

51 The motor may be constructed for any de-
 sired power and speed and especially suit-
 able for giving a lower speed of rotation
 than the synchronous speed of the generator
 5 of the wave transmission line.

In the form of the invention shown in
 Figs. 6, 7 and 8, the mechanical ratchet is
 replaced by a friction clutch actuated from
 the wave transmission line. The rotor shaft
 10 21 carries a double coned member 22 adapt-
 ed to be engaged by either of the two cone-
 shaped clutch members 23, 24. The clutch
 members 23, 24 are oscillated in their planes
 by connecting rods 25, 26, attached to a pis-
 15 ton 27 which is actuated by the pressure in
 the wave transmission line, the piston 27 be-
 ing supported in a mean position by the
 springs 28, 29, which should be of such
 strength that the piston in its mean position
 20 is in equilibrium under the action of the
 springs to the mean pressure in the line.

The shaft 21 is capable of sliding a short
 distance in a longitudinal direction and its
 movement in this direction is controlled by
 25 a double acting piston 31, the lower end of
 which through the passage 32 is directly con-
 nected to the wave transmission line while
 its upper face is subjected to the pressure ex-
 isting in the chamber 33. The liquid passes
 30 into this chamber by leakage passed from
 the piston 31 with the result that the pressure
 in the chamber is practically constant and
 equal to the mean pressure in the wave trans-
 mission line.

35 It will be seen therefore that as the lower
 side of the piston is subjected to the full va-
 riations of pressure in the transmission line
 an oscillating motion will be given to the
 shaft 21. The effect of this is that when the
 40 shaft is pressed upward, that is, when there
 is an increase of pressure in the transmission
 line, the double conical piece 22 will engage
 with the clutch member 23. For increase in
 pressure in the wave line, therefore, the
 45 clutch member 23 being actuated by the pis-
 ton 27 will drive the shaft. When the pres-
 sure in the transmission line is below the
 mean pressure, the pressure above the piston
 31, being greater than the pressure in the
 50 line, will drive the shaft 21 downward, dis-
 engaging the member 22, from the member
 23 and causing it to engage with the member
 24. During this half period the pressure is
 decreasing the main piston moving away
 55 from the shaft 21.

It will thus be seen that the shaft 21 will
 be given a unidirectional drive, the clutch
 members being so arranged that during the
 movement of the piston 27 toward the shaft
 60 the driving is effected by the clutch member
 23 while when the piston is moving away
 from the shaft the driving is effected by the
 clutch member 24.

It will be seen that many variations in the
 65 construction above described are possible;

for instance instead of the chamber 33 a
 spring might be employed adjusted to press
 the shaft downward with a constant pressure
 equal to the mean pressure in the wave
 transmission line. A spring, however, would
 70 give rise to difficulty as it would require an
 absolutely constant mean pressure in the
 main line or an adjustment of the spring ac-
 cording to the pressure in the line.

If desired, instead of a chamber filled 75
 with liquid the piston moving the shaft
 longitudinally may be put into communi-
 cation with a wave transmission line differ-
 ing in phase by 180 degrees from that driv-
 ing the main piston, and in this case the 80
 motor would operate in a similar manner
 to that above described.

If two lines are employed, the main pis-
 ton also may be made double-acting, one side
 being connected to each phase of the trans- 85
 mission line. In this type of motor it is
 desirable that the oscillating parts should
 be kept light in order to avoid any ap-
 preciable variation of phase between the
 pressure in the wave transmission line and 90
 the angle of oscillation of the stator mem-
 bers. If the oscillating parts are heavy
 they should be balanced by two springs act-
 ing in opposite directions and calculated so
 as to form a condenser adapted to counter- 95
 act the effects of inertia.

The simple clutch illustrated in Figs. 6,
 7 and 8 is only suitable for comparatively
 small powers. For large machines driving
 heavy loads a hydraulic clutch is more suit- 100
 able; for instance the rotor member may
 carry a number of pistons actuated by an
 eccentric or corrugated track carried by the
 driving member. The pistons pumping
 liquid among themselves through a special 105
 distributing valve are adapted to cut off
 the communication between one set of pis-
 tons during one half period and to open the
 communication between these pistons dur-
 ing the next half period. An example of 110
 motor of this type is illustrated at Figs. 9
 and 10. In this motor the driven shaft 41
 carries a block 42 in which work two sets
 of pistons 43, 44. These pistons work in
 cylinders uniformly distributed around the 115
 axis of the shaft and the two sets of pistons
 are in communication among themselves
 through apertures 45, 46 respectively. A
 piston 47 is provided capable of moving in
 the axial direction, this piston being pro- 120
 vided with passages 48 by which liquid can
 pass to both sets of cylinders in the rotor.
 The piston is hollow and is supplied with
 liquid through the inlet 49. The inlet 49 is
 125 connected to a chamber filled with liquid or
 to one phase of a two-phase line while the
 other phase of the transmission line is con-
 nected to the inlet 50 so that the alternating
 pressure acts on the outer end of the
 piston 47. 130

It will be seen that with this construction the alternations in the wave line cause a reciprocation of the piston 47, so that during successive half periods each set of pistons in the rotor is put into communication while the other set is cut off from communication by the piston 47. Surrounding the pistons of the rotor are two eccentric or suitably shaped races 51, 52 connected with reciprocating members 53, 54, these members being reciprocated by pairs of pistons 55, 56, held in a mean position by means of springs and subjected at their two ends to alternating fluid currents from two transmission lines one transmission line being connected to the inlets 57, 58, while another is connected to the inlets 59, 60, the two wave lines differing in phase from each other by 180 degrees.

Instead of tracks of the form illustrated which may be called a two-pole track the track may be shaped with more poles, that is to say in such a manner that for one revolution of the rotor two or more impulses are given to the rotor pistons.

The operation of this motor is similar to those above described, the clutching of the oscillating member to the rotor being effected by the fluid pressure on the rotor pistons at the correct periods to produce continuous rotation in one direction.

It will be seen that this type of motor also is capable of considerable modification; for instance, a single group of pistons alone may be employed, but in this case the torque will not be so uniform; the rotor would be driven during half period only and if the load is such that it can recoil it may be necessary to use a heavy flywheel or ratchet device to prevent reversing of the rotor.

It will be seen that this type of motor may be built with pistons moving parallel to the rotor shaft, the operation being similar to that above described. In this manner very large motors may be built having any speed below the synchronous speed of the generator. If higher speeds are required multiplying gearing may be employed, but such motors would rarely be required and the method is more adapted for small powers.

In the form of the invention shown in Figs. 11, 12, 13 and 14, the stator pistons 61, and rotor pistons 62, work parallel to the rotor shaft 100. The oscillating members of the stator are actuated in the same manner as 51 and 52 of Fig. 10 and consists of disks 63, 64, capable of oscillation in their planes and having on their side faces corrugations, a developed view of which is shown at Fig. 12. There are two sets of stator pistons 61, 61^a, and two sets of rotor pistons 62, 62^a. The stator pistons are arranged in cylinders shown in plan at Fig.

13 and are arranged in two groups of four each as illustrated. The pistons of the group 61 are connected in parallel through pipe connections 65, 66, with one wave line, while the group 61^a are connected through pipe connections 67, 68, to a second wave line differing in phase from the first by 180 degrees, or are connected to a suitable chamber filled with liquid.

The corrugated track on the oscillating members 63, 64, is such that when an alternating pressure is applied to the two groups 61, 61^a, an angular oscillation of the members 63, 64, is produced whose amplitude is about equal to the angle $\frac{\alpha}{2}$ Fig. 13.

Similar tracks are provided on the rotor sides of the members 63, 64, and the pistons on this side are free or locked against rotation relatively to the track by the distributor piston 47 operating in a manner similar to that described with reference to Fig. 10.

The outlets 69, 70, are connected, like 50 and 49 of Fig. 10, to the two wave lines feeding the stator pistons or one of them, 70, may be connected to a chamber which may be the same as that used with one of the stator groups of pistons.

It will be seen that this type of motor may have any desired ratio speed to the periodicity of the wave line the reduction depending upon the angle α between the two groups of pistons, 61, 61^a.

For high speed machines these groups may be reduced to a single piston for a group, the corrugation being reduced to a simple inclined plane working as a swash-plate. In this case the angular oscillation of the members 63, 64, is about 180 degrees and the speed of the rotor would be nearly the synchronous speed of the wave line.

Instead of using a distributor positively driven by the alternating pressures in the wave line, an automatically driven distributor may be used adapted to close communication between the rotor pistons on one group 62, and close the communication between the rotor pistons of the other group by the change of direction of oscillation of the stator members.

Other methods of operating the distributor may be employed, for example, the rotor may be formed as a simple rotating member carrying only the tracks for the piston, and the pistons may reciprocate in the stator oscillating members, and in such case each of the stator members may have an independent distributor operating by inertia, closing the passages between the cylinders in which the pistons work when the oscillation is in one direction, and opening these passages when the oscillation is in the opposite direction.

Instead of a distributor operated by iner-

tia, a distributor operated by friction may be employed. A motor having such an inertia driven distributor is shown in Figs. 15, 16 and 17. The stator in this case includes two pairs of pistons 80, 81, only one pair being illustrated; the figure is cut off centrally, the lower half being exactly similar to the upper half. The pistons 80, 81, of the stator are not exactly diametrically situated, but are so placed that the two planes passing through the axis of the rotor and the axes of the two pistons are inclined to each other at an angle somewhat less than 180 degrees, say 170 degrees. The bolts 101 of pistons 80, 81, bear against a track 83, which consists of a simple inclined plane rigidly fixed to the stator oscillating member 84. This member carries three pistons 85, working in cylinders which communicate through narrow slots 86. This communication, however, can be periodically cut off by a rotating sleeve 87 fitting around the rotor shaft 88 and having slots corresponding with the slots 86. At one position of the sleeve relatively to the oscillating member 84 communication is allowed between the cylinders in which the pistons 85 work through the slots and the annular space 89. The small passage 90 is provided along the axis of the rotor shaft 88 and liquid under the mean pressure of the wave transmission line is admitted to this passage by the connection 91. To obtain this mean pressure, it is only necessary to connect the transmission line to the passage 90 by a pipe of very small bore whose friction is sufficiently great to prevent variation in the pressure of the liquid admitted to the cylinders 92. The cylinders are thus filled with liquid at the mean pressure of the wave transmission line.

The pistons 85 act on a track 93 on the rotor. This track consists merely of an inclined plane rigidly fixed to the rotor shaft on a flange 94. The sleeve 87 carries three brackets 95 which support a ring 96 forming a certain inertia against the angular oscillation of the sleeve.

The operation of this motor is as follows:—

The pistons 80, oscillating under the alternating impulses produce an angular oscillation of the stator member 84 with an amplitude approaching 180 degrees, in the case assumed the amplitude is 170 degrees. During this oscillation the cylinders 92 impinge against the brackets 95 of the sleeve 87 and the effect of the inertia of the ring 96 is to close and open alternately the passages 86. When the passages 86 are open during a half oscillation the pistons 85 are free to move in their cylinders and thus will simply roll over the track 93 without affecting the rotor. During the next half oscillation,

however, the apertures 86 are closed and the pistons 85 are locked against the track 93 and thus cause the rotor to rotate during the half revolution.

As the machine is built symmetrically on its upper and lower halves, the stator pistons of the lower half being so placed that they oscillate their stator member in the opposite directions to that in which the stator member 84 of the upper half oscillates, the rotor shaft would be picked up by the lower stator member during the half period it is left free by the upper stator member. In this way the rotation is always in one direction, as in the previous modification.

The motor shown in Figs. 15, 16 and 17 rotates at nearly the synchronous speed. Any lower speed may be obtained by arranging the stator pistons at a smaller angle than 180 degrees and suitably shaping the track 83. The thrust bearing 97 illustrated is provided to take up the thrust coming from the mean pressure acting on the unbalanced area of the wall of the sleeve and the pressure due to leakage between the sleeve and shaft. If small holes are perforated in the member 84 above the sleeve the thrust bearing may be dispensed with.

Instead of providing an inertia ring 96, this may be made quite light and restrained by a constant frictional force in the nature of a light brake, sufficiently strong to insure relative rotational slip between the sleeve and the stator member.

What I claim is:—

1. A rotary motor comprising: means for receiving and utilizing an alternating fluid current including an oscillating member, a rotor, and unidirectional driving means driving said rotor in a constant direction from said oscillating member.

2. A rotary motor comprising: means for receiving and utilizing an alternating fluid current including an oscillating member, a rotor, a driving device for said rotor actuated by said oscillating member, a clutch interposed in said driving device, and means actuated by the alternating fluid current for operating the clutch.

3. A rotary motor comprising: means for receiving and utilizing an alternating fluid current including a pair of oscillating members, a rotor, and means for connecting said rotor alternately with each of said oscillating members to produce unidirectional rotation of said rotor.

4. A rotary motor comprising: means for receiving and utilizing an alternating fluid current including a pair of oscillating members, a rotor, and clutch means, actuated by said alternating fluid current, for connecting and disconnecting said rotor alternately with each of said oscillating

members to produce unidirectional rotation of said rotor.

5 5. A rotary motor comprising: means for receiving and utilizing an alternating fluid current including a pair of oscillating members, a rotor, and clutch means for connecting and disconnecting said rotor alternately with each of said oscillating members to

produce unidirectional rotation of said rotor, said clutch means including pistons actuated by said alternating fluid current and cooperating corrugated tracks on said oscillating members.

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

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G. CONSTANTINESCO.
TRANSMISSION OF IMPULSIVE FORCES THROUGH LIQUIDS.
APPLICATION FILED JULY 23, 1917.

1,334,282.

Patented Mar. 23, 1920.
4 SHEETS—SHEET 1.

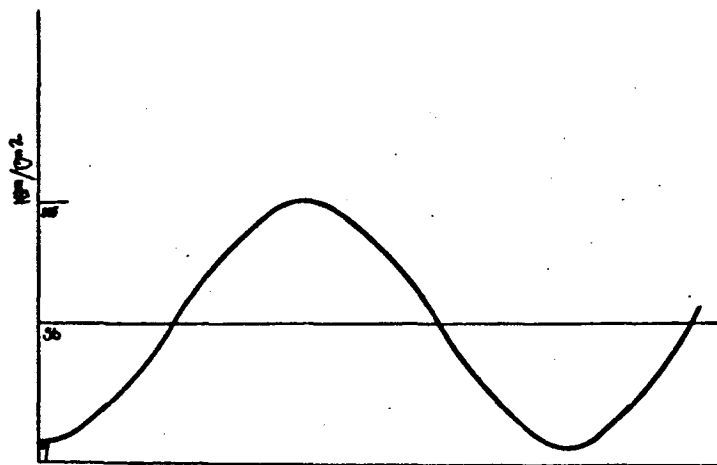


Fig. 1

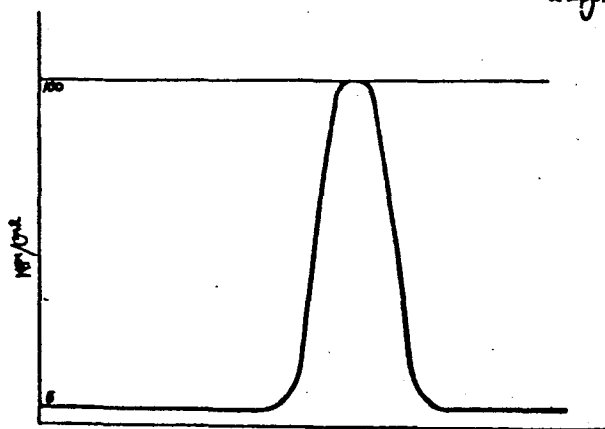


Fig. 2

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4 SHEETS—SHEET 2.

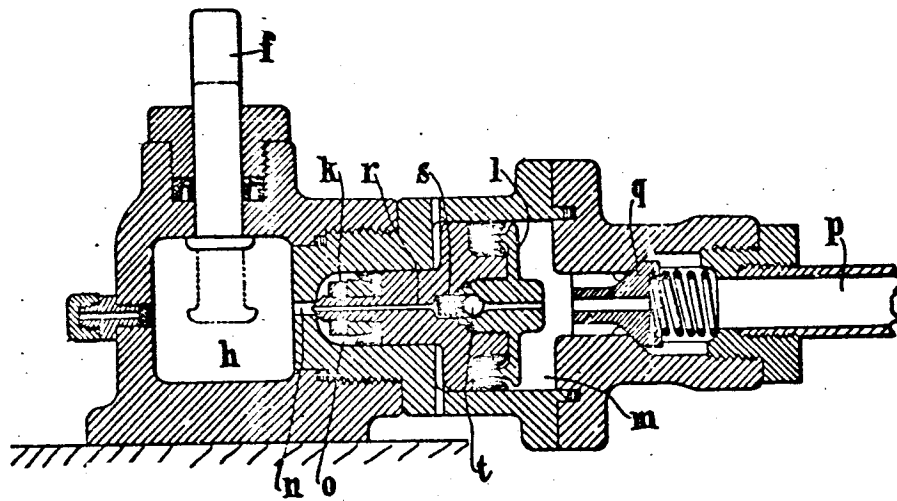


Fig. 4.

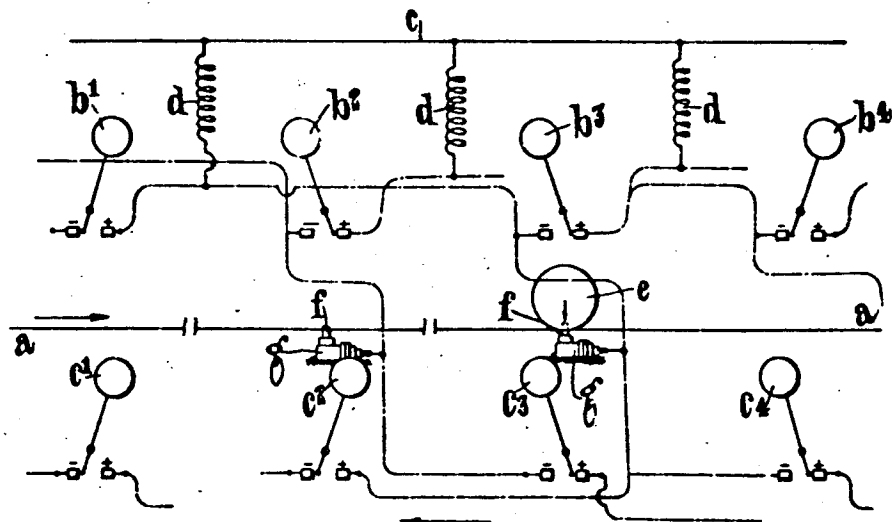


Fig. 3.

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by

Arthur Becken

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Patented Mar. 23, 1920.
4 SHEETS—SHEET 3.

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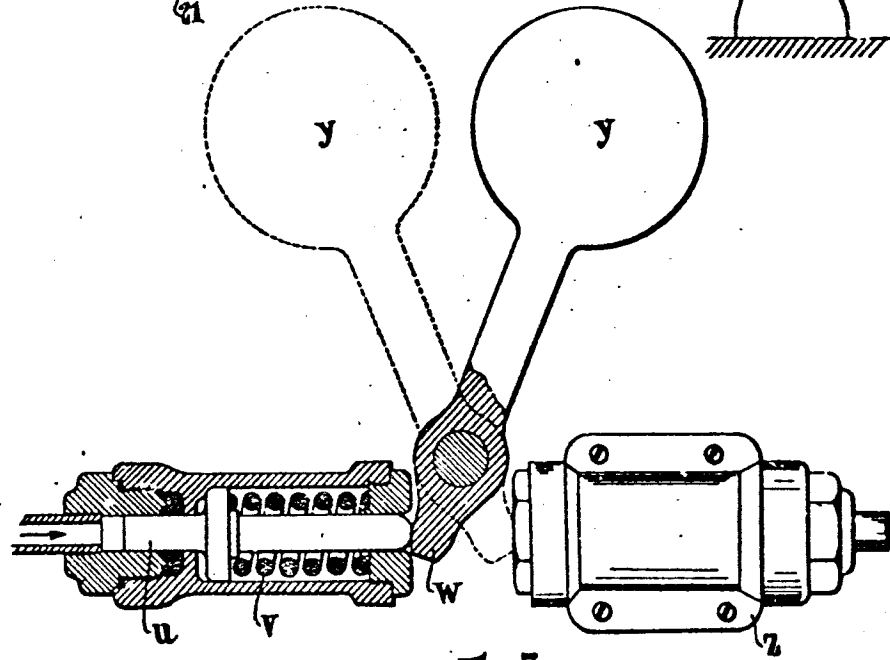
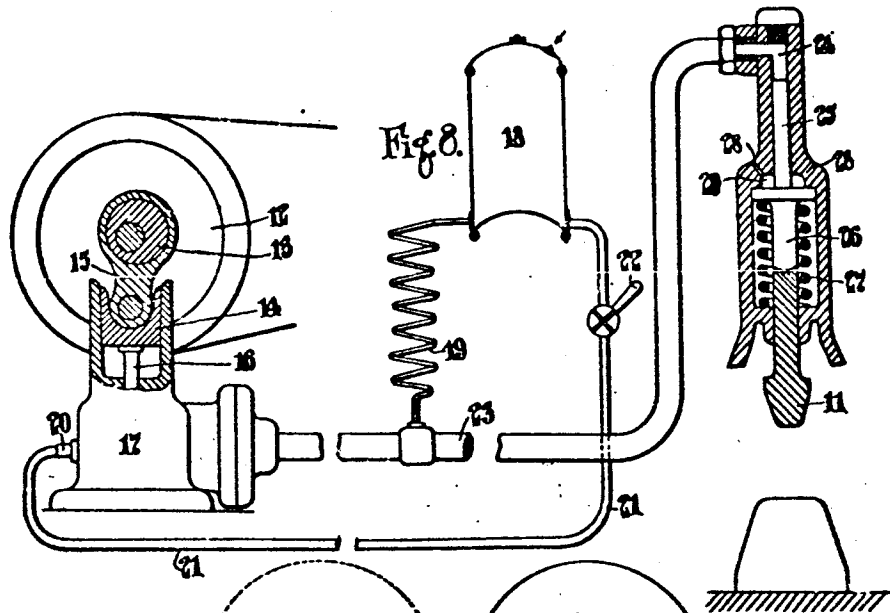


Fig. 5.

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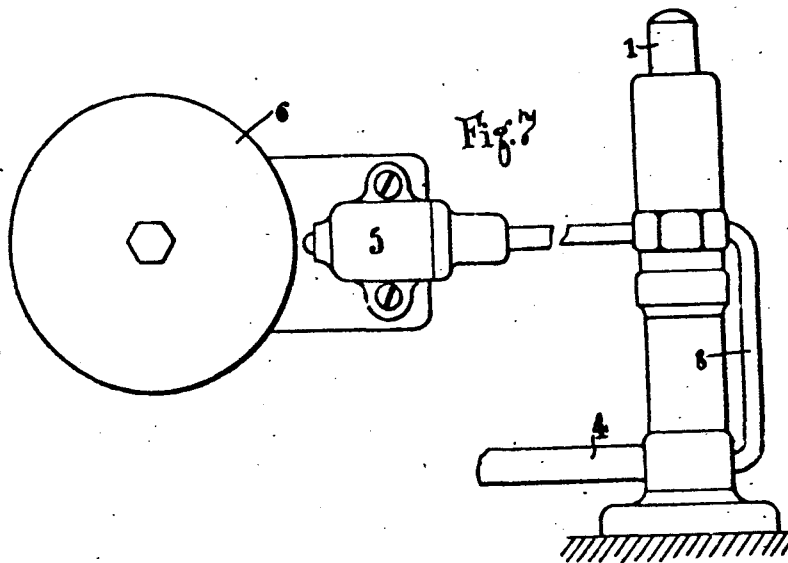


Fig. 7

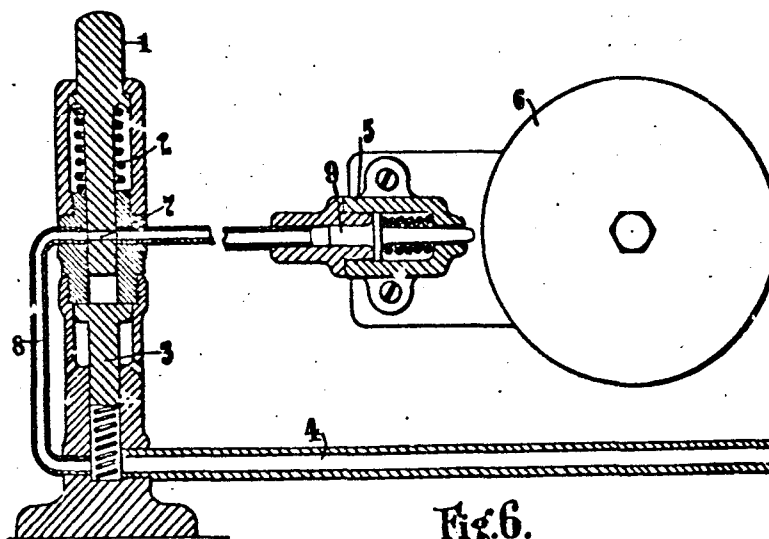


Fig. 6.

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UNITED STATES PATENT OFFICE.

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TRANSMISSION OF IMPULSIVE FORCES THROUGH LIQUIDS.

1,334,282.

Specification of Letters Patent. Patented Mar. 23, 1920.

Application filed July 23, 1917. Serial No. 182,206.

To all whom it may concern:

Be it known that I, GOGU CONSTANTINESCO, a subject of the King of Great Britain and Ireland, residing at "Westoe," Stanley avenue, Alperton, in the county of Middlesex, England, have invented certain new and useful Improvements in the Transmission of Impulsive Forces Through Liquids, of which the following is a specification.

The present invention relates to the transmission of impulsive forces through liquids from one point to another.

In British Letters Patent No. 9,029 of 1913, there is described a method of transmitting power by wave motion in liquids by means of a series of periodic changes of volume and pressure traveling along a liquid column, and apparatus is therein shown and described for transmitting changes of volume and pressure of harmonic form.

Referring to the accompanying drawings:

Figure 1 is a diagram illustrating the type of pressure wave described in British Patent Specification No. 9,029 of 1913;

Fig. 2 is a diagram showing the type of wave produced according to the present invention;

Fig. 3 is a diagram showing the application of the invention to the operation of a railway signaling system;

Fig. 4 is a section of a suitable form of impulsive wave generator for use in the system;

Fig. 5 shows a signaling instrument adapted to be used in the railway signaling system illustrated;

Fig. 6 shows a ship's telegraph device in section, while

Fig. 7 is an elevation showing a similar ship's telegraph, one instrument being employed, say, on the bridge and the other in the engine room of a steamship;

Fig. 8 shows the application of the invention to the operation of a hammer.

The type of wave which we have heretofore generated by the method and apparatus described in the said Letters Patent is shown in Fig. 1 of the accompanying drawings, where the abscissæ of the curve represent distances from the source of energy and the ordinates represent the pressures at the different points along the pipe at any particular time.

The type of wave produced according to the present invention is diagrammatically illustrated in Fig. 2 in which there is a rapid rise of pressure above the mean pressure. The abscissæ of the curve represent the distances along the pipe from the source of energy while the ordinates represent the pressures at different points along the length of the pipe at any particular time. It will be seen from a comparison of the figures that in the first case a mean pressure of greater than half the amplitude of the pressure variation is required, while in the latter case the mean pressure need only be slightly above atmospheric pressure.

The invention is especially applicable to cases in which it is required to transmit considerable forces acting only during a very short time at a receiver situated at a distance from the generator.

It will be seen that in transmitting impulses according to this invention as in the case of the wave transmission described in our Letters Patent above mentioned, the transmission of the energy is not instantaneous but a time interval elapses between the generation of the wave at the generator and its reception at the receiver, this time being equal to the time which would be taken by the wave to travel from the generator to the receiver in the liquid considered.

It is extremely difficult to design a receiver to take up the whole of the energy of the forward traveling wave.

Should it happen that the energy of the wave is not entirely absorbed by the receiver there is danger that the wave is reflected back toward the generator and again reflected toward the receiver, thus giving a second impulse on the receiver piston, and it has been found that three or more such reflections may occur with the result that instead of one impulse on the receiver several impulses may be obtained from a single wave from the generator. It is, therefore, in most cases essential to destroy the reflected wave as soon as it starts back from the receiver. This may be effected as follows: Between the receiver and the transmission line we insert a check valve giving a free passage to the flow of liquid from the line toward the receiver, but considerable friction in the opposite direction. This may

be effected by making a small permanent opening in the valve. The valve would close on its seat on the return of the wave from the receiver and the energy of the wave 5 would be destroyed as the liquid passes through the small hole in the valve. The introduction of this reflected wave absorber alters completely the conditions of the liquid wave, and in apparatus we have tested 10 with a 3 meter length of transmission line while without the absorber the amplitude of the second reflected wave as nearly 70 per cent. that of the first wave and a third reflected wave was of amplitude of 30 per cent. of that of the first wave, when the reflection absorber was inserted no trace of the reflected waves was noticeable.

For some practical applications it is practically always necessary to introduce a reflection absorber owing to the extreme difficulty of regulating the strength of the wave exactly in accordance with the work done by the receiver. Only in cases in which the line is extremely long and the loss due to friction considerable, is it possible to neglect the reflected wave which in such case is sufficiently damped and is extinguished before it again reaches the receiver.

In the application of the invention to railway signaling as illustrated in the example given in the Figs. 3, 4, 5, and in which there is diagrammatically represented a railway line *a* having on one side a series of signals b^1 b^2 b^3 b^4 for trains running in one direction, and on the other side a series of signals c^1 c^2 c^3 c^4 for trains running in the other direction. In the neighborhood of each pair of signals b^1 c^1 , b^2 c^2 , b^3 c^3 , and b^4 c^4 , there is provided a wave generator *g* shown in section in Fig. 4, adapted when the wheel of the train runs over it to send impulsive waves along liquid wave transmission lines connected to signal motors illustrated in Fig. 5 and arranged to operate certain of the signals according to the direction and position of the train on the line. Each of the signal motors is capable of operating a signal in either direction from the "line clear" position to the "danger" position, or 50 from the "danger" position to the "line clear" position.

In the diagram shown in Fig. 3, assuming a train is moving from left to right in the direction of the arrow, and assuming that it has reached the position indicated by the wheel *e* opposite the signals b^3 c^3 , before the wheel reached the instrument *g* at b^3 c^3 , the signals b^3 b^4 were in the "line clear" position and the signals b^1 b^2 in the "danger" position while on the other side of the line the signals c^4 c^1 were in the "line clear" position and the signals c^2 c^3 in the "danger" position; on the train reaching the generator opposite b^3 c^3 the plunger *f* is 65 actuated and sends an impulsive wave along

the transmission line, as indicated, to the signals b^1 and b^2 and also to the signals c^3 and c^4 .

The effect of the impulses thus sent to the signaling instruments is to move the signal b^3 from "line clear" to "danger" and to move the signal b^1 from "danger" to "line clear" so that two signals stand at "danger" in front of an overtaking train. On the other side of the line the effect of the wave sent is to put the signal c^3 from the "danger" position to the "line clear" position and to put the signal c^4 from the "line clear" position to the "danger" position. The signals c^3 c^4 shown in the "danger" position in the diagram should in order to secure safety for the trains in both directions in the same line, be one block ahead of that illustrated. The arrangement of the connections, however, forms no part of the present invention 85 as different systems of signaling may be employed using the impulsive impulses traveling along liquid columns.

Separate generators may be provided at the different signal stations for trains moving in the opposite direction to that above described, and the means for operating these devices may be so arranged that a train passing in one direction operates one set of generators while a train passing in the opposite direction operates another set of generators.

In the impulse generator illustrated in Fig. 4 there is provided a plunger *f* working in a chamber *h* and adapted to be actuated by a blow on its upper end. The diameter of the plunger may be about two centimeters, which will be suitable if the impulse is produced by a weight of three tons passing over the upper end of the plunger. The forcing in of the plunger will produce a pressure of about 1000 kilograms per square centimeter in the chamber *h*. The pressure in the chamber *h* acts on the end of a conical valve *k* having at its other end a piston *l* working in a chamber *m* of considerably greater diameter than the aperture *n* or intermediate chamber *o*. The chamber *m* is connected to the transmission line *p* through a wave absorbing device *q* intended to absorb the reflected waves, and liquid is fed into the wave transmission line at a mean pressure of about 5 kilograms per square centimeter. An aperture *r* is bored through the piston and valve *k*, *l*, and in an enlarged chamber *s* in the passage *r* there is provided a spring ball valve *t*.

The operation of this apparatus is as follows:—

On forcing down the plunger *f* the pressure rises in the chamber *h* to a very high value and this pressure acting on the ball *t* overcomes the pressure in the line so that the whole of the differential piston and valve *k*, *l*, moves forward; immediately the 130

conical valve leaves its seat the pressure in the chamber *k* can act on a very much larger area of piston, acting over the whole of the diameter of the chamber *o*. The effect of this is that there is a very sudden increased movement of the differential piston so that a powerful impulsive wave is sent along the pipe *p*, the wave absorber *q* opening so that a wave of considerable intensity passes along the transmission line. This wave is led by the transmission line to those signal motors which it is desired to operate.

The signal motor illustrated at Fig. 5 consists of a plunger *u* pressed toward the generator by a spring *v* and having its rear end pressed against the short arm *w* of the signal *y*. An exactly similar motor *z* is provided to actuate the signal in the opposite direction. Should the whole of the energy of the wave not be taken up in actuating the signal there will be produced a liquid wave which will travel back along the transmission line until it reaches the wave absorber *q* which consists of a conical valve having an aperture therethrough. By this wave absorber the liquid wave is taken up and successive reflections and waves traveling indiscriminately up and down the pipe are prevented. This unidirectional wave absorber may be fitted with advantage at the receiver end, and preferably a number of them are fitted at intervals along the line.

In order to supply liquid to the line there is provided a suitable compensating tank containing liquid under the mean pressure of the transmission line. This tank feeds a pipe *c* which is connected to suitable points in the transmission line by pipes *d* which should be at a quarter wave length as explained and claimed in U. S. application Serial No. 246,396, filed July 23rd, 1918, and in order to put any generator out of operation all that is necessary is to connect the chamber *k* of that generator to the compensating line or tank; in this way the increase in the pressure in the chamber *k* due to the actuation of the plunger will be insufficient to send the impulse along the transmission line.

In the ship's telegraph device illustrated in Figs. 6 and 7 there is provided on the bridge and in the engine room an instrument illustrated in section in Fig. 6 and in outside elevation in Fig. 7. Each instrument comprises a hand plunger 1 normally pressed up by a spring 2. This hand plunger, when suddenly pressed down, as, for instance, by a blow with a hammer, comes in contact with a second plunger 3 pressed upward by a spring, and the downward movement of this plunger sends an impulse along the wave transmission line.

In order to avoid actuating the bell at the receiving end when sending an impulse, the action from the wave transmission line

4 below the plunger 3 to the motor 5 which actuates the bell passes through an aperture 7 in the plunger 1; the first movement downward of this plunger thus closes the passage 8 from the lower plunger 3 to the motor 5. When a signal is to be received, however, the plunger 1 is in its upper position and there is a free passage from the transmission line 4 through the passage 8 to the plunger 9 of the trigger motor, which is accordingly actuated to sound the bell 6.

In the form of the invention shown in Fig. 8, the hammer 11 is actuated by impulsive waves produced by a rotary generator 12. The generator comprises an eccentric 13 driving a piston 14 by means of a link 15. At the bottom of the piston there is provided a plunger 16 projecting into a chamber 17, in which the impulses are generated, constructed as illustrated in Fig. 4 and having within it a differential valve and piston such as *k*, *l*, Fig. 4. The effect of this is that the impulse is not sent to the transmission line by the generator 12 until the plunger has reached a certain point in its downward stroke, at which point the sudden impulse is transmitted to the line. There is provided a compensating tank 18 containing liquid with air above it at a pressure of, say, 5 kilograms per square centimeter. This tank is connected by a pipe 19 of small bore to the transmission line, and there is also provided from the outlet 20 from the chamber *k* a pipe 21 having a cock 22 and leading also to the compensating tank 18. When the cock 22 is open the pressure in the chamber *k* will not be sufficient to send an impulse along the line. The transmission line 23 is connected to the upper end of a chamber 24 in which works a plunger 25 attached to the hammer 26. This hammer is pressed upward by a spring 27, and breathing holes 28 are provided from the chamber 29 above the hammer. A wave absorber may be fitted to the generator, and, if desired, also at the entrance to the chamber 24.

Having now fully described and ascertained my said invention and the manner in which it is to be performed, I declare that what I claim is:—

1. A system of transmitting an impulse through a liquid column comprising: a container for a column of liquid, means for suddenly and violently impressing a change of volume in the liquid at one end of said column and thereafter allowing the pressure to fall to normal to thereby create an impulsive wave that travels through the liquid column, and means connected with said container for receiving and utilizing the energy of the wave thus produced.

2. A system of transmitting an impulse through a liquid column comprising: a container for a column of liquid, means for

suddenly and violently impressing a change of volume in the liquid at one end of said column and thereafter allowing the pressure to fall to normal to thereby create an impulsive wave that travels through the liquid column, means connected with said container for receiving and utilizing the energy of the wave thus produced, and means for absorbing the energy of waves reflected from said receiving and utilizing means.

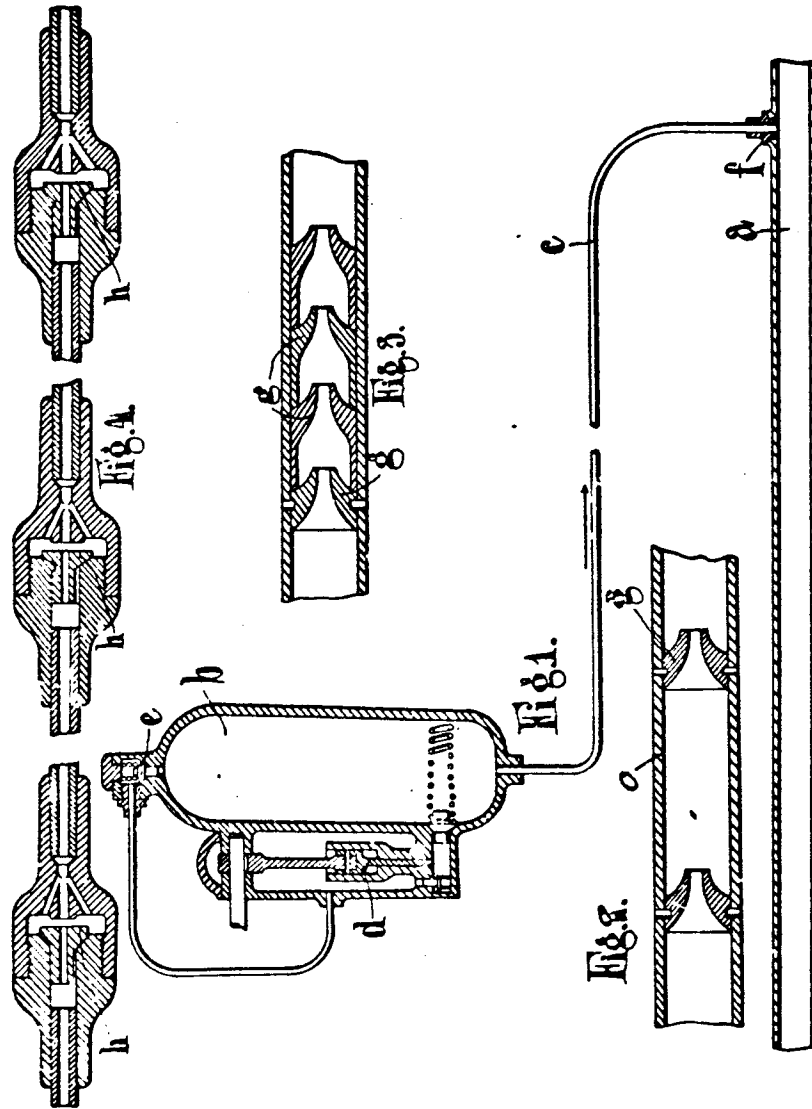
In testimony whereof I have signed my name to this specification.

GOGU CONSTANTINESCO.

G. CONSTANTINESCO.
MEANS FOR FEEDING LIQUID WAVE TRANSMISSION LINES.
APPLICATION FILED DEC. 13, 1917, RENEWED OCT. 28, 1919.

1,334,285.

Patented Mar. 23, 1920.



Gogu Constantinesco

INVENTOR

BY *Wm. T. Becken*

ATTORNEY

UNITED STATES PATENT OFFICE.

GOGU CONSTANTINESCO, OF ALPERTON, ENGLAND, ASSIGNOR OF ONE-HALF TO
WALTER HADDON, OF LONDON, ENGLAND.

MEANS FOR FEEDING LIQUID WAVE-TRANSMISSION LINES.

1,334,285.

Specification of Letters Patent. Patented Mar. 23, 1920.

Application filed December 13, 1917, Serial No. 207,021. Renewed October 28, 1919. Serial No. 334,079.

To all whom it may concern:

Be it known that I, GOGU CONSTANTINESCO, a subject of the King of Great Britain and Ireland, residing at "Westoe," Stanley avenue, Alperton, in the county of Middlesex, England, have invented certain new and useful Means for Feeding Liquid Wave-Transmission Lines, of which the following is a specification.

The present invention relates to wave transmission systems.

The invention consists in feeding means for a wave transmission line transmitting either harmonic or impulsive waves comprising a small bore pipe of considerable length, or a pipe provided with unidirectional dampers adapted to damp out the waves passing from the main transmission line to the feeding means.

The invention further consists in the improved means for feeding wave transmission lines hereinafter described.

Referring to the accompanying diagrammatic drawings:—

Figure 1 shows a wave transmission line with a feed pipe reservoir and pump;

Fig. 2 is a section showing suitable dampers for placing in the feed pipe;

Fig. 3 shows a modified form of damper; while

Fig. 4 shows check valves suitable for use instead of the dampers shown in Figs. 2 and 3.

In carrying the invention into effect according to the example illustrated in Fig. 1 as applied to an impulse wave line *a*, the wave line is connected to a reservoir *b* through a pipe *c* of considerable length and having a relatively small bore. Liquid is pumped into the reservoir *b* by a pump *d* and the reservoir is provided with a non-return valve *e* so that when a definite predetermined pressure is reached the pump merely circulates liquid through the reservoir.

The object of the pump *d* is to pump liquid from any suitable reservoir into the vessel *b* from which it passes through the pipe *c* into the wave transmission pipe *a* to make up for any leakage which may occur from this pipe.

We have found by mathematical analysis that the wave in the main line *a* splits into two parts at the junction *f* with the feeding line almost in proportion to the relative sec-

tions of the pipes provided that the feeding line is sufficiently long. Under these conditions if the feeding line has a relatively small bore compared with the main line, very little energy will be lost in the feeding line.

This is only the case where the feeding line is sufficiently long; for instance, if the feeding line were very short or reduced to a simple aperture, a very considerable amount of energy would be lost owing to the fact that the flow through the short line, or through the aperture, would follow a simple hydraulic law. For instance, the velocity of the liquid through a very short piece of pipe, neglecting friction, if water is employed would be given by the following formula:—

$$v = 1420\sqrt{p}$$

where *v* is the velocity in centimeters per second and *p* the pressure in kilograms per square centimeter. For example, if *p*=100 kilograms per square centimeter, *v* is equal to 14200 centimeters per second, which is a very high velocity. If a sufficiently long pipe is employed a sudden rise of pressure would create a wave traveling along the pipe with substantially the speed of sound, but the instantaneous velocity of the liquid would be only *v*=71 if water be employed. In this case, if *p*=100 kilograms per square centimeter, *v*=700 centimeters per second, or nearly twenty times less than in the case of the short pipe. It follows from this that very much less energy would pass into the feeding line from the main line. The length of the feeding line should be preferably of the order of the wave length, and at least a quarter of the wave length due to the sudden rise of pressure. This wave length can be calculated approximately by the formula:—

$$\lambda = 145000 \phi \text{ for water}$$

and

$$\lambda = 12500 \phi \text{ for petroleum products,}$$

where ϕ is the duration of time taken by the percussion which produces the wave. For example, if the main wave consists of a rise of pressure from a minimum to a maximum and then back to a minimum during a time interval of $\frac{1}{100}$ of a second, the wave length in water would be $\lambda=290$ centimeters, and the feeding tube in this case should be at least 73 centimeters long. Care should be

taken that the feeding tube is not an exact multiple of the half wave length due to the subdivision of the time period between successive percussions in the case in which these percussions succeed each other at regular intervals. In this case the loss of energy in the feeding tube might become considerable on account of resonance occurring in the feeding tube. If this cannot be avoided a wave damping device should be introduced in the feeding tube in order to destroy the waves. Such a damping effect may be readily obtained if a fairly long tube of very small bore is used, in order to increase friction, say, of several wave lengths, but it can be provided for in a shorter tube by a wave absorber such as hereinafter described. Such an absorber, examples of which are shown in Figs. 2, 3 and 4, may consist, as shown in Fig. 2, of simple diaphragms or nozzles *g* of restricted area fitted at the pump end or at intervals along the feeding tube *c*.

A suitable form of damper both for harmonic and impulsive waves may be formed of conical or like nozzles, such as *g*, placed either at intervals, as shown in Fig. 2, or close together, as shown in Fig. 3. I prefer, however, to use perforated check valves, such as *h*, Fig. 4, in order not to interfere with the free flow of liquid from the pump or reservoir to the main line.

Having now fully described and ascertained my said invention and the manner in which it is to be performed, I declare that what I claim is:—

1. A hydraulic transmission system comprising: a pipe containing liquid through which power is transmitted by variations of pressure and volume therein, and means preventing considerable energy losses in said pipe while supplying liquid thereto to compensate for liquid losses in the system.

2. A hydraulic transmission system comprising: a pipe containing liquid through which power is transmitted by variations of pressure and volume therein, and a feed pipe communicating with said first pipe to supply liquid thereto to compensate for liquid losses in the system without causing substantial energy loss therein.

3. A hydraulic transmission system comprising: a pipe containing liquid through which power is transmitted by variations of

pressure and volume therein, and means for supplying liquid to said pipe to compensate for liquid losses in the system including a feed pipe of small diameter as compared with said first pipe and of considerable length.

4. A hydraulic transmission system comprising: a pipe containing liquid through which power is transmitted by variations of pressure and volume therein, means for supplying liquid to said pipe to compensate for liquid losses in the system including a feed pipe of small diameter as compared with said first pipe and of considerable length, and unidirectional dampers located in said feed pipe.

5. Means for supplying fresh liquid to a wave transmission line comprising: a pump, means for supplying liquid to said pump, a strong vessel completely filled with liquid, said pump pumping liquid into said vessel, a pipe in which power is transmitted by variations of pressure and volume traveling along the pipe and a long pipe of small diameter connecting said strong vessel with said transmission pipe.

6. Means for supplying fresh liquid to a wave transmission line comprising: a pump, means for supplying liquid to said pump, a strong vessel completely filled with liquid, said pump pumping liquid into said vessel, a pipe in which power is transmitted by variations of pressure and volume traveling along the pipe and a long pipe of small diameter connecting said strong vessel with said transmission pipe, a by-pass from said vessel back to the suction side of said pump, said by-pass being controlled by a valve.

7. Means for supplying fresh liquid to a wave transmission line comprising: a pump, means for supplying liquid to said pump, a strong vessel completely filled with liquid, said pump pumping liquid into said vessel, a pipe in which power is transmitted by variations of pressure and volume traveling along the pipe, and a long pipe of small diameter connecting said strong vessel with said transmission pipe, said pipe of small diameter having placed therein wave absorbers.

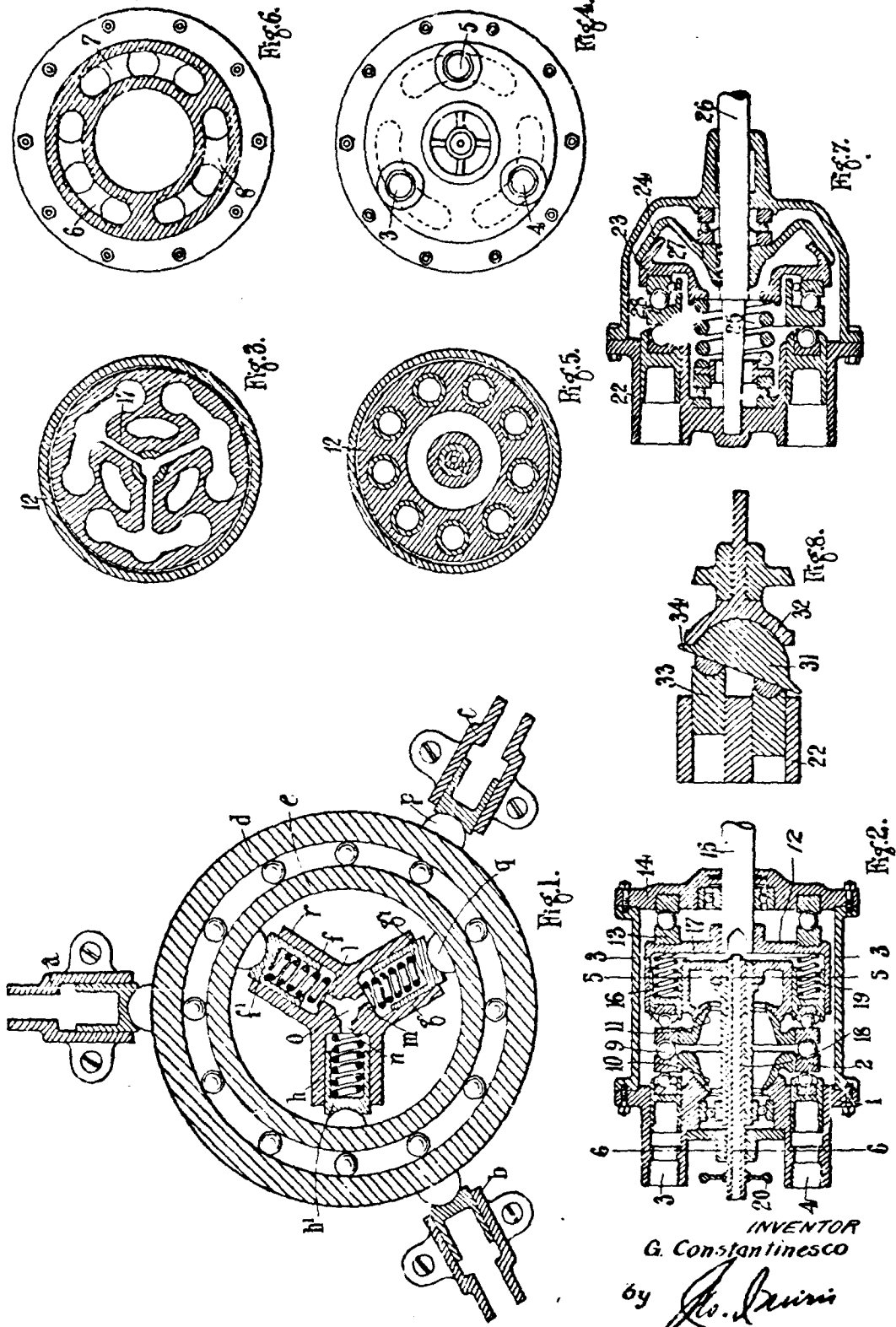
In testimony whereof I have signed my name to this specification.

GOGU CONSTANTINESCO.

G. CONSTANTINESCO.
ALTERNATING LIQUID CURRENT MOTOR.
APPLICATION FILED AUG. 25, 1921.

1,432,672.

Patented Oct. 17, 1922.



INVENTOR
G. Constantinesco
by *A. Drimi*
Attorney

UNITED STATES PATENT OFFICE.

GEORGE CONSTANTINESCO, OF WEYBRIDGE, ENGLAND, ASSIGNOR TO WALTER HADDON,
OF LONDON, ENGLAND.

ALTERNATING LIQUID CURRENT MOTOR.

Application filed August 25, 1921. Serial No. 495,221.

(GRANTED UNDER THE PROVISIONS OF THE ACT OF MARCH 3, 1921, 41 STAT. L., 1313.)

To all whom it may concern:

Be it known that GEORGE CONSTANTINESCO, a subject of the King of Great Britain and Ireland, residing at Carmen Sylva, Beechwood Avenue, Oatlands Park, Weybridge, in the county of Surrey, England, have invented certain new and useful Improvements in Alternating Liquid Current Motors (for which I have filed an application in Great Britain Oct. 3, 1916, Patent No. 110,003), of which the following is a specification.

The present invention relates to motors operated by alternating liquid currents of the kind described in the specification of Letters Patent Reissue No. 14738, and has for its object the construction of asynchronous rotary motors actuated by such currents. The term alternating liquid current is defined in specification of Patent No. 1334290.

It will be readily seen that if an eccentric is situated on a shaft, and cylinders and pistons are arranged around the eccentric at angles of 120 degrees apart, and if these pistons are acted on by alternating liquid vibrations also differing in phase by 120 degrees, the effect of the liquid vibrations acting on the pistons is to produce as it were a series of impulses exerted in order about the axis of the shaft acting on the eccentric in a direction parallel with the shaft and exerting a torque if the shaft is made to rotate initially at the synchronous speed.

Such motors have been described in Letters Patent Serial No. 1211679 and Letters Patent Reissue No. 14738. It will be seen, however, that such a motor will not start, and will not exert a torque, unless running at the synchronous speed.

The present invention consists in an asynchronous motor actuated by polyphase alternating liquid currents.

The invention further consists in a rotary motor comprising a stator, transmitter and rotor, the rotor being provided with means allowing it to slip relatively to the rotating impulses, such slip being effected against a resistance.

The invention further consists in a rotary motor comprising a stator, transmitter, rotor, reactance and collector, the collector

consisting of a short-circuiting device carried by the rotor itself, while the reactance is also carried by the rotor, and consists in a suitable elastic supporting device.

The invention also consists in a motor comprising a stator having three cylinders placed at 120 degrees apart, with pistons working in such cylinders, and actuated by three phases of an alternating three-phase wave transmission system, the transmitter comprising rings interposed between the stator pistons and the pistons of the rotor, such rotor pistons working in cylinders against the action of springs and a resistance, such as that of liquid pumped through small apertures.

The invention further consists in adjustably restricting the passages through which liquid in the rotor is pumped.

The invention further consists in the improved constructions of asynchronous motor hereinafter described.

It will be seen that very many different forms of motor can be constructed and that many different applications and combinations of the machine are possible, as is the case in asynchronous induction polyphase electric motors. The motor is analogous to the electric motor of this type, and is analogous thereto in its many applications.

Referring to the accompanying diagrammatic drawings:

Figure 1 is a section of the motor constructed according to the invention;

Figure 2 is an axial section of a modified form of three-phase asynchronous motor;

Figure 3 is a section on the line 3—3, Figure 2;

Figure 4 is an end elevation of the motor shown in Figure 2;

Figure 5 is a section on the line 5—5, Figure 2.

Figure 6 is a section of the outer part of the stator on the line 6—6, Figure 2;

Figure 7 is an axial section of a simple form of asynchronous motor suitable for low powers;

Figure 8 is an axial section of a modified form.

In the form of the invention shown in Figure 1, the stator comprises three cylinders, *a*, *b*, *c*, which are connected to the

three phases of a three-phase wave transmission line. The transmitter is formed by an ordinary ball bearing, whose outer ring d , is actuated by the stator pistons through ball segments p slidable in the pistons and on the ring d , and the inner ring e transmits pressure to the rotor pistons through ball segments q slidable in the pistons and on the ring e . The rotor r comprises three cylinders f, g, h , in which the pistons f^1, g^1, h^1 work against springs. The space within the pistons is filled with liquid or viscous material. The reactance of the rotor is provided by the three springs on which the pistons work. The three cylinders f, g, h , are connected by narrow passages l, m, n , with a central common chamber o .

With a motor as above described, if the cylinders a, b, c , be connected to the three alternating liquid columns of a three-phase wave transmission system, the centre of the transmitter rings d, e , will be displaced, the displacement being constant in magnitude, and rotating around the centre of the stator.

It will be seen that the cylinders of the rotor are only free to rotate round the centre of figure of the cylinders f, g, h , while the pistons f^1, g^1, h^1 , follow the movements of the ring e of the transmitter. The relative movement of the pistons f^1, g^1, h^1 , to the cylinders f, g, h , will therefore pump the liquid contained in the rotor cylinders through the small passages l, m, n .

It can be shown by mathematical analysis that the frictional resistance to the flow of liquid through the narrow channels l, m, n , and the pressure of the springs, and the liquid pressures in the rotor cylinders, will give a resultant torque on the rotor cylinders which is constant in direction and magnitude. The rotor therefore will start rotating with an angular velocity smaller than the angular velocity of the rotating displacement of the transmitter. The rotor further will be capable of developing a torque. The result is that the rotor rotates in the same direction as the rotating displacement, due to the stator pistons, which displacement may be regarded as a rotating mechanical field, due to the stator. The rotor, however, always has a slip relatively to the rotating field, which is due to the pumping of liquid by the pistons of the rotor through the restricted passages l, m, n , into and out of the common chamber o . By diminishing the section of the passages l, m, n , the slip may be reduced indefinitely, until the speed of the rotor approaches very nearly to the synchronous speed of the rotating field. The torque obtained from the motor is nearly the same as the torque obtained from the equivalent motor having a rotor with an ordinary eccentric, the eccentricity of which would be determined by the strength of the

springs used in the rotor. The drop in efficiency, as compared with fixed eccentric motors, will be determined by the slip. For efficiency, therefore, it follows that the slip should be kept as small as possible by decreasing the passages l, m and n .

On the other hand, if the passages l, m , and n are very small, the starting torque of the motor is also small, and to obtain a powerful starting torque, the passages l, m and n must be increased. This can be effected by closing the passages l, m, n , more or less, according to the speed of the motor, by a suitable plug worked from the outside.

According to another form of the invention, the flow from each of the three cylinders of the rotor may be collected by means of a suitable collector outside the rotor.

In the form of the invention shown in Figure 2, the stator 1 is provided with three pistons for each phase. These pistons are operated in order around the circumference, producing the rotating field acting on the transmitter 2. The three phases of the transmission line are connected to the three inlets 3, 4, 5, each of which communicates with three of the pistons of the stator by the passages 6, 7, 8, Figure 6. The transmitter consists of a bearing 9 supported on spherical surfaces 10, 11, on the stator and rotor respectively. The rotor 12 is also provided with nine pistons, arranged in groups of three, and is supported longitudinally by a thrust bearing 13 between it and the back plate 14 of the stator. The rotor 12 is suitably keyed to the shaft 15, and its cylinders 16 communicate with a hollow in the shaft by the passages 17. A hollow adjustable valve spindle 18 is provided, which enters the hollow shaft, and is adapted to more or less close the communication between the cylinders of the rotor. The rotor pistons are pressed against the transmitter by springs 19. The valve spindle 18 is adjustable from the outside of the motor by the hand wheel 20, and is formed with a taper end, so that as the spindle is screwed in or out, it adjusts the apertures of the passages connecting the rotor cylinders, and thus adjusts the friction opposed to the movement of the rotor pistons. A connection is provided at the outer end of the spindle 18, to a constant pressure device pumping liquid into the rotor cylinders at a constant pressure, so that the mean pressure is kept high enough to ensure that the cylinders are always full of liquid. The liquid required for this purpose may be taken from the line by which the stator is fed by long pipes of very small bore, sufficiently long to avoid waste of energy. In larger sized machines, it is convenient to fit a pump to the motor, for maintaining a constant pressure in the rotor, by means of oil, which also effects the lubrication.

When starting a motor according to this modification, in order to obtain a large starting torque, the handle 20 must be turned so as to open as far as necessary the passages 17 connecting the rotor cylinders. When the motor has attained a normal speed, the handle will be turned so as to partially close these passages until the slip is reduced to the minimum practicable.

It will be seen that the ball bearings illustrated may be replaced by other anti-friction bearing surfaces, and other devices may be used to avoid friction. Further, it is desirable that good ventilation should be provided in order to dissipate the heat generated in the rotor when working with considerable slip. The lubricating oil may be circulated by a pump to effect cooling of the rotor if desired.

In the form of the invention shown in Figure 7, the cylinders and pistons in the rotor are dispensed with. In this form of the invention, the three phases are connected to the stator 22, actuating three pistons which communicate motion to the oscillating body 23, which is in frictional contact with the rotor 24 over the spherical surface between them, and is acted on by a spring 25, which tends to keep it normal to the axis of the motor. The rotor 24 is suitably keyed to the shaft 26. In this case the reactance is provided by the spring 25. In this case a general ball bearing 27 is also provided, to keep co-axial the parts 23 and 28.

The working of the motor shown in Figure 7 is as follows:—The rotating field produced by the pulsations of the three phase alternating current in the stator 22 causes the deflection of the plane of the front face of the part 28, which is thus inclined to its normal position at right angles to the axis of the motor, the line of maximum inclination in this plane rotating uniformly about the axis. This inclination is effected against the action of the spring 25, which thus produces the necessary reactance on the members 23, 28. The friction between the members 23 and 24 operates in a similar manner to the liquid friction in the modifications above described, with the result that a torque is produced, acting on the member 24, causing the shaft 26 to rotate. The friction between the parts 23 and 24 should be sufficient to prevent unduly large slip.

In the examples given above, only three phase motors have been described. It will be seen, however, that similar constructions can be adopted for any number of phases.

Further, the stator may be worked by an n -phase line, and the rotor may be an m -phased rotor. The friction device shown in Figure 7 corresponds to an infinite number of phases in the rotor and a limited number of phases in the stator. In order to get a

continuous torque, however, three phases at least are necessary. If two phases only were employed, the motor would revolve if initially turned in one direction or the other. The torque, however, would not be constant, but of a pulsating nature. With three or more phases, however, the torque is constant and in one direction. In order to reverse a motor constructed according to this invention, it is only necessary to interchange the phases in the stator by a suitable reversing switch.

In a modified form of motor shown in Figure 8 instead of using a spring as a reactance in order to limit the inclination of the oscillating member, the reactance may be provided by friction between the transmitter 31 and the rotor 32. The limitation of the stroke of the stator pistons 33 is provided for by the flange 34 which bears against the rotor at one point. The necessary friction arises from the pressure of the pistons in the axial direction transmitted through the transmitter to the rotor 32. A thrust bearing may, if desired, be interposed between the pistons 33 and the flange 34 as in the modifications described above.

It will be seen that with motors as above described the maximum torque possible is the torque which is obtained at synchronous speed, that is, when the slip is zero, and it is not possible to obtain the higher torque on starting. The speed of motors according to this invention also cannot exceed synchronous speed equal to that of the generator producing the wave motion in the transmission line.

It should be understood that the maximum torque on starting asynchronous motors according to the invention is a function of the resistance and capacity of the rotor circuit. If the resistance is diminished below a certain limit, the starting torque diminished instead of increasing. Similarly, in a monophasic motor constructed similarly to that above described but with two pistons instead of three, there is a certain critical relation between resistance and reactance at which with a very slight impulse the rotor will immediately be caused to rotate. This property can be made use of in adjusting the resistance in such a machine by means of a suitable plug, as above described, so as to obtain that value of resistance at which the motor will start easily with a very small impulse.

I claim:

1. An asynchronous rotary alternating liquid pressure motor comprising in combination; a stator; a transmitter; means for imparting impulses to said transmitter successively, producing a rotating mechanical field; a rotor; and non-rigid connecting means allowing slip between said rotor and

said rotating mechanical field and means opposing resistance to said slip as set forth.

2. An asynchronous rotary alternating liquid pressure motor; comprising a stator, a transmitter, a rotor having pistons, a reactance and a collector, said collector comprising a chamber inside said rotor and passages leading from said chamber to said pis-

ton, while said reactance comprises a non-rigid mechanical connection permitting slip. 10
In testimony whereof I have signed my name to this specification.

GEORGE CONSTANTINESCO.

Witnesses:

JAB. E. ALLSOP,
W. F. M. ADAMS.

Certificate of Correction.

It is hereby certified that Letters Patent No. 1,432,672, granted July 25, 1922, upon the application of John Lewis Milton, of Cleveland, Ohio, for an improvement in "Magneto-Ignition Systems for Internal-Combustion Engines," were erroneously issued to "The Teagle Company, of Cleveland, Ohio, a Corporation of Ohio," whereas said Letters Patent should have been issued to *Motor Ignition & Devices Company, a Corporation of West Virginia*, said corporation being assignee, by *mesne assignments*, of the entire interest in said invention, as shown by the records of assignments in this office; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 26th day of December, A. D., 1922.

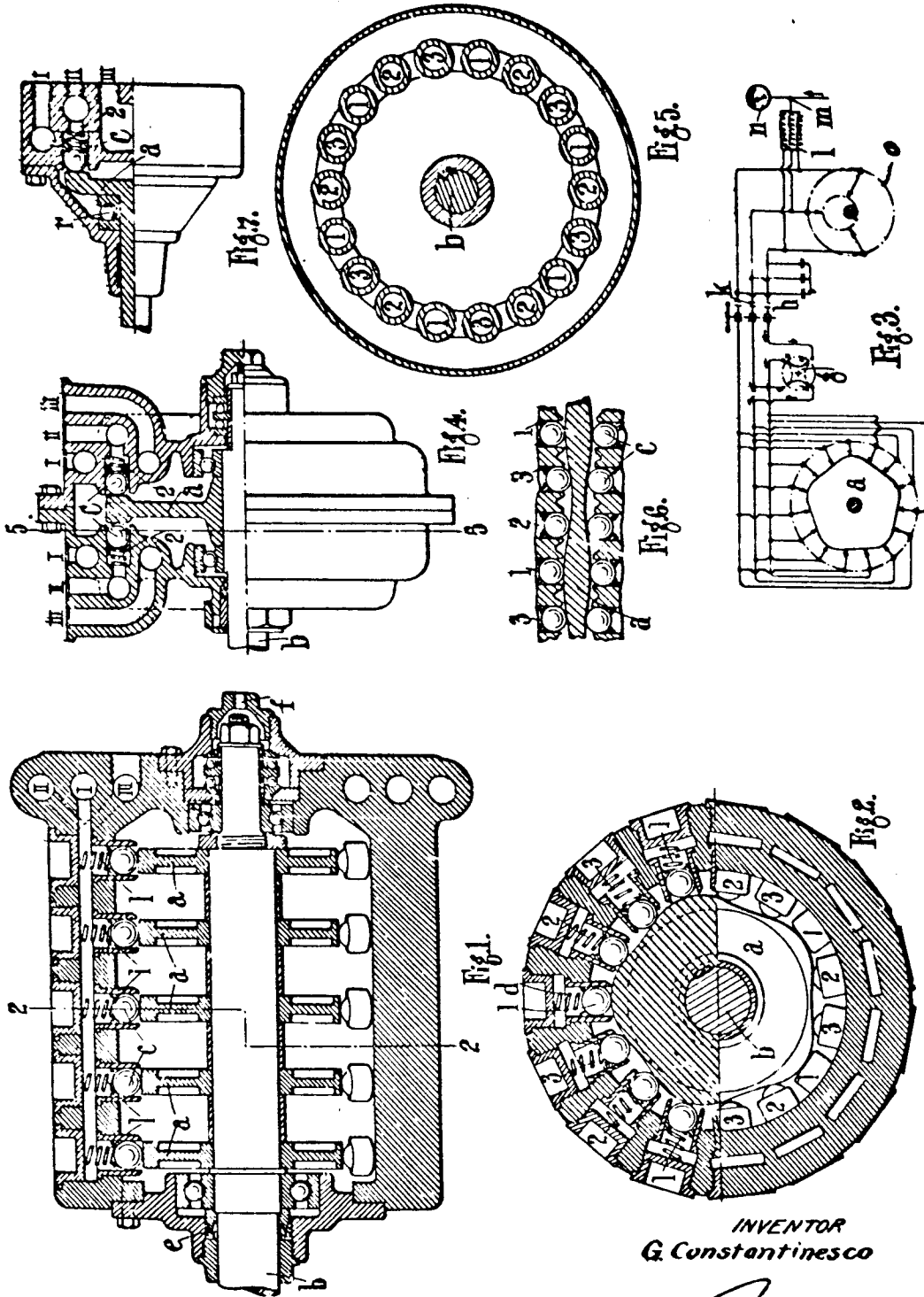
[SEAL.]

KARL FENNING,
Acting Commissioner of Patents.

G. CONSTANTINESCO.
SYNCHRONOUS ALTERNATING LIQUID CURRENT MOTOR.
APPLICATION FILED AUG. 25, 1921.

1,432,673.

Patented Oct. 17, 1922.



INVENTOR
G. Constantinesco

by *A. Guirri*
Attorney

Patented Oct. 17, 1922.

1,432,673

UNITED STATES PATENT OFFICE.

GEORGE CONSTANTINESCO, OF WEYBRIDGE, ENGLAND, ASSIGNOR TO WALTER HADDON,
OF LONDON, ENGLAND.

SYNCHRONOUS ALTERNATING LIQUID CURRENT MOTOR.

Application filed August 25, 1921. Serial No. 495,222.

(GRANTED UNDER THE PROVISIONS OF THE ACT OF MARCH 3, 1921, 41 STAT. L., 1313.)

To all whom it may concern:

Be it known that I GEORGE CONSTANTINESCO, a subject of the King of Great Britain and Ireland, residing at Weybridge, Surrey, England, have invented certain new and useful Improvements in Synchronous Alternating Liquid Current Motors (for which I have filed an application in Great Britain Oct. 3, 1916, Patent No. 110,065), of which the following is a specification.

The present invention relates to alternating liquid current motors and especially to motors for use in wave transmission systems, and has for its object the production of a synchronous rotary motor running at a speed differing from that of the generator and actuated by a polyphase alternating liquid current. The term alternating liquid current is defined in the specification of Patent No. 1,334,290.

In Letters Patent Reissue No. 14,738 it is shown how energy can be transmitted from one point to another by means of a series of periodic variations of pressure and volume, travelling along one or more liquid columns. For example, if a motor is formed by three cylinders and pistons placed at 120° apart, the pistons differing in phase of motion also by 120°, such a motor will be kept rotating by the pulsations of a three-phase liquid wave transmission line fed by a similar generator. This is the simplest form of synchronous motor.

A motor of the type described would be very difficult to start, and would be incapable of starting against an inertia fixed on the shaft, as the effects of inertia increase considerably with the speed, and would prevent starting where the synchronous speed is high.

The object of the present invention is to obtain a synchronous alternating liquid current motor running at a very much lower speed than the speed of the generator.

The invention consists in a valveless alternating liquid current motor comprising three groups of pistons in cylinders, each group being connected by suitable connections to one of three liquid columns, the group being arranged around the motor in such a manner that the movements of the different groups differ by 120° in phase,

while the rotor is so shaped that the pistons reciprocating in contact with it move with a simple harmonic motion as the rotor revolves.

The invention also consists in a valveless polyphase alternating liquid current motor so constructed that the speed of the rotor is different from the speed of the generator.

It will be readily seen that such a machine may either act as a motor or generator according as the power is applied to rotate the shaft or to the movement of the liquid columns acting on the shaft.

The invention further consists in constructing the apparatus in such a manner that the speed of the rotor is a sub-multiple of the speed of the generator.

The invention also consists in the improved motors hereinafter described.

It has been proposed in a gas engine to reduce the speed of rotation of the driven shaft relative to the piston speed by causing the pistons to act through links on inclined surfaces on the inner surface of a ring moving with the driven shaft. It has also been proposed in fluid pressure engines with distributing valves to cause the pistons to act on cam surfaces designed to move the shaft through a part only of a revolution during one complete reciprocation of a piston.

It will be seen that if the rotor is shaped in such a manner that for one revolution of the rotor there are M reciprocations of each of the pistons, and if the rotor is fed from a three or more phase transmission line in which the frequency is N , the frequency of the revolutions of the motor will be $\frac{N}{M}$ so that the gearing ratio resulting is $\frac{1}{M}$.

A reversing valve may be introduced between the generator and the motor, and condensers having inertias may be employed in the line as described in the specification of Letters Patent Reissue No. 14,738.

Referring to the accompanying drawings:—

Figure 1 is an axial section and Figure 2 is a section on the line 2—2, Figure 1, of a motor constructed according to the invention.

100

Figure 3 is a diagram showing the method of connecting the synchronous motor, adapted to run at a reduced speed to a three-phase ne.

5 Figure 4 is an axial section of a motor adapted to run at a reduced speed in which the pistons are arranged to act parallel to the axis of the motor.

Figure 5 is a section on the line 5-5 of Figure 4, while

10 Figure 6 is a developed section on the circumference of the rotor.

Figure 7 shows a construction adapted for small power motors.

15 In the form of the invention shown in Figures 1 and 2, the rotor comprises five similar discs *a* carried on a shaft *b*, each of these discs being shaped as shown in Figure 2, so that for one revolution of the rotor the point of contact of the disc with one of the balls *c* in the cylinders *d* is displaced radially five times, so that the disc in rotating imparts to the ball *c* a true harmonic displacement having a frequency five times as great as the number of revolutions of the shaft *b*. The balls *c* in this machine act as pistons and fit in cups sliding in the cylinders *d*, springs being provided to balance their inertia. In this construction the ball is free to rotate so that there is rolling contact between the balls *c* and discs *a*.

Any leakage which occurs past the balls is replaced by suitable appliances in the wave transmission line. As the leakage accumulates there is provided a leather cup or other suitable stuffing box *e* to prevent the escape of the oil from the machine. The interior of the machine is connected through a return pipe *f* to a collecting tank situated near the generator, so that a slow circulation of the leaking fluid is maintained. From the collecting tank a suitably arranged pump may be employed to pump the oil back into the three-phase transmission line.

In the motor illustrated the cylinders 1, 1, 1, 1, 1, 1, communicate with a collecting channel I, the cylinders marked 2 and 3 respectively communicate with channels II, III. 50 These three channels form closed rings communicating with the three pipes of the three-phase line leading from the generator. The connections are diagrammatically shown in Figure 3. In this figure there is diagrammatically shown at *g* a reversing cock adapted to interchange the connections between two of the phases for the purpose of reversing the direction of rotation of the motor.

60 Three condensers are shown connected to the line at *h*, in order to take up the rise of pressure which would occur on reversing or when stopping the motor by closing the lines at *h*. Capacities such as the long steel vessel described in Patent No. 1,334,283 may be

substituted for these condensers. The three phases of the transmission line may be connected as at *l* to three small bore pipes, whose other ends are connected to a common point *m*. As there is no variation of the 70 pressure at the point *m*, oil may be pumped in at this point at the mean working pressure, in order to compensate for leakage, so that check valves are dispensed with. A pressure gauge may be fitted at *n* to indicate the mean pressure in the pipes. 75

The use of the small bore pipes *l* has the advantage that it balances the mean pressure in the three-phase line as is necessary after each reversal. The pipes *l* should be 80 sufficiently long and of sufficiently small diameter to avoid any appreciable loss of power through heating.

The arrangement of pipes of small bore as above described affords a very simple 85 method of feeding lines in order to keep the three-phase transmission line at a constant mean pressure, all that is necessary being to pump the fluid in by means of an ordinary constant pressure pump, regulating the flow 90 from the pump according to the reading of the gauge *n*. The generator *o* is shown diagrammatically connected to the lines on the right hand side of Figure 3.

In the form of the invention shown in 95 Figures 4, 5 and 6 the speed of the motor is one-sixth of the transmission line frequency. In this modification the piston balls *c* act parallel to the shaft *b* instead of perpendicular to it as in the case of Figures 1, 2 and 3, and the discs *a* are shaped at the sides of their circumference as illustrated in the developed view, Figure 6. The cylinders 1, 1, 1, etc., 2, 2, 2, etc., 3, 3, 3, etc., are connected to the conduits I, II, III in three 105 groups as before. Moderate size motors can conveniently be constructed in this manner.

In the form of the invention shown in Figure 7 the cylinders 1, 1, 2, 2, etc., are only placed on one side of the disc *a* which 110 is shaped as before on this side only. The pressure of the pistons in this case is taken up by a thrust bearing *r*.

I claim:—

1. A valveless alternating liquid current 115 motor comprising three groups of cylinders, pistons working in said cylinders, three liquid columns, each of said liquid columns being connected to a group of said cylinders, said groups of cylinders being arranged 120 around the motor in such a manner that the movements of the three different groups of pistons differ from each other in phase by 120 degrees and a rotor so shaped that the pistons in contact with it move with a simple harmonic motion as set forth. 125

2. A valveless alternating liquid current motor, comprising three groups of cylinders, pistons working in said cylinders, three liquid columns, each of said liquid columns 130

being connected to a group of said cylinders, said groups of cylinders being arranged around the motor in such a manner that the movements of the three different groups of
5 pistons differ from each other in phase by 120 degrees, and a rotor so shaped that the pistons in contact with it move with a simple harmonic motion, said rotor operating in conjunction with each of said groups of pistons more than once during a complete 10 revolution as set forth.

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

GEORGE CONSTANTINESCO.

Witnesses:

W. F. M. ADAMS,
JONES G. ALLSOP.