **3** and the clamping member **10**.

It may be desirable in case of certain working fluids, e. g., steam or aggressive or corrosive agents, that the cylinder 4 is acted upon by a different fluid which is not hot or not aggressive. To this end, the cylinder may be filled with a stopping or shut-off liquid, such as, condensed water, oil of high resistivity against temperature and the like. The piston 7 may then be provided with a simple collar or stuffing box type packing and the fluid under pressure may act upon the piston through the stopping liquid. Similar indirect action of the working fluid may be effected through the agency of serpentine pipes or cooling serpentines, steam traps, diaphragms or the like.

Referring now to Fig. 2, a U-shaped bow 13 is provided in the pipe 11, 12 for the compensation of heat elongations in the pipe. The pipe 11 is fixedly mounted at 14 and the pipe 12 is fixedly mounted at 15. It will be understood that when a hot working fluid, such as, steam, passes through the pipe, the same expands and the compensating device 13 is compressed. As a result, reaction forces are produced therein which act upon the pipe lines 11 and 12.

In order to balance these reaction forces, each of the two pipes 11 and 12 is provided with a relieving or balancing device consisting of a weight 16 on a lever 17 which is swingable together with a pinion 19, about a stationary pivot 18. A rack 20 which engages the pinion 19 is connected with clamping members 21 mounted on the respective pipe lines. Thus, the left hand weight 16 through the pinion and rack exerts a push or pull upon the pipe line 11, depending on the inclination of the lever 17 which is adjusted in such a manner that the reaction force exerted by the balancing device 13 is compensated to a great extent with respect to its effect upon the pipe 11. In the position of the lever as shown it is assumed that the balancing device 13 has been mounted with a negative bias, i. e. in a spreaded state. Due to this negative bias, the pipe lines 11 and 12 are stressed by the bow 13 already in an inoperative condition and in order to balance this stress, the levers have been arranged in the position as shown. In case of a heat elongation due to rising temperature, the levers will be swung in the direction towards their vertical position and, as they have reached the same, there are no more forces exerted upon the ends of the bow 13 by the weights 16. Advantageously, the parts are adjusted in such a manner that this position is reached when the bow is without tension, i. e., when the negative initial tension or bias is neutralized. With further heat elongation, the levers 17 will be moved into positions where they are oppositely inclined and exert tensile stresses upon the pipe lines for balancing the pressure forces exerted by the bow 13. As a result, the pipes 11 and 12 will not be stressed by the bow as in the case of arrangements without the balancing devices 16—21.

Fig. 3 shows the same arrangement of pipe lines with a U-shaped bow as in Fig. 2, but comprising additional means for balancing the pressure forces produced by the working fluid under pressure due to the bend in the pipes 11, 12. To this end the racks 20 are provided at their free ends with pistons 22 which are slidable in a common cylinder 23, connected, about midway between its ends, and through a pipe line 24, with the pipe 12 so that the pressure existing in the pipe 12 acts directly also between the two pistons 22. Accordingly, the fluid under pressure in the cylinder 23 produces forces in the direction of the arrows 25 and 26, which forces correspond in magnitude to the forces occurring on the bends. As a result, the pipes 11 and 12 are relieved from the axial forces produced by the spring action of the bow 13 as well as from the forces produced by the pressure of the working fluid.

Fig. 4 shows an arrangement in which means are provided for balancing both, the axial forces occurring at the bend 27 of the pipe line 28 and the bending moments occurring due to heat expansion at the point where the pipe line is connected to a vessel 29. The pressure force set up by the action of the fluid pressure upon the bend is balanced by a device similar to that shown in Fig. 1, comprising a cylinder 30 and a piston 31 which is slidable therein and connected, by means of a rod system 32, with a clamping member 33 fixedly secured to the pipe 28 near the bend 27. The rear end of the cylinder 30 communicates with the main pipe 28 through a small tube 34. The clamping member 33 is provided with a downwardly projecting arm 35 acting upon a weight 36 which is slidable in a cross slot formed in two lateral extensions 37, 38 of a vertical arm 39 of a two-armed lever which is swingable about a stationary axis 40. The horizontal arm 41 of the two-armed lever is pivotally connected at 41′ to an arm or stud 42 of a clamping member 43 fixedly mounted on the pipe 28 near the point 44 where the same is connected to the vessel 29.

It will now be clear that the force exerted by the fluid pressure at the bend 27 in the direction of the arrow 45 if the pipe line is under action of a hot fluid under pressure is balanced by a force exerted by the piston 31 in the direction of the arrow 46. The piston 31 acts independently from the heat elongation of the pipe line 28 due to the temperature of the working fluid and due to this heat elongation, a bending moment is produced at 44, in the direction of the arrow 47. This bending moment, however, is also balanced since on displacement of the member 33 and arm 35 to the left due to heat elongation the weight 36 is displaced in the lever arm 39 towards the extension 37, whereby a moment is exerted with respect to the pivot 40 in such a manner that the force exerted upon the arm 42 by the lever arm 41 is downwardly directed and causes a counter-moment in the direction of the arrow 48, oppositely to the arrow 47 which indicates the original moment due to heat expansion. The larger the heat elongation is, the larger is the bending moment exerted in the direction of the arrow 47, but the larger is also the counter-moment exerted in the direction of the arrow 48, whereby a complete balance may be effected under any working conditions.

The extension 38 at the lever arm 39 permits the production of a counter-moment in an opposite direction. This possibility is important where the pipe line 28 is installed in the usual manner with a bias or initial tension with respect to the connecting point 44. In this case the middle position of the weight 36 corresponds to a condition of heat elongation in which the bias is just balanced. As will be understood, it is also possible to provide gears and the like in the system.

Fig. 5 shows an embodiment in which the pressure force exerted at the bend 49 of a line 50 in the direction of the arrow 51 is balanced by a mechanical device rather than by making the bend directly a fixed point of the pipe line system. This device consists of a casing 52 which surrounds the pipe line and is stationarily mounted, and an annular piston 53 which is secured to the line 50. Through apertures 54 the fluid under pressure is capable of entering from the pipe line 50 into the casing 52 and to act upon the annular piston 53, thus exerting thereon a force in the direction of the arrow 55 which is opposed to the pressure force 51 acting at the bend. Stuffing boxes 56 and 57 prevent the fluid from escaping through the small annular play between the relatively movable parts. It will be understood that if the effective surface of the annular piston is exactly of the same size as the interior cross section of the pipe line 50, the two forces will exactly balance each other. The pipe line connected to the balancing device is thereby relieved of the tensile stresses produced by the pressure force 51 at the bend.

The pipe 50 of the said balancing device shown in Fig. 5 is connected to a stuffing box compensator which according to the invention may be used for the compensation of the various forces occurring on and in the pipe line immediately at or near their points of attack. As will be seen, the compensator comprises a casing 58 and a pair of stuffing boxes 59 and 60 at both ends, without any additional devices, such as, balancing pistons or the like. The diameter of the packing surfaces does not exceed the diameter of the smooth pipe so that the frictional forces occurring in the stuffing box compensator are smaller than in the case of compensators having additional balancing pistons.

It will be noted that in case of heat expansion, the piston 53 makes relatively small motions only in the stuffing box 57 as long as the heat expansions can be compensated in the compensator 58. In order to prevent the expansion of the pipe from causing an unduly large displacement of the piston in the casing 52 in case of any jamming of the pipe ends in the stuffing box 58, stop collars 56′ and 56″ are provided on the pipe 49 on both sides of the stuffing box 56.

The balancing device 52 shown in Fig. 5 is of a particular importance where it is desired not only to relieve the pipe lines of tensile stresses but even to apply compressive stresses of a predetermined magnitude. In this case the annular pistons of such balancing devices have to be made larger as to their cross-sectional area than the interior cross section of the pipe. In this manner, an over-balance may be produced in the form of an excessive pressure load. The cylinders and pistons shown in Figs. 1, 3 and 4 would also have to be made larger for the purpose of over-balancing than the interior cross-section of the pipe line.

Where an over-balanced state, i. e. a resultant compressive stress is produced in the line, stuff-ing box type compensators for heat expansion, if any, have also to be provided with additional pistons, as shown, for instance, in Fig. 6. In this case, pipes 61 and 82 which are provided with annular pistons 63 and 64 project into a stuffing box casing 65. The cross sections of the annular pistons 63 and 64 are made larger than the interior cross-sections of the pipes 81 and 62. The two pistons 63 and 64 represent two different forms. The effective area 66 of the annular piston 63 is positioned outside the casing 88, while the corresponding area 67 of the piston 64 is positioned at the inner end of the pipe line 62.

In the left hand part of Fig. 6 there is shown another embodiment of a stuffing box compensator in which the right hand pipe 61 is connected to a tube member 68 while the left hand pipe 69 is connected to a casing 70. The inner pipe 68 is provided with an annular piston 72 which is mounted in a stuffing box 71 and the dimensions of which correspond to those of the aforementioned annular pistons. The operation of this device 68, 70, 71 is similar to that of the device 65 except that the pipe 69 is in this case fixedly supported by the casing 70. On the other hand, it is also possible with any of the aforementioned balancing devices to mount the casing or bearing in such a manner that it is free to slide on its base in an axial direction.

Referring now to Fig. 7, a sluice valve 73 is interposed in a pipe line 74, 74′. If the sluice valve 73 is in its closed position, the fluid pressure acts upon the same in the direction of the arrow 97 and produces a tensile stress in the pipe 74. The balancing means according to the invention may be used not only to balance the tensile stress, but even a pressure force may be produced in the pipe 74. The balancing means comprise casings 75 and 76 and annular pistons 77 and 78 secured to the pipes. The casings 75 and 76 are fixedly mounted on a common base plate 79. The casing 75 on the left hand side is connected, through a tube 80, with the pipe 74′ on the right of the slide valve 73 and the casing 76 on the right is connected, through a tube 81, with the pipe 74 to the left. It will thus be clear that the right hand device 76, 78, will be operated when the pipe 74 is under pressure during the closed position of the slide valve while the left hand device 75, 77 will be operated when the pipe 74′ only is under pressure. As a result, no connecting points of the pipe line, not even the flange joints 82 and 83 of the casing of the sluice valve are stressed by tensile stress. Since the cross section of the annular pistons 77 and 78 in accordance with the above considerations are preferably made larger than the right hand pipe cross section, the pistons 77 and 78 serve to take up a part of the stress of the flange bolts, so that the same may be made smaller accordingly.

Fig. 8 shows an example of a quarter bend in which a plunger 85 which is slidable in a casing 84 and guided in a stuffing box 89 serves for balancing or over-balancing the stresses in the pipe system. The end 88 of the right hand pipe takes the form of a plunger passing through the casing 84 and guided in stuffing boxes 87 and 88. An aperture 90 in the plunger 86 is normally positioned approximately in the middle of the casing 84. The downwardly extending pipe (not shown) is to be connected to the flange 91 of the casing 84. The point 85′ of the plunger 85 is connected, by means of a rope or chain 92, with the point 93 of the plunger 86, and the rope or chain is passed over a roller 94 or the like secured to the casing 84, all as indicated in Fig. 8. purely schematically in dotted lines. It will thus be understood that it is possible to transmit the forces acting upon the plunger 85 upon the plunger 86 and thereby to counter-act the pressure-forces acting upon the end face thereof.

For the purpose of over-compensation the cross-section of the plunger 65 may be made larger than that of the plunger 86. Moreover, it is possible to provide a transmission ratio in the form of a gearing or leverage between the points 85′ and 93, whereby a plunger of any desired dimensions to suit, for instance, any special constructional conditions or to reduce the friction in the stuffing box may be attained.

Fig. 9 shows a bend which as to its general arrangement corresponds to that according to Fig. 8. The difference consists in the fact that a bellow-shaped member 95 is provided in place of the plunger 85. This offers the advantage that a stuffing box and the friction thereby produced are avoided. The rope 92 is secured on or near the end wall 96 of the bellow.

Where it is intended that a resultant pressure stress be produced in the pipe lines, the devices shown in Figs. 2 and 3 for the compensation of the elastic reaction forces of the resilient heat expansion compensator have to be adjusted in a different manner, i. e. in such a manner that the levers 17 in the condition without strain of the compensator 13 have not yet reached their vertical position.

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