H. J. BOUVIÈR.

RECOIL DEADENER FOR WATER MAINS.

APPLICATION FILED AUG. 24, 1918.

1,357,837. **Patented Nov. 2, 1920.**

2 SHEETS—SHEET 1.

Fig. 1

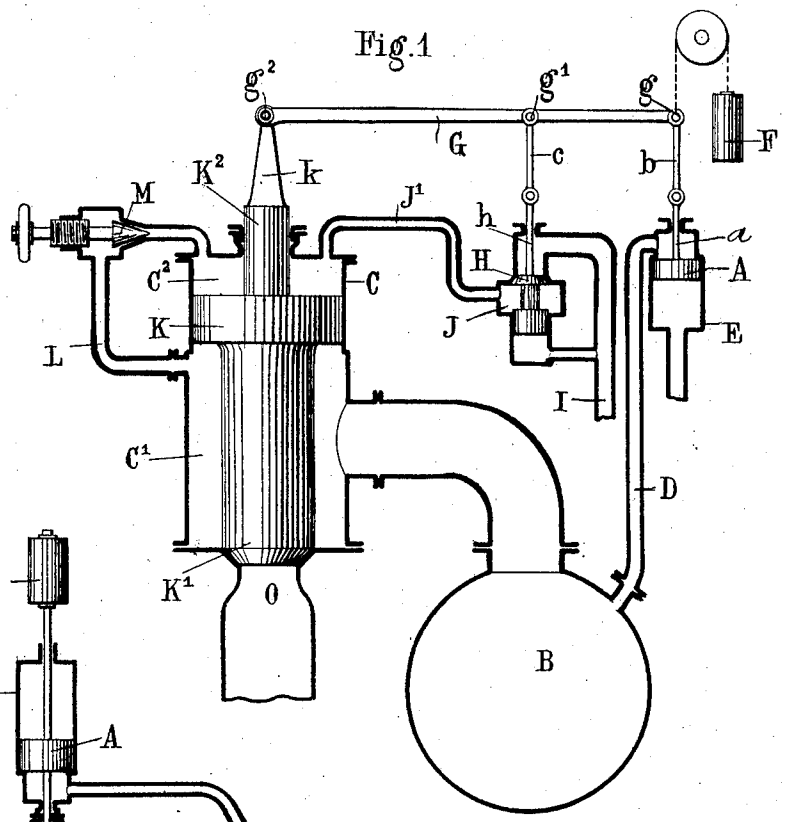

Fig. 2

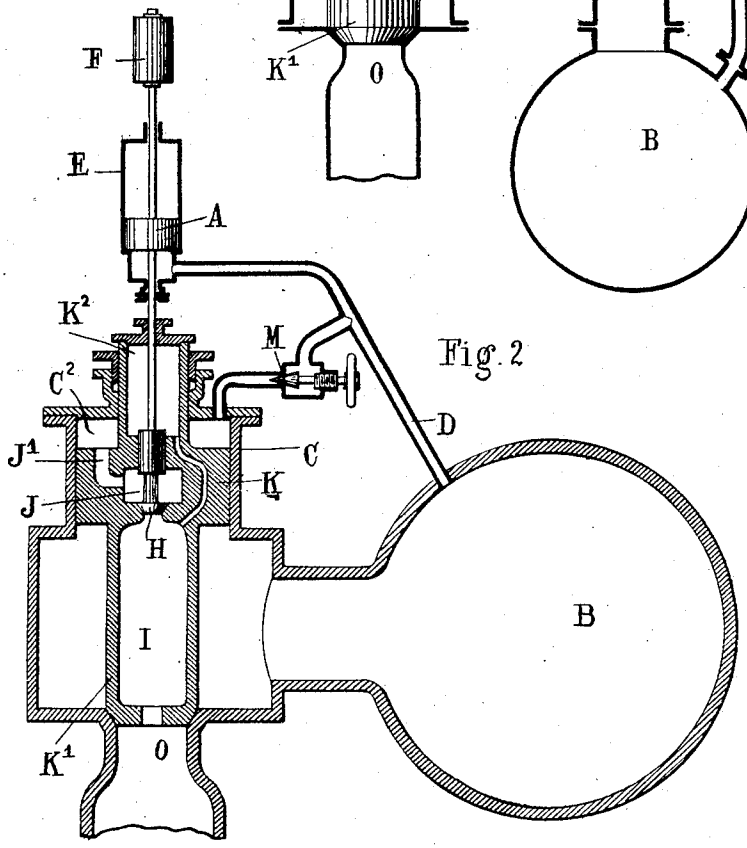

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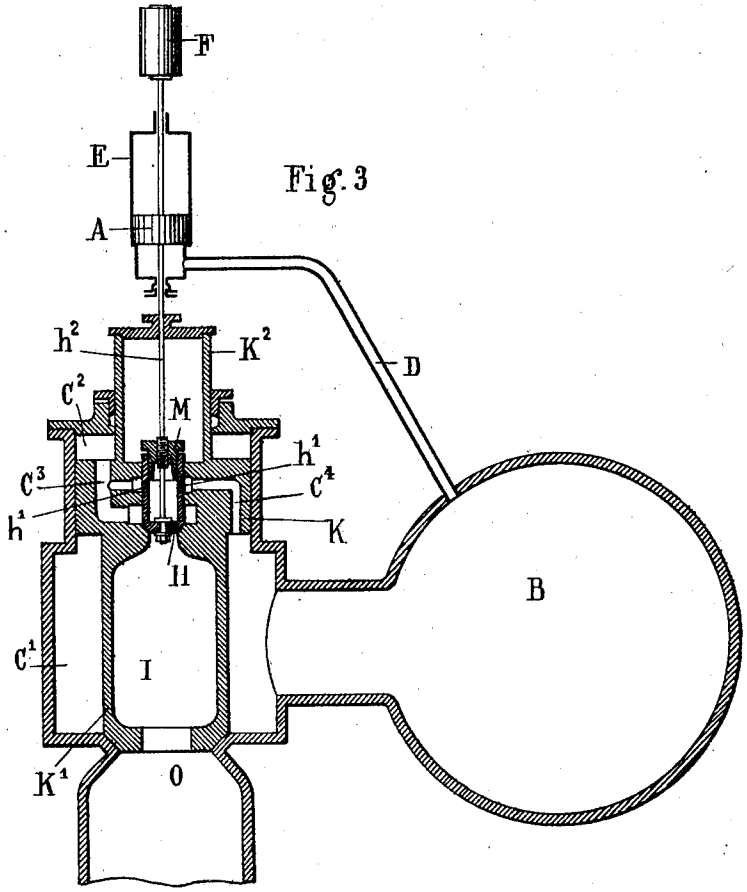
Fig. 3



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UNITED STATES PATENT OFFICE.

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RECOIL-DEADENER FOR WATER-MAINS.

1,357,837. Specification of Letters Patent. Patented Nov. 2, 1920.

Application filed August 24, 1918. Serial No. 251,305.

To all whom it may concern:

Be it known that I, HENRI JOSEPH BOUVIER, a citizen of the Republic of France, and a resident of 6 Rue Hector Berlioz, Grenoble, department of Isère, France, have invented new and useful Improvements in Recoil-Deadeners for Water-Mains, of which the following is a specification.

The present invention has for its object an apparatus intended to prevent the occurrence of hydraulic recoils in water mains, particularly in the mains under high pressure which feed turbines, or other hydaulic apparatus and which, through their regulation, are likely to produce in the water mains more or less sudden variations in the flow of such mains.

It is well known that any sudden variation of flow gives rise to a series of waves each comprising a period of over pressure and a period of depression relatively to the pressure which existed before such variation.

The periods of over pressure become dangerous or injurious when they result in pressures in excess of the static pressure *i. e.* the pressure withstood by the water main when there is no flow, as it is always the static pressure which serves as a basis for the calculation of the strength to be given to the wall of a high pressure main.

If arrangements can be made so that the pressure in a main can never exceed, except by a very feeble amount the static pressure under any circumstances, there will be produced both a condition of safety and a condition of economy in the cost of construction of such mains, as there will be no need to allow excess thicknesses capable of withstanding accidental excess pressures.

In the matter hereinbelow following, any pressure which is above the static pressure will be called excess pressure.

It will be readily understood that if, at the moment when a hydraulic recoil occurs and as soon as the period of excess pressure starts, it is possible instantaneously to open a discharge aperture of sufficiently large section, the first wave which will have produced such excess pressure will find itself stopped in its development, it will, in reality, be deadened and the undulatory phenomenon which always accompanies the hydraulic recoil will rapidly disappear.

When all excess pressure has disappeared it will be desirable to effect the closure of the discharge aperture momentarily open, in order that this aperture may open afresh when it becomes necessary and also to avoid needless expenditure of water.

In order however to effect such closure there is one essential condition, namely, that it should be effected so slowly that it cannot, in its turn, give rise to a fresh hydraulic recoil which might be just as dangerous, if not more so, as the initial recoil.

The rapid opening of the discharge aperture and the carrying out of its slow and gradual closure, constitute a twofold object to be realized, which two-fold object forms the subject of the present invention.

The apparatus enabling this result to be obtained comprises, in principle, a piston which is displaced in the cylinder. This piston receives on one of its faces the pressure which exists at each moment in the water main. In the direction opposite to the stress exerted by the water on the piston the latter receives the action of a force practically equal, or slightly superior to that which is exerted on the piston when the static pressure exists in the water main. This force may be obtained by the action of a counterweight for instance.

Owing to the loss of load which occurs as soon as there is a flow, the stress exerted by the counterweight always remains higher than that which the water exerts on the piston, so long as there is no excess pressure in the main.

If however there should occur in the main a pressure in excess of the static pressure, the piston will be forced in the opposite direction. The cylinder and the piston are disposed in such manner that the latter is stopped in a fixed position when it is subjected to the preponderating action of the counterweight, *i. e.*, when in the working condition there exists in the main a pressure lower than the static pressure, and that it may, on the contrary, be displaced if the pressure of the water produces a stress greater than that of the counterweight.

This piston therefore in reality forms an excess pressure indicator.

The indicator piston is connected to the valve of a servo-motor, which itself actuates the shutter of a discharge aperture of sufficiently large section which is constantly in communication with the water main.

The connection of the indicator piston and shutter is insured in such a manner that if

the piston undergoes displacement by the effect of the water pressure, this displacement is immediately followed by a corresponding opening of the discharge aperture.

If therefore there occurs a sudden variation of flow in the main, giving rise to hydraulic recoil and consequently to an excess pressure, the discharge aperture will open instantaneously as soon as the excess pressure makes itself felt; if this opening provides a sufficient section of out flow its first effect will be to limit the excess pressure to a very low amount and afterward to allow of deadening the inertia of the water in the main.

At the same time as the inertia of the water is deadened the excess pressure falls off and soon the pressure in the main becomes lower than the static pressure. From that moment the displacement of the indicator piston which was produced by the momentary excess pressure is stopped and the action of the counterweight once more becomes preponderating, so much so that the piston at once tends to return to its initial position of departure. This stoppage of the piston and its tendency to return in the opposite direction are utilized to bring about the movement of closure of the discharge aperture, but contrarily to what occurred on the opening of this aperture the movement of closure must remain independent of the displacement of the indicator piston, and the speed of this movement of closure will be rendered as small as may be necessary by means of a special device which forms one of the principal features of the present invention.

Figs. 1, 2 and 3 in the drawing hereto annexed represent diagrammatically and by way of example, several forms of construction of appliances which allow of obtaining the results which have just been set out.

The apparatus represented on Fig. 1 consists essentially of an indicator piston A, which receives on one of its faces the pressure existing at each moment in the principal main B, which is in connection with the chamber C′ of the servo-motor C, and, through the agency of the pipe D, with the cylinder E in which moves the piston A.

The pressure thus exerted on the piston A varies according as the loss of load in the pressure main is more or less great, it also varies at the moment when variations of flow occur in the main, but for each installation this pressure assumes a perfectly determined value p when the main is subjected to the static pressure of the water, *i. e.* when no flow occurs in the main.

In the direction opposite to the stress p there is made to act on the piston A a force equal or slightly superior to the value of p.

This force may be obtained either by means of a counterweight, F, as shown on the drawing, or by means of a fluid maintained at a constant pressure, or by means of a counter pressure spring having sufficient flexibility to exert a practically constant stress, or finally, by means of the simultaneous action of a counterweight and a spring.

The rod a of the piston A is connected by means of the connecting rod b to one of the joints g of a lever G. To the joint g' there is attached by means of a connecting rod c the rod h of a valve H. This valve can open or close the aperture of an outlet pipe I. The chamber J, from which the outlet pipe I starts, is in constant communication, by means of the pipe J′ with the annular space C^2 of the cylinder C of the servo-motor. In this cylinder C a piston K can move which is connected on the one hand to the piston K′ forming a discharge valve and which, on the other hand, is prolonged by a cylindrical part K^2 of a lesser diameter than K′. The cylindrical part K^2 is itself connected by the rod k to the joint g^2 of the lever G. Finally the annular space C^2 is connected direct to the principal main B by means of the pipe L, at a point of which there is interposed a needle M, allowing of reducing to the necessary extent the section of the aperture of passage of the water passing from the main B to the annular space C^2. When the valve H is closed, the pressure of the main is exerted on both sides of the piston K, but the diameter of the cylindrical part K^2 being less than that of the valve piston K′, the difference in the pressures exerted on the two faces of the piston K, has the effect of pressing the valve piston K′ hard on its seat. If the valve H should open it places the annular space C^2 in communication with the outlet pipe I. There then occurs a reduction of pressure in the space C^2, because the aperture left open by the needle M is too small for this pressure to be maintained. The stress exerted on the piston K on the C′ side then becomes greater than that exerted on the C^2 side and at that moment the piston K rises, taking with it the piston K′, which results in the opening of the aperture of the discharge pipe O.

If, now, the valve H closes, the piston K is immediately stopped in its upward stroke, as the pressure of the main B is immediately restored in the annular space C^2 which at once brings about a movement in the opposite direction of the piston K, but the speed of this movement of descent will depend on the flow in the aperture, the section of which is regulated by the needle and this speed will be slower in proportion as the section left free by the needle is smaller. It is therefore possible to regulate the speed of closure of the discharge aperture O in such a way that this closure produces no appreciable excess pressure in the main B.

The opening and closing of the discharge aperture O being dependent on the opening or the closing of the valve H, it will suffice to effect the displacement of this valve in order to produce either the outflow of a certain volume of water through the aperture O or the closing of this aperture. This is the part which is to be performed by the indicator piston A. Whenever the pressure in the main B exceeds the value for which the counterweight F is regulated, *i. e.* whenever there occurs in the main a pressure in excess of the static pressure, the piston A will descend and will continue to descend as long as the pressure in the main remains higher than the static pressure; this displacement will bring about the opening of the valve H and of the discharge aperture O. That is the moment when there takes place the intervention of the mode of connection produced by the lever G between the piston A, the valve H and the piston K^2. The piston K^2 in rising causes the lever G to swing about the point *g*, the effect of which is to lift the valve H and to bring about the closing of this valve when the piston K has effected a stroke corresponding to that just made by the piston A.

To sum up, the lever G effects a movement of subordination of the valve H in reference to the two pistons A and K. The height of lift of the piston K′, which always corresponds to the stroke performed by the piston A, will therefore be greater in proportion as the effect of the excess pressure in the main B shall have produced a more considerable displacement of the piston A. This movement of lift of the discharge valve K′ will cease as soon as the indicator piston A ceases to descend. When the valve piston K′ has completed its upward stroke the pressure in the main B will continue to drop, both owing to the fact of the deadening of the inertia of the water in the main and owing to the fact of the flow in this main.

From that moment, the piston A, yielding to the effect of the counterweight F, tends to return on the opposite direction, that is, toward its point of departure. This movement of recoil however will be prevented by the fact that the valve H is resting on its seat and the stress which tends to lift the piston A will have no other effect than to press this valve harder on its seat.

Therefore, as soon as the pressure in the main becomes inferior to the static pressure, the piston A no longer has any action on the whole of the other parts. From that moment, the valve H being closed, the piston K starts descending slowly, which brings about the closure of the discharge aperture O. The lever G then oscillates around the point *g′* and the piston A rises as and when it is allowed to do so by the downward movement of the piston K.

This downward movement of the piston K is effected in a time which is determined by the position of regulation of the needle M, which time will be made long enough to prevent the speed of closure of the discharge aperture giving rise to any appreciable excess pressure.

It is desirable to point out carefully that if this condition were not insured the apparatus, far from giving rise to the safety which it is proposed to obtain for the water main, would, on the contrary, form a true danger to the main.

If the shutter were to close with too great a speed, the excess pressure due to this speed would react on the indicator piston A, which would descend once more, which would immediately produce a fresh movement of opening of the discharge aperture C, which opening would be followed by a fresh closure, then by a new excess pressure in the main, a fresh opening and so forth, so that in reality there would be produced an oscillating movement of the shutter K′, a movement similar to that used in the elevating apparatus called hydraulic rams. This movement of oscillation would have the consequence of producing an entire series of hydraulic recoils, when the object of the apparatus is precisely to avoid them.

The slow and gradual closure of the discharge aperture is therefore an essential and primary condition for the obtaining of the proposed technical result.

It should be remarked that during the descending movement of the piston K, *i. e.* while the closing of the discharge aperture O takes place, the piston A is always ready to obey the effect of a new excess pressure, if any should be produced in the main B owing to the fact of a fresh variation of the flow to the motors or engines driven by the water under pressure. The piston A, as soon as it receives the action of this new excess pressure, will descend and instantaneously will bring about a fresh opening of the valve H and a new ascending movement of the piston K, itself giving an increase of the degree of opening of the discharge aperture O.

It results however from the disposition described that at any moment, the apparatus is always ready to act if, owing to any cause, the pressure in the main should exceed the static pressure.

The disposition described also allows of giving the discharge aperture and the lift of the shutter K′ of that aperture dimensions calculated to answer all the requirements which may correspond to the applications of the system to pressure mains, even when the latter deliver large volumes of water under comparatively feeble pressures.

For this, it will suffice to choose a suitable ratio between the two arms of the lever G.

When, on the contrary, it is a question of pressure mains with relatively high pressure delivering comparatively small quantities of water, the system can be simplified and be given the disposition which is represented at Fig. 2; in this variant the piston A directly actuates the valve H and the latter can be placed inside the piston K of the servo-motor. The needle M will still regulate the flow in the annular space C^2.

With the arrangement shown on the drawing, if an excess pressure occurs in the main B, the piston K will follow the displacement of the valve H, and consequently of the piston A. The stroke of the piston K will, in that case, be exactly equal to that of the piston A (while in the arrangement of Fig. 1, this stroke was amplified in a ratio resulting from the dimensions adopted for the two arms of the lever G). In this second arrangement, the return movement of the piston K will likewise be effected with the desirable slowness, thanks to the regulation which needle M allows of carrying out.

The slow and progressive return movement of the piston K of the servo-motor may also be obtained by a suitable arrangement given, with that object, to the valve H, which can be designed in such a way that it opens a large aperture when it is a question of insuring the movement of opening of the discharge valve of the main, and, on the contrary, only opens an aperture of very small section when it is a question of bringing about the movement of closure of the shutter K′.

By way of example, Fig. 3 indicates a form of valve which allows of obtaining this result. When the valve H rests on its seat, the space C^2 of the cylinder of the servo-motor is in communication with the other side C′ of the cylinder through the agency of the branches C^3 and C^4 and apertures of small section h' cut in the wall of the valve H. The section of these apertures h' can be reduced if need be and regulated by means of the plug M screwthreaded and screwed on to the body of the rod h^2 of the valve H. If, on the contrary, the valve H opens under the action of the rod h^2, the space C^2 will be put into communication by means of the branch C^3 with the outlet pipe I, throughout the annular space uncovered by the valve H in rising.

The section offered for the outlet of the water from the space C^2 may therefore be made much greater than the section of the small apertures h' in such manner that the pressure in the space C^2 will drop as soon as the lift of the valve H occurs; the piston K will therefore immediately follow the lifting movement of the valve H.

As soon however as the indicator piston A ceases to rise, the piston K, continuing to rise, will bring the seat of the valve H into contact with this valve and immediately the pressure of the main will be re-established in the space C^2, the effect of which will be immediately to bring about the movement of lowering of the piston K, a movement which will take place very slowly as it will depend on the flow in the apertures h'. There will thus be assured the slow and progressive closing of the discharge aperture O by the shutter K′.

In the variants of Figs. 2 and 3, and also in the arrangement Fig. 1, it should be pointed out that while the descending movement of the shutter takes place, the piston A is always ready to obey any new excess pressure which might occur in the main, as soon as this excess pressure should exceed however slightly the static pressure. Any new excess pressure would immediately have the effect of causing a fresh lift of the shutter K′, which would produce a new increase of the degree of opening of the discharge aperture.

The fact that, at every moment the apparatus is always ready to obey any excess pressure exceeding the static pressure constitutes one of the characteristic points of the present invention.

It must be clearly understood that the invention is not limited to the devices described above and represented in Figs. 1, 2 and 3 which may receive all variant compatible with the principle on which it is based. In this order of ideas it may be pointed out, for instance, that the servo-motor may be made independent of the main B and that it may be actuated by a liquid under pressure other than the water in the pressure main.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. An apparatus for automatically deadening "hammering" in water pipes, comprising an indicator piston constantly subjected on one face to the pressure in the pipe, means constantly acting on said piston to equalize to a certain extent said pressure, a valve operatively connected to said piston, a servo-motor controlled by said valve and comprising a differential piston, a discharge gate operatively associated with the latter, means for rendering the displacement of the differential piston and of the discharge gate proportional to that of the valve and of the indicator piston, in combination with means for slowly admitting liquid from the pipe to the side of the differential piston opposite that of the discharge gate to insure the slow closure of the latter.

2. An apparatus for automatically deadening "hammering" in water pipes, comprising an indicator piston constantly sub-

jected on one face to the pressure in the pipe, means constantly acting on said piston to equalize to a certain extent said pressure, a valve operatively connected to said piston, a servo-motor controlled by said valve and comprising a differential piston, a discharge gate operatively associated with the latter, means connecting the valve to the differential piston, and means for slowly admitting liquid from the pipe to the side of the differential piston opposite that of the discharge gate to insure the slow closure of the latter.

3. An apparatus for automatically deadening "hammering" in water pipes, comprising an indicator piston constantly subjected on one face to the pressure in the pipe, means constantly acting on said piston to equalize to a certain extent said pressure, a servo-motor controlled by said valve and comprising a differential piston, a discharge gate associated with the latter, a lever operatively connecting said indicator piston, valve and differential piston, and means for slowly admitting liquid from the pipe to the side of the differential piston opposite that of the discharge gate to insure the slow closure of the latter.

In testimony whereof I have signed my name to this specification.

HENRI JOSEPH BOUVIER.

Witnesses:
ED. MAIGONNIER,
AL. MALPLAT.