PATENT SPECIFICATION

Convention Date (Germany): Nov. 12, 1932.

430,337

Application Date (in United Kingdom): Nov. 13, 1933. No. 31634/33.

Complete Specification Accepted: June 13, 1935.

COMPLETE SPECIFICATION

Improvements in and relating to Shock-absorbers

I, WILHELM LANGGUTH, formerly of Stuttgarter Strasse, Böblingen, Wurtemberg, Germany, but now of 61, Rue Corot, Ville-d'Avray (Seine & Oise), France, of German nationality, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

It is known that nearly all machines and arrangements the operation of which produces shocks are provided with shock-absorbers. These shock absorbers are adapted to deaden the shock and to absorb the energy of the shock by a resilient distortion. For that purpose, use is preferably made of materials having high properties of resiliency (steel, rubber, and the like), or cylinders in which air or gaseous mixtures are compressed or rarefied. Devices are also known in which liquids (water, oil, and the like) are driven out or drawn in through small openings (nozzles). Devices also exist in which use is simultaneously made of solid, liquid or gaseous, bodies for absorbing shocks. It is possible to cause the various bodies to act separately, in groups, or all together.

The absorption of shocks plays a particularly vital part in all aeroplanes and in all vehicles. Relatively to the other stresses generated, shocks upon landing and shocks due to running conditions come into consideration to such a degree that the security and consequently the value of an aeroplane or of a vehicle depend to a large extent on satisfactory absorption of shocks. Pneumatic shock-absorbers are usually composed of a cylinder filled with air, in which a piston is inserted when a shock occurs. The air which is in front of the piston is thus compressed and the shock is absorbed. The compression chamber is frequently composed of several compartments communicating with one another only through small orifices. In this manner the absorption of shocks is improved both during the forward stroke and during the return stroke of the piston. Arrangements also exist in which the piston acts on a liquid, which, during the forward stroke of the piston, is injected through nozzles into an entirely closed air chamber.

In proportion as the liquid fills the air chamber, the air contained in the latter is compressed. All these devices form the subject-matter of numerous modifications and combinations of different kinds. But in all cases the air or any other gaseous body is compressed and in this manner the absorption of the shock is obtained. The degree of shock-absorption is a function of the absorption of the work of the compressed fluid, which latter absorption can be determined by calculation or by experiments and can be illustrated in a stroke-force diagram.

As however for practical reasons the available resilient stroke in aeroplanes and vehicles is usually very limited, relatively high final forces as shown by the stroke-force diagrams.

The present invention has for its object to provide a shock-absorber in which the final force shown by the stroke-force diagram is but slightly greater than the static load, owing to a plurality of stages of pressure during the compression, the resilient stroke and work absorption being approximately equal.

On the other hand the invention makes it possible to obtain, in the case of unilateral load on the wheels, a final force approximately equal to or smaller than that in the case of a simultaneous load on all the wheels. In an aeroplane having for instance two or more wheels, when the wheels are distributed throughout the length of the wings, it is to be noted that in a unilateral landing of the wheels the elements of construction are not stressed to an appreciably greater extent than when the aeroplane runs on level ground.

The invention consists in a pneumatic shock absorber with a plurality of chambers, in which at a given value of the pressure in the primary chamber due to movement of a piston therein, the said chamber is placed in communication with a secondary chamber in which at this instant there exists a pressure equal to the said given value, whereby on increase of pressure in the primary chamber the pressure curve of the primary chamber is deviated in such a way that the tangent to the new portion of the curve at the point of deviation is nearer the horizontal than the tangent to the old portion of the curve at the same point.

In carrying out the invention, in addition to the compression chamber existing in every air-pressure cylinder, there are provided one or more other compression chambers, which are put into communication with the primary compression cylinder by slide or other valves mechanically operated or with automatic action, or through the uncovering of apertures by the piston. According to the adjustment of the valves or slide valves, the supplementary compression chambers come into action, either separately or in groups, or altogether.

The accompanying drawing illustrates, partly diagrammatically, some forms of construction of the invention.

In the example illustrated in Figure 1, above the compression chamber *a* is provided a second compression chamber *b*, separated from *a* by a valve *v*. The stroke-force diagram of a compressed-air cylinder of this kind is shown in Figure 6. In the diagram, the positions of the piston *k* are, as usual, drawn on the horizontal axis (abscissa) and the the forces P acting on the piston *k* are drawn on the vertical axis (ordinate). This stroke-force diagram is equal, for the piston area $F-1$, to the stroke-pressure diagram. On the vertical axis as therefore traced in the air pressures *p* exerted in the cylinder. In this Figure the curve A represents in the stroke-pressure diagram, by way of example, the air pressures *p*, or in the stroke-force diagram, by way of example, the pressures P of the piston, if the air was compressed only in the compression chamber *a* of Fig. 1. This constitutes therefore, by way of example, the diagram, of a known shock-absorber.

The mode of operation and useful effect of the shock-absorbers according to the present invention shown in Figs. 1 to 5, will clearly appear from the following explanations:

In the example of Fig. 1, in the compression chamber *a* there exists an air pressure of $p=2$, in the initial position *o* of the piston *k*. When the piston *k*, entering the cylinder, has reached for instance the position *x* indicated in broken lines, the volume has diminished in the compression chamber *a* and the air pressure has risen for instance from $p=2$ to $p=5$ (see also fig. 6). Owing to this pressure, the valve *v*, which is controlled by a spring *d*, is pushed back in the guide *e* until the orifices *f* are uncovered. From this fact, the compression chamber *b*, which according to the present invention must be filled with pre-compressed air at a pressure of about $p=5$ to be adopted in the present example, enters into action for the following compression phase. No expansion of air therefore takes place, as approximately the same pressure exists within the air chamber *b* as in the air chamber *a* at the time the valve *v* uncovers the orifices *f*. The piston *k* continuing its stroke, the increased volume $(a+b)$ is then compressed. In the stroke-pressure diagram, as shown in Fig. 6, the rate of increase of pressure therefore diminishes at $p=5$. The compression then no longer progresses according to curve A but according to curve B.

The point of the curve A where the change takes place and the magnitude adopted for the additional volume *b* are obviously immaterial for the purpose of the present invention. The greater the volume *b*, the flatter is the curve B.

The choice of the diminution in the rate of increase of pressure and the course of the graduated curve can be adapted to the conditions existing in each separate case. The construction and mode of control of the valve *b* are likewise immaterial. A flap valve may quite as well be used as a disc valve or a slide valve, and it can be controlled by air pressure, by spring pressure or by thrust rods as shown in Fig. 1*a*. In the constructional form shown in this figure, the primary chamber *a* is separated from the secondary chamber *b* by a flap valve *v*. The valve *v* is pivotally mounted around a hinge v^1 which is provided with a spring which constantly urges the valve *v* to close. On the piston *k* is fixed a rod-abutment *m* which, when the piston reaches the height *x*, contacts against the valve *v* and opens the latter. On the return of the piston, the valve *v* is closed by the action of the spring of the hinge v^1.

During the return stroke of the piston *k*, in the example of Figure 1, the orifices remain open until the piston *k* has reached the postion *x*. Up to that point uniform expansion of air therefore takes place in the chambers *a* and *b*. In the position *x* of the piston the spring *d* has caused the valve *v* to move down to such an extent that the orifices *f* are covered. During the continuation of the return stroke of the piston k the pressure therefore remains constant in the compression chamber b, and the expansion now takes place only in the chamber a. The shock due to the return of the piston k can be absorbed in the usual manner by a rubber pad g. The piston k may also be provided with small perforations h through which a portion of the compressed air can pass, during the forward stroke of the piston, into the space situated behind the piston k, for the purpose of subsequently absorbing the return shock of the piston. It is to be understood that any other known shock absorbing means can also be provided. The parts designated by n are fluid-tight packings, t designates filling screws, and r an extension of the shock absorber.

Therefore if in Fig. 6 the surface located under the curve A for instance up to the vertical line E represented the necessary work absorption, it would be reduced by the diminution in the rate of increase of pressure, at $p=5$, by the area enclosed by the lines A, B and E.

This diminution can be compensated by the slight increase of the stroke s up to the vertical line Z. In this manner, in the present example, the final force P is reduced by about 60% by an increase of the stroke s of about 10%. According to the choice of the pressure stage, any required ratio can be obtained, within definite limits, between the final load and the stroke.

Figure 2 illustrates by way of example an arrangement in which the compression chamber b is constituted by a double casing of the compression chamber a, a supplementary compression chamber c also being provided. In this arrangement the piston k is hollow and has orifices i in its upper surface. The interior of the piston k thus constitutes a portion of the compression chamber a. Instead of the valve v of Fig. 1, a slide-valve gear is provided in the present example. In the initial position o, the rod m of the slide valve, which is connected to the piston k, closes the orifices f and q of the compression chambers b and c. When the piston k has reached the position x, the slots z formed in the hollow rod m of the slide valve uncover the orifices f. The compression chamber a is then in communication with b. The piston k continuing to enter the cylinder, the air is compressed in the chambers a and b until the piston k has reached the position y. In this position the slots z again uncover the orifices q, and the compression chamber c enters into action for the following compression phase. According to the invention the chamber c is filled with pre-compressed air, the pressure of which, at the time the orifices q are uncovered by the slots z, is approximately equal to the pressure of the air in a and b in the position y of the piston

This arrangement of the pressure chamber, in which the air discharged from a can directly enter the chambers b and c, will be designated hereinafter by the expression " pressure chambers connected in parallel ". It is also obviously possible so to arrange the pressure chamber c that the air delivered from a must first enter the chamber b, and, from the latter, the chamber c. This arrangement will be designated hereafter by the expression " pressure chambers connected in series". According to the present invention, however it is also possible to use simultaneously pressure chambers connected in series and/or in parallel arranged in groups.

In the form of construction of Fig. 2, the pressure (see fig. 6) would therefore rise according to the curve A. In the position x of the piston the chamber b enters into action, and, in the continuation of the forward stroke of the piston k, the pressure rises according to the curve B. In the position y of the piston, the chamber c comes into action and the increase of pressure subsequently takes place according to the curve C. These changes of pressure can be repeated at will for any positions of the pistons.

In the arrangement shown in Figure 2 the additional compression chambers are placed in communication with the primary chamber by a common valve.

If desired however each additional compression chamber may be provided with a valve whereby communication with the primary chamber may be established.

Figure 3 illustrates a form of construction in which the orifices f are directly controlled by the piston k. For that purpose, the upper and lower ends of the piston are provided with perforations i. The total compression chamber a is therefore composed of the spaces situated before, behind and within the piston k. Since, during the penetration of the piston k into the cylinder, the diminution of the space in front of the piston is greater than the increase of the space behind the piston, a compression of the air contained in the chamber a therefore also occurs in this case.

The increase of the space behind the piston k is made smaller as the piston rod u is made thicker. In the initial position o of the piston k the orifices f are closed by the piston k. It is only when the piston k has reached, during its forward stroke, the piston x, that the orifices f are uncovered and that the diminution in the rate of increase of pressure occurs. It is also to be understood in the present case that other pressure chambers may be provided at the side of the chamber b or behind the latter. Instead of direct communication between the primary and additional compression chambers as shown in Figures 1 to 3, communication may be effected by means of conduits.

Since for reasons of space, or, in areoplanes, for the purpose of avoiding increased air resistances, an extension of the resilient system or an increase in width as shown in Figures 1 to 3 are impossible or undesirable, a form of construction is illustrated in Figure 4, in which the additional pressure chamber b is separated from the compression chamber a. In this example the compression chamber b can be arranged in the fuselage or at any other place. The two compression chambers a and b communicate with one another solely by a flexible conduit or pipe w. The details of construction may be modified as desired and the construction can be adapted to the special conditions of each particular case. In this example the valve v is controlled by means of compressed air, which is contained in a guide socket e placed behind the valve v. This air pressure is so adjusted that in the position x of the piston the orifices f are uncovered by the valve v. The air delivered from a is then sent through the conduit w to the compression chamber b. It is of course also possible to arrange the valve v at the inlet of the compression chamber b, or at any other suitable place. Considerations of practical utilisation will indicate in each case the most favourable arrangement.

When an aeroplane for instance is provided with several shock absorbers the invention also presents the characteristic feature that in the case of unilateral landing of the wheels, the shock-absorbers are subjected to a stress approximately equal to or less than in the case of normal landing.

Figure 5 shows an example of construction in which four shock-absorbers 1, 2, 3 and 4 are provided. When these four shock-absorbers are uniformly loaded the air is compressed according to the curve A of Fig. 6 in each of the four compression chambers a up to the position x of the pistons. In the position x of the pistons, the orifices f are uncovered by the valves v and, during the continuation of the forward stroke of the pistons k, the air contained in the four shock-absorbers is compressed through the pipe lines w into the common compression chamber b. The capacity of the compression chamber b is such that the subsequent increase of the pressure for each shock-absorber takes place for instance according to the curve B of Fig. 6. The mode of action and the work-absorption of each of the individual shock-absorbers are therefore, in the case of an equivalent load, approximately the same as if each cylinder was provided with its own compression chamber b, as illustrated in the examples of figs. 1 to 4. If, however, in the case of a landing in which the contact of the aeroplane with the ground first takes place on one side only, so that the shock-absorber 1 is then alone loaded, the air contained in the compression chamber a corresponding to this shock-absorber 1 would be compressed up to the position x of the pistons according to the curve of Fig. 6.

For this position of the pistons, the orifices f of the shock-absorber 1 are uncovered. The compression chamber b, which in these conditions is set in action, now however fulfils the function of a capacity four times as great as if the four shock-absorbers had to support simultaneously an equal load. The increase of pressure therefore takes place four times as slowly for the same resilient strokes. In Fig. 6, therefore, the pressure does not rise, after the stage of pressure x, according to the curve B, but, in the example chosen, according to the curve D. Under the action of the unilateral shock the wheel under consideration can therefore yield much more easily and allow the other wheels to come to rest on the ground. The same is true for all vehicles and other devices.

If for instance, the shock-absorbers 1 and 2 of Fig. 5 are simultaneously loaded, the increase of pressure, after the stage of pressure x of Fig. 6 takes place according to a curve between the curves B and D.

The number of shock-absorbers acting on a common compression chamber b, and also the place where the latter is arranged, are obviously immaterial. Each shock-absorber may also be provided for instance with its own compression chamber b, and these compression chambers may, then communicate either all together or in groups by means of pipe lines. It is likewise possible to arrange one or more compression chambers either in parallel or in series with the compression chamber b. In any case the rate of increase of the pressure is adapted to cause an essential diminution of the final load P in the stroke-force diagram, and consequently diminution of the strain exerted on the constructional elements participating in the reception and transmission of the load.

Owing to the great flexibility of the resilient system the position on the ground of aeroplanes and other vehicles is considerably improved and the security is increased.

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. A pneumatic shock absorber with a plurality of chambers, in which at a given value of the pressure in the primary chamber due to movement of a piston therein, the said chamber is placed in communication with a secondary chamber in which at this instant there exists a pressure equal to the said given value, whereby on increase of pressure in the primary chamber the pressure curve of the primary chamber is deviated in such a way that the tangent to the new portion of the curve at the point of deviation is nearer the horizontal than the tangent to the old portion of the curve at the same point.

2. A pneumatic shock absorber, according to Claim 1, in which the communication takes place for a given position of the piston, through the medium of slide or other valves, mechanically operated or with automatic action, or through the uncovering of apertures by the piston.

3. A pneumatic shock absorber according to Claim 1, comprising a primary chamber and additional compression chambers, the latter being arranged in parallel or in series, or arranged in groups in parallel or in series.

4. A pneumatic shock-absorber according to Claims 1 to 3, in which a plurality of additional compression chambers are placed in communication with the primary chamber by a common valve.

5. A pneumatic shock absorber according to Claims 1 to 3, in which each additional compression chamber is provided with a valve whereby communication with the primary chamber may be established.

6. A pneumatic shock absorber according to Claim 1, in which the compression chambers are connected together through the medium of flexible pipes or conduits.

7. A shock absorber according to Claims 1 to 3, in which the compression chambers communicate together in groups, directly or by means of conduits.

8. A shock absorber-arrangement, characterised by the feature that it is formed of several shock-absorbers according to Claims 1 to 3, possessing in common a secondary compression chamber on which they act independently, in groups, or all together.

9. A shock absorber arrangement according to Claim 8, in which several additional compression chambers are arranged in parallel or in series, or in groups in series and/or in parallel with the common secondary chamber.

10. A shock absorber arrangement as claimed in Claims 1 to 3, comprising several shock absorbers, each of which shock absorbers possesses its own secondary compression chamber or additional compression chamber, all or groups of which in any case communicate with one another, by means of conduits.

11. A shock absorber arrangement according to claim 10, characterised by the feature that it is provided with one or several additional compression chambers which are arranged separately relatively to the secondary chamber and connected to the latter through channels, the shock-absorbers acting on the additional chambers, separately, in groups or together.

12. The improved shock absorber or shock-absorbing unit, substanitally as described with reference to the accompanying drawings.

Dated this 9th day of November, 1933.

MARKS & CLERK.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1935.

Fig. 1

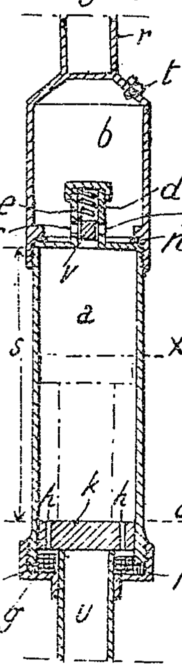


Fig. 1a

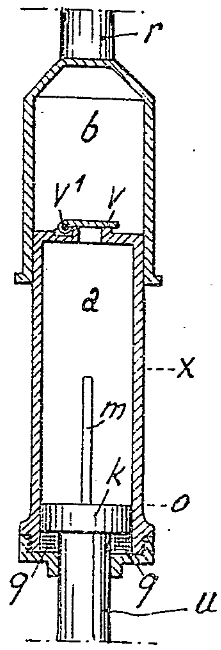


Fig. 2.

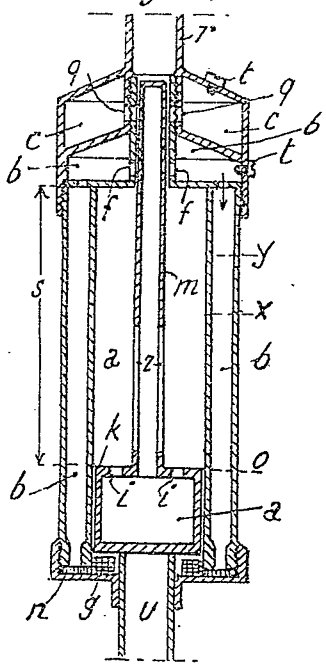
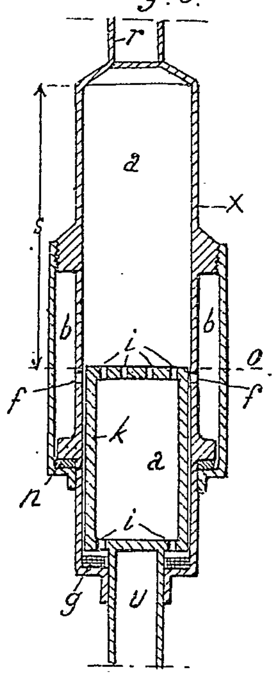


Fig. 3.



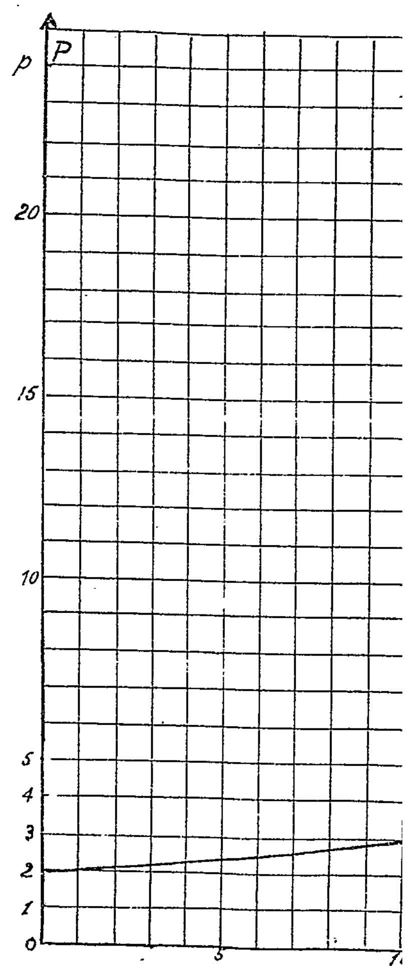


Fig. 6.

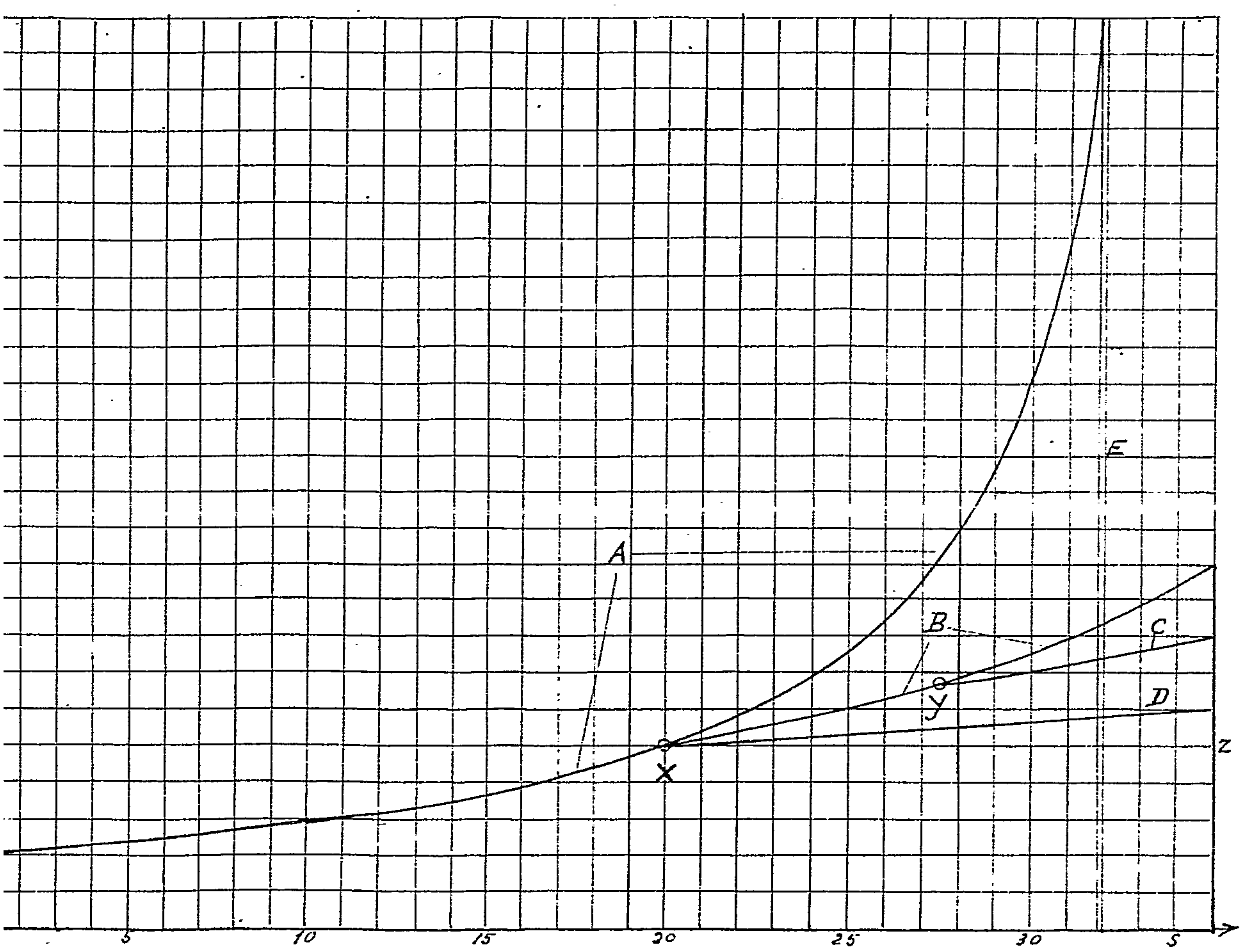


Fig. 1

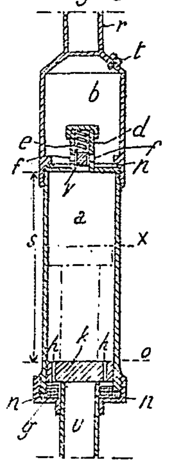


Fig. 1a

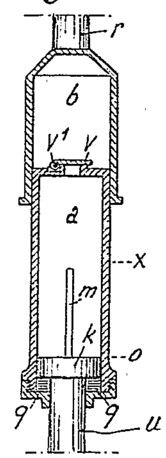


Fig. 2.

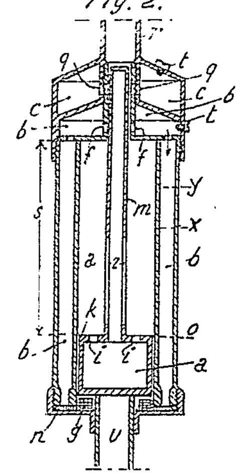


Fig. 3.

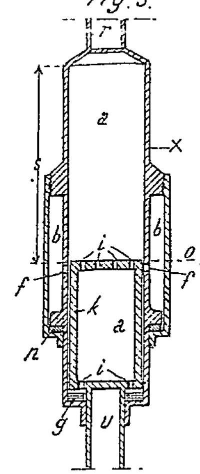
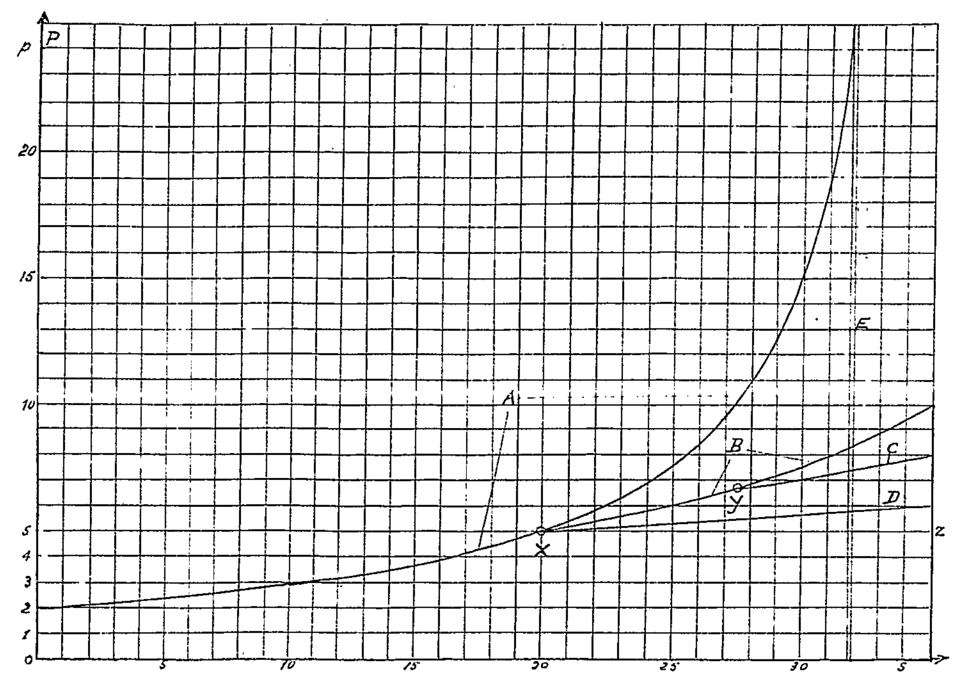


Fig. 6.



[This Drawing is a reproduction of the Original on a reduced scale.]

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 4.

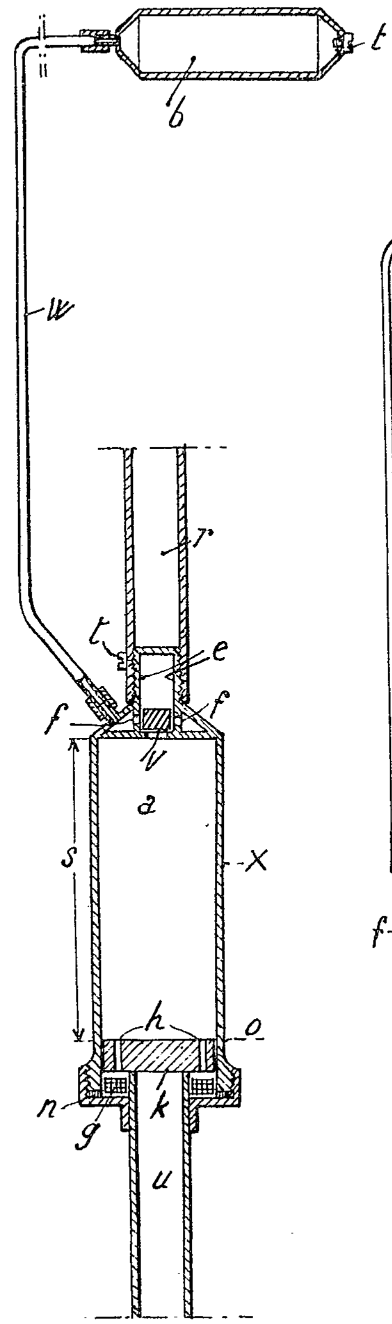
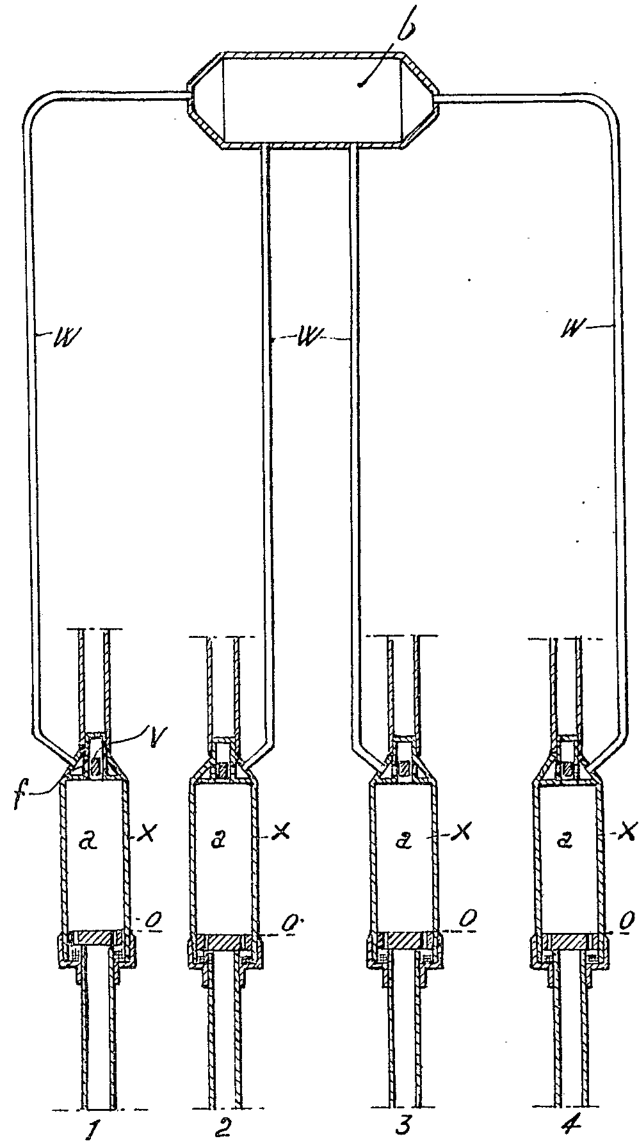


Fig. 5.



Malby & Sons, Photo-Lith