Oct. 9, 1934. G. H. SCHIEFERSTEIN 1,975,978

MEANS FOR TRANSMITTING ENERGY IN OSCILLATORY FORM

Filed March 16, 1932 2 Sheets-Sheet 1

Fig.3.

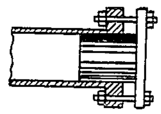


Fig.4.

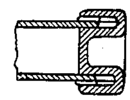


Fig.5

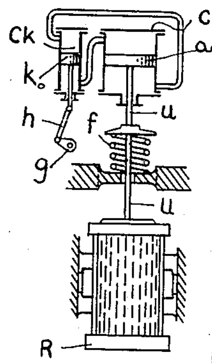


Fig.6.

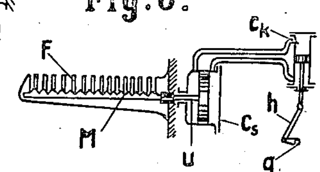


Fig.1.

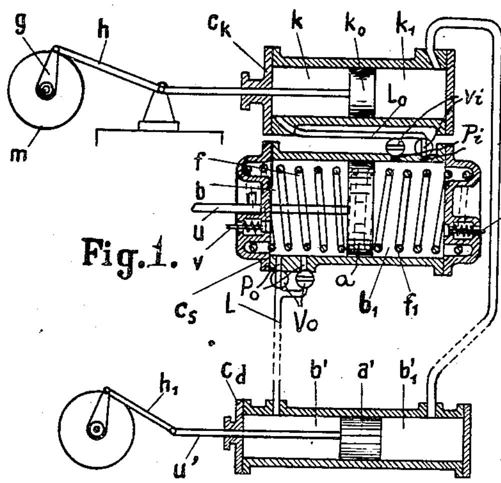


Fig.7.

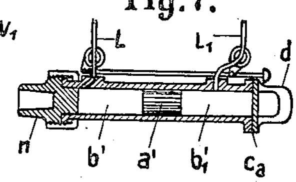


Fig.8.

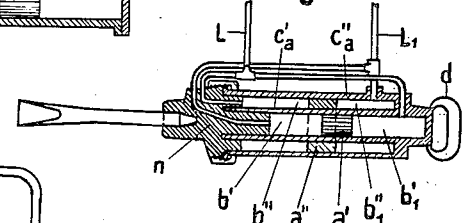
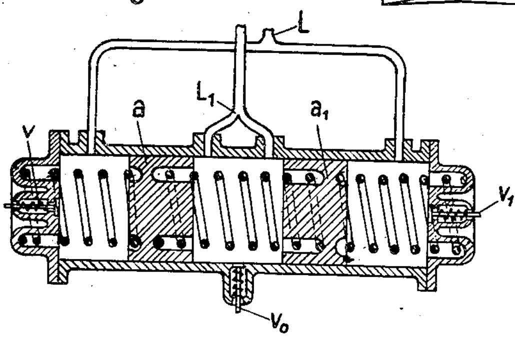


Fig.2.



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Oct. 9, 1934. G. H. SCHIEFERSTEIN 1,975,978

MEANS FOR TRANSMITTING ENERGY IN OSCILLATORY FORM

Filed March 16, 1932 2 Sheets-Sheet 2

Fig. 9.

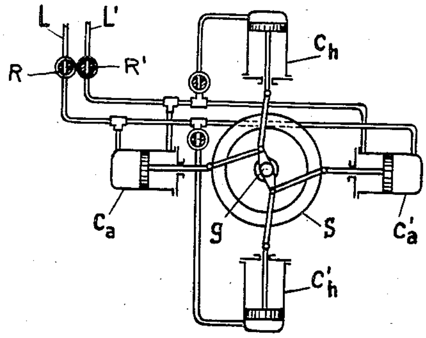


Fig. 10.

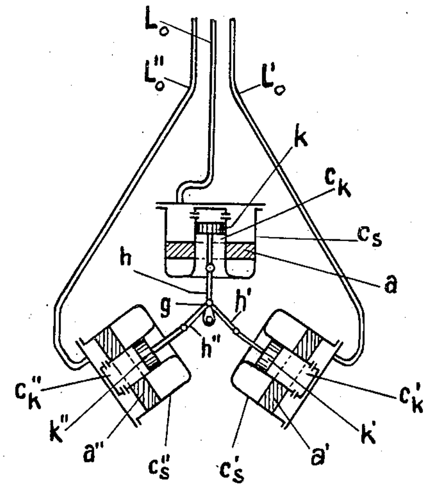


Fig. 11.

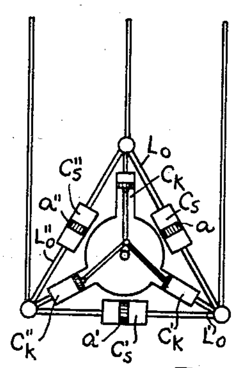


Fig. 13.

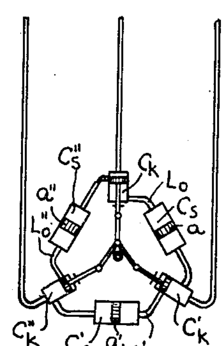


Fig. 15.

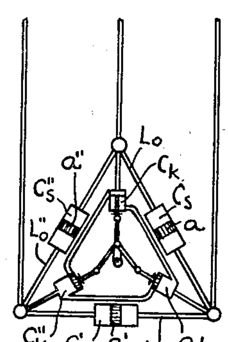


Fig. 12.

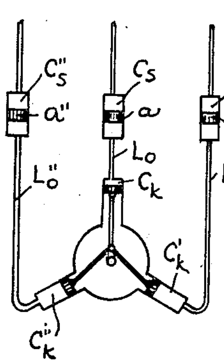
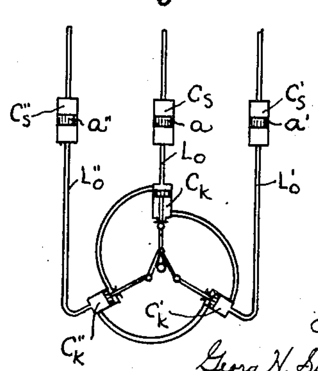


Fig. 14.



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Patented Oct. 9, 1934 1,975,978

UNITED STATES PATENT OFFICE

1,975,978

MEANS FOR TRANSMITTING ENERGY IN OSCILLATORY FORM

Georg Heinrich Schieferstein, Berlin, Germany

Application March 16, 1932, Serial No. 599,326
In Germany October 31, 1924

10 Claims. (Cl. 60—62.5)

This invention relates to means for transmitting energy in oscillatory form.

It is known that mechanical phenomena can be dealt with in exactly the same manner as electrical, by assuming, inter alia, that a self-inductance L is replaced by a mass m, and a capacity C by the elasticity

$$\frac{1}{c}$$

(c representing the mechanical field resistance, equal to the spring force per centimetre).

In many instances, however, this comparison also enables one to ascertain the specific characteristic features of different arrangements that are difficult to differentiate. Thus, for example, devices are employed in the mechanical arts, in which inert masses are reciprocated between elastic means, but cannot be classed with loose-coupled, freely oscillating mechanisms, from which—as can be ascertained by comparison—they differ just as much as the technical low-frequency alternating current does from high-frequency oscillation. It may even be asserted that the difference between the two kinds of movement is more clearly defined in mechanics than in the case of electricity. In electrotechnics, the whole—or pratically the whole—of the amount of energy of the low-frequency alternating current generated, for example, by a dynamo, is uniformly reciprocated—irrespective of the circuit arrangement employed—in a positive manner, with the tempo of the periodicity, whereas the energy generated in any high-frequency generator is first passed to an accumulative unit (oscillatory circuit) in which a multiple of the energy produced per period oscillates, and from which only a fraction may be withdrawn per period. That is to say, in the case of the damped, low-frequency (or positive) type of movement, the entire amount of energy is generated and consumed at each period, whereas in the comparatively slightly damped (or high-frequency) type of movement, a collector is charged from the source of energy, in the first place, in which collector a multiple of the energy generated and consumed per period oscillations, and to which only just as much energy is supplied as is consumed by waste and useful damping per period.

Both in electrotechnics and in mechanics, the said collector is a self-contained unit, and the energy flowing to and fro therein is only in loose connection, both with the source of energy and the point or points of consumption. That is to say, both the source of energy and the point of consumption are loose-coupled with said collector, whereas in the low frequency, (or positive) type of movement the source of energy is, in all cases, close-coupled (i. e. to the extent of 100% or nearly so) with the other part of the device.

Oscillation phenomena can therefore only be termed loose-coupled when, in the entire arrangement, an oscillatory unit is employed as a collector of energy, to which energy, in oscillatory form, is supplied, or withdrawn from, by means of loose coupling.

The present invention, which is based on the discovery that oscillatory units can also be employed, in mechanics, in cases where gaseous or elastic liquid media are used—as open systems, for practical reasons, whereas, on the other hand, couplings can also, in this case, be designed as circuits, in complete analogy with electrotechnics—specifies the technical means for solving the aforesaid problem.

Further features and advantages of the invention will be apparent from the following description and illustrations as shown in the drawings, in which

Fig. 1 is a side elevational view partially in section of an energy transmitting system containing an energy transmitting cylinder, an energy accumulating cylinder, and a working cylinder connected to a single closed circuit;

Fig. 2 is a side elevation in section of an accumulating cylinder in which a pair of pistons move in opposite directions to produce an equalizing action of the masses;

Fig. 3 is a side elevational view, partially in section, of a means for varying the length of the cylinder space;

Fig. 4 is a section of a side elevational view, showing a second modification of a means for varying the length of the cylinder;

Fig. 5 is a side elevational schematic view showing the use of an energy transmitting device for driving a frame saw;

Fig. 6 is a side elevational schematic view illustrating how an energy transmitting unit according to the invention may be used for driving a mowing machine blade;

Fig. 7 is a section of a side elevational view showing the drive of an impact device;

Fig. 8 is a section of a side elevational view showing the drive of an impact device having double pistons;

Fig. 9 is a diagrammatic side elevational view showing the arrangement for driving a shaft by use of a plurality of working cylinders with the aid of starting cylinders;

Fig. 10 is a diagrammatic view showing an arrangement for driving a common drive shaft by use of a mechanical alternating current; and

Figs. 11 to 15 are diagrammatic views of modifications of the arrangement according to Fig. 10.

The open oscillatory unit in mechanics corresponds, therefore, to the electrotechnical closed circuit (oscillatory circuit). On the other hand, the coupling device, both in the open and closed-circuit form, is adapted for practical application in mechanics.

Fig. 1 represents a typical embodiment of such a complete device which consists:

1. Of a generator of mechanical oscillations, formed substantially by a source of energy, such as an electromotor *m* and crank mechanism *g, h;*

2. Of an elastic coupling, consisting of the piston k_0 and the two media, *k* and k_1, enclosed in the (coupling) cylinder c_k;

3. Of the oscillatory unit, consisting of a mass *a* and the elastic media *b* and b_1, also enclosed in a (collecting) cylinder c_s; and finally,

4. Of the energy absorbing (working-) mechanism. This latter may perform hammering or stamping, sawing, embossing, pounding, cutting, or any other kind of work that is in reciprocatory form. It consists substantially of the mass *a'* and the two elastic cushions *b'* and b'_1, which are enclosed in the (working) cylinder c_d.

In order to set in motion the oscillatory unit composed of the mass *a* and the two gas or air cushions *b*, b_1, the piston k_0—the diameter and stroke of which must be in accordance with the damping conditions—is reciprocated by the crank mechanism *g, h*. In this manner the air on either side of the piston k_0 and also of the mass *a*, is alternately compressed and expanded (positive and negative pressure) and consequently a reciprocating movement is imparted to the mass *a*, which, as a freely oscillating system, swings with a wider amplitude at each fresh impulse of energy. This oscillatory unit, therefore, serves, in the aggregation, as an alternating-current compressor. A characteristic differentiating feature between the coupling and the oscillating device consists in their capacity for absorbing energy. In all cases the coupling device can only transmit, at each oscillation, a fraction of the energy which is transformed from the kinetic into the potential form, and vice versa, twice during each period, in the oscillatory unit. The alternating pressure which is thus generated, with the tempo of the natural frequency of the oscillatory unit, naturally occurs also in the conduits L and L_1, and is transmitted, through the air cushions *b'*, b'_1, to the mass *a'*, which, in turn, is enabled to perform useful work of some kind or other, during its reciprocation.

Turning now to the arrangement of the conduit (L_0) which establishes communication between the air cushion *k* in the coupling cylinder and, in the first instance, the air cushion b_1 in the collecting cylinder (oscillatory system), and further between the air cushions *b* and *b'* (L) or b'_1 and k_1. It will be seen that this is not a "mechanical oscillatory circuit"—though it is undoubtedly a closed, energy-transmitting circuit—but a "coupling circuit", that is to say not a circuit in which the entire energy oscillates in a closed form, but a circuit which, during each period, is able to supply to, or withdraw from, the oscillatory system, only a portion of its store of energy, whereas, in itself, the oscillatory system represents a non-closed device composed of mass and elasticity.

As already mentioned, the oscillatory unit itself serves the purpose of storing up in the system a greater amount of energy than is supplied to, or withdrawn from, it. This greater amount of energy oscillating in the system can manifest itself in the form of an increased pressure in the elastic medium, or as an increase in the velocity of the moved masses, or in both forms. Even a diminution of one of the two values can be obtained, according to the dimensioning of the oscillatory unit, but, of course, at the expense of a corresponding further increase of the second value. Consequently, the total energy of the oscillatory unit is always substantially greater than that supplied by the coupling member.

A certain advantage is obtained by introducing, into the interior of the system, directional means, such as two springs *f* and f_1 (Fig. 1), which prevent the mass *a* from beginning to move, while operating under the action of unilaterally introduced small quantities of air. Of course, the elasticity of these springs is additive to the elasticity of the air cushions, so that the resultant elasticity determines the specific frequency of the whole system. Nevertheless, the degree of elasticity of the directing means need only be so arranged that the piston *a* is retained in the midway position.

In order that these elastic means *f* and f_1 may not unduly increase the clearances, the cylinder heads can be designed as shown in Fig. 1, or as in Fig. 2, in which latter case the masses *a* and a_1 are correspondingly recessed. The directing means may also be mounted outside the cylinder as shown in Fig. 5.

Suction valves *v* and v_1 are provided for the replacement of the coupling medium (compression air, gas or liquid) lost through leakages in the stuffing boxes and the like.

Wherever, for reasons connected with the working operations, it is desired for the reciprocating piston *a'* to encounter a cushion of air, the intake or outlet conduits L or L' can be arranged so near the centre as to be closed by the piston, at an earlier or later period, before reaching the end of its stroke. In the coupling cylinder c_s, which has to supply the energy, this is usually unnecessary, though on the other hand, it might often be of advantage in the working cylinder c_d, which may be regarded as a coupling cylinder for the purpose of the withdrawal of energy. However, in certain circumstances, it may be desirable, even in one and the same arrangement, to allow the one side of the piston to encounter an air cushion, whereas useful work, such as beating action, is to be performed at the other side as will be later referred to in connection with the device in Fig. 7.

For the purpose of modifying the degree of coupling, or of the amount of energy to be accumulated in the oscillatory unit, a plurality of intake and outlet passages P_i, P_o may be provided at different distances from the centre and adapted to be closed by cocks V_i, V_o.

Fig. 2 represents an oscillatory unit in which an equilibrium of forces is obtained by the employment of two masses *a* and a_1, oscillating with a phase displacement of 180°. With this object, the coupling conduits L and L_1 are branched, as shown, to lead into the spaces of the collecting cylinder. Suction valves *v*, v_0 and v_1 are provided for replacement of the yieldable energy transmitting medium lost through leakages in the stuffing boxes and the like. This arrangement prevents the transmission of vibrations to the environment.

In order to modify the natural frequency of the oscillatory unit, or the compression in the working cylinders, the cylinder heads may be made adjustable. Fig. 3 shows this adjustment effected by means of flanges and bolts. In Fig. 4, the cylinder head is screwed on to the cylinder, and thus rendered adjustable.

Fig. 5 shows the above described arrangement adapted, for example, for driving a frame saw. R is the frame of a frame saw, which is connected directly with the piston a of the oscillatory unit by means of the piston rod u. c_s is the collecting cylinder and c_k the coupling cylinder in which the coupling piston k_o is actuated from the crank mechanism g, h. The directional means for the oscillatory unit consist of gravity in the downward direction and a spring f in the upward direction.

Fig. 6 shows another typical application, for driving the knife of a mowing machine. The finger bar F is attached to the frame of the mowing machine, whilst the knife M is connected with the piston rod u of the oscillatory unit. Since, in mowing-machine knives, the stroke is shorter but the periodicity is higher than in the case of a frame saw, the cylinder c_s of the oscillatory unit is preferably shorter, but of greater diameter, for operating a mowing machine. The crank mechanism g, h is actuated from one of the wheels supporting the machine, through transmission gear not shown in the figure.

A few other typical embodiments will now be described, in which the energy is drawn from a special working cylinder c_d (Fig. 1), connected in the coupling circuit, and not from the actuated mass of the oscillatory system.

In Fig. 7 for example, the working cylinder c_a is designed so that the whole arrangement can serve as a percussion tool. The passage L_1, which may be fitted with a supply cock or valve, is displaced so far towards the middle of the cylinder that the striker a', reciprocated by alternating pressure, closes the passage before reaching the end of its stroke, and encounters an air cushion, whereas the passage L admits the air to the under side of the striker right at the end of the stroke, or also through the tool holder n which receives the chisel or bit. Percussion tools of this type, however, have a relatively powerful recoil, whether actuated by alternating air pressure or in the uniflow principle, so that the user often suffers injury through the continuous vibration.

A device, constructed on the same principle, but in which the inertia action is completely balanced, is shown in Fig. 8. In this tool, two concentric cylinders c_a' and c_a'', are provided. The inner cylinder c_a' houses a movable striker a', whilst an annular striker a'', of the same piston area, is movably mounted in the outer cylinder c_a''. The mass of both strikers is identical, and the air supply is arranged in such a manner that, when the one striker is subjected to pressure from the right hand side, the other is subjected to a pressure from the left, so that they move in opposite directions, with a phase displacement of 180°. In this case also, the strikers close the inlet passages and encounter an air cushion, before they reach the handle end of the tool, whereas, in the other direction, they strike against the percussion or stamping tool, or on the intermediate member n carrying said tool. This effect can, of course, also be obtained by using strikers of different mass and correspondingly different stroke. For constructional reasons, it may be sufficient for the masses to be not quite completely balanced, for example when it is desired that one of said masses is to give a greater impact than the other, but this does not affect the invention itself. As in the aforesaid instance, the air may be admitted through the said intermediate member, on the one side, and through the tool itself on the other. In this case also, one or more of the air inlet passages may be adapted to be closed—or opened, in starting—by means of valves or cocks.

When the device is employed as a percussion or stamping tool, the working energy is transmitted by the reciprocating mass a of the oscillating column of air, as shown. It is, however, also conceivable that this reciprocating movement can be transmitted to the outside by a piston rod u—Fig. 1—of the oscillatory unit in the cylinder c_s, or by a piston rod u' of the working cylinder c_d. In the former case, the working cylinder may, of course, be entirely dispensed with, and the conduit L_1 may be connected with L_1 directly in rear of the oscillatory unit. The piston rod u in turn, may then be employed to actuate a frame saw, jig screen, mowing machine knife or a ratchet mechanism, etc.

Moreover, it is possible to supply, from a single oscillatory system a, b, b' of sufficient dimensions, a plurality of working cylinders intended to transmit portions of the energy.

On the other hand, it is possible to allow the piston a' to act on the crank of a drilling tool, or similar machine, through the agency of the piston rod u' and connecting rod h'. In this manner, an alternating flow pneumatic motor is obtained, which, of course, may be of single- or multi-cylinder design.

Fig. 9 shows an alternating-flow motor with two double-acting working cylinders c_a and c_a', acting on a common crank shaft g with cranks set at 180° and adapted to be fitted with a flywheel S.

The two conduits L and L', which, on the provided cocks R and R' being opened, are traversed by an alternating current of air (mechanical alternating current), are connected to the working cylinders, as shown. Inasmuch as such a motor behaves like an alternating-current motor—that is, does not start unassisted—it is provided—after the manner of the auxiliary means adapted for alternating current motors—with the two single-acting auxiliary cylinders c_h and c_h', disposed at right angles to the working cylinders. They may, however, be replaced by one, double-acting auxiliary cylinder, suitably connected with the two conduits. The auxiliary cylinders are preferably of smaller dimensions than the main cylinders. When the motor has attained its normal working speed, the auxiliary cylinders are put out of action by closing the cocks, and the motor continues to run in synchrony, though it may fall out of step, like a monophase synchronous motor, in the event of a considerable overload.

In a similar manner and by suitable arrangement, mechanical polyphase current can be produced, and corresponding mechanical polyphase motors actuated. Fig. 10 is a diagrammatic representation of the requisite arrangement for a triple-cylinder generator of mechanical polyphase current, and serving, at the same time as an example of a merely single-acting arrangement of the subject of the invention. In this case, the coupling cylinders c_k, c_k' and c_k'' are built into the collecting cylinders c_s, c_s' and c_s'', the pistons of which are designed as annular masses, and the three resulting cylinder units are offset at 120° about a common crank g. The coupling cylinders communicate with the collecting cylinders through passages L_o, L_o' and L_o''.

As a matter of principle, the collecting cylinder may, of course, also be separated from the coupling cylinders, as shown in Fig. 1, in which case the connections can be arranged, for example, in the following manner:—

When coupling cylinders, open at one end, are employed, they may, with advantage, be disposed in star connection (Fig. 11), and the collecting cylinders be arranged parallel to the coupling cylinders.

In Fig. 12, coupling cylinders, open at one end in star connection, are again employed, the collecting cylinders on the other hand, being disposed in the conduits themselves. Consequently, both types of cylinders are connected in series.

In Fig. 13, double-acting coupling cylinders, in triangular connection, are employed, the collecting cylinders being disposed in the connecting conduits, that is, in series connection with the first-named cylinders.

Fig. 14 shows the same method of connection of the coupling cylinders, but with the collecting cylinders disposed in the conduits, after the manner of Fig. 12.

Finally, Fig. 15 shows both the coupling and collecting cylinders in triangular connection, parallel to one another.

The entire omission of control devices is inherent in the principle of the alternating movement. That is to say, whereas mechanisms that are operated by pneumatic pressure on the ("direct-current") uniflow principle must be provided with control devices, a simple tube, containing a close-fitting mass in the form of a piston will suffice—in the region of mechanics—to actuate a piston by the aid of an alternating flow, being reciprocated by said flow, even without any controlling device or the like.

Consequently, all the mechanisms are quite simple, and also light and inexpensive, since the control parts in the working member are not moved with it, and, of course, must not be taken into consideration with it.

Moreover, in the case of large outputs, such as a large number of tools working simultaneously, the alternating-current system does not require the large accumulators needed for the uniflow system, and, in addition, the readiness with which the tools become frozen up by a gaseous material expanding in a single direction, is eliminated because, in all cases, an expansion period is followed by a compression period of equal energy.

I claim:

1. In an apparatus for the transmission of energy, the combination of a plurality of units each comprising a cylinder and a piston movably arranged in the cylinder, a closed circuit containing elastic fluid columns, all cylinders being connected to said closed circuit in such a manner that upon pulsating motion of the said elastic fluid columns the said pistons are put in reciprocating motion and vice versa, means for putting one of the pistons in reciprocatory motion, means for imparting the reciprocatory motion of another piston to an energy absorbing mechanism, a mechanically oscillatory unit which consists of a mass comprising one of said pistons and of elastic means comprising elastic fluid, the said pistons being so shaped and operated that under operating conditions the relation between the volume displaced by the piston forming part of the mechanically oscillatory unit and the volume displaced by the other or by each of the other pistons corresponds to the relation between the amount of energy accumulated in the mechanically oscillatory unit and the amount of energy going through the mechanically oscillatory unit in each period, the mass and elasticity of the fluid columns contained in said circuit being such that the natural frequency of said columns lies beyond the frequency of operation.

2. In an apparatus for the transmission of energy, the combination of a plurality of units each comprising a cylinder and a piston movably arranged in the cylinder, a closed circuit containing elastic fluid columns, all cylinders being connected to said closed circuit in such a manner that upon pulsating motion of the said elastic fluid columns the said pistons are put in reciprocating motion and vice versa, means for putting one of the pistons in reciprocatory motion, means for imparting the reciprocatory motion of another piston to an energy absorbing mechanism, means for modifying the amount of the transmitted energy, a mechanically oscillatory unit which consists of a mass comprising one of said pistons and of elastic means comprising the said elastic fluid, pistons being so shaped and operated that under operating conditions the relation between the volume displaced by the piston forming part of the mechanically oscillatory unit and the volume displaced by the other or by each of the other pistons corresponds to the relation between the amount of energy accumulated in the mechanically oscillatory unit and the amount of energy going through the mechanically oscillatory unit in each period, the mass and elasticity of the fluid columns contained in said circuit being such that the natural frequency of said columns lies beyond the frequency of operation.

3. In an apparatus for the transmission of energy as defined by claim 1 in which three units are provided, the piston of the first unit being connected to a driving mechanism, the piston of the second unit forming part of the mechanically oscillatory unit, the piston of the third unit being connected to an energy absorbing mechanism, all units being connected to the closed circuit in series.

4. In an apparatus for the transmission of energy as defined by claim 1, in which the cylinder of the mechanical oscillatory unit is provided with two pistons operated with a phase displacement of 180°, the corresponding spaces of the said cylinder being connected to the closed circuit by branched pipes.

5. In an apparatus for the transmission of enegy as defined by claim 1, in which the cylinders of some of the units are subdivided in two concentric chambers for receiving two separate pistons operated with a phase displacement of 180°, the corresponding spaces of said chambers being connected to the closed circuit by branched pipes.

6. In an apparatus for the transmission of energy as defined by claim 1, in which for the purpose of asymmetrical energy transmission the cylinder of a unit imparting reciprocatory motion to an energy absorbing mechanism is connected to the closed circuit on that side in which the useful work is given up by means of a channel opening in the neighborhood of the cylinder cover, while the connecting channel on the other

side of the cylinder is periodically covered by the piston so as to form an enclosed cushion accumulating energy in one of the limiting positions of the piston.

7. In an apparatus for the transmission of energy as defined by claim 1 in which a plurality of separate closed circuits are provided which are equally displaced with regard to energy transmission and each being connected to a plurality of units, the piston of each one of the units connected to the separate circuits being connected to a common power transmitting shaft with a displacement corresponding to the phase displacement within the separate circuits.

8. In an apparatus for the transmission of energy as defined by claim 2 in which the means for modifying the amount of the transmitted energy consists in that the cylinder of the mechanically oscillatory unit is provided with a plurality of inlet passages located at different points along its axis and controlled by valves by means of which the piston of the mechanically oscillatory unit is periodically isolated in such a manner that it comes into contact with the closed elastic fluid cushions.

9. In an apparatus for the transmission of energy as defined by claim 2 in which the means for modifying the amount of the transmitted energy consists in that the heads of some or all cylinders are arranged so as to be axially displaceable in order to vary the capacity of such cylinders.

10. In an apparatus for the transmission of energy as defined by claim 2 in which the means for modifying the amount of the transmitted energy consists therein that the closed circuit is provided with regulating valves for changing the pressure of the elastic fluid contained in the said circuit.

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