G. CONSTANTINESCO.
LIQUID WAVE TRANSMISSION OF POWER.
APPLICATION FILED APR. 17, 1917.

1,334,290. Patented Mar. 23, 1920.

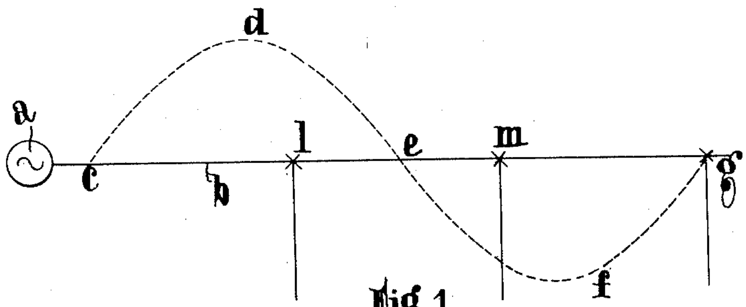

Fig. 1.

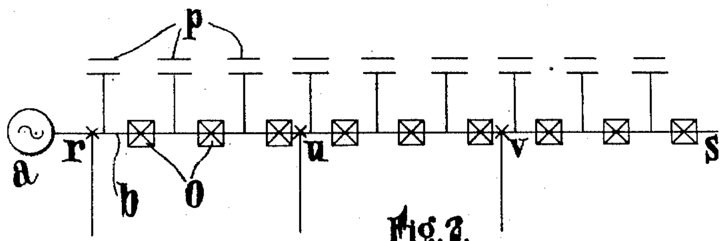

Fig. 2.

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LIQUID WAVE TRANSMISSION OF POWER.

1,334,290. Specification of Letters Patent. Patented Mar. 23, 1920.

Application filed April 17, 1917. Serial No. 162,674.

To all whom it may concern:

Be it known that I, Gogu Constantinesco, a subject of the King of Great Britain and Ireland, and resident of Westoe, Stanley avenue, Alperton, Middlesex, England, have invented certain new and useful Improvements in Liquid Wave Transmission of Power, of which the following is a specification.

The present invention relates to systems of transmitting power by wave transmission through liquids.

In the United States patent applications Serial Nos. 24,231, 24,230 and 63,762, methods have been described by which power is transmitted from one point to another by a series of periodic variations of pressure and volume traveling along a liquid column or columns.

In such applications the power is transmitted in a manner analogous to that in which sound waves are transmitted through liquids.

According to one method described, three columns of liquid are employed between a generator and a receiver, that is to say, the piece of apparatus by which the power is utilized at the point where it is required.

According to one form, which may be called a three-phase system, three pipes are employed between the generator and receiver. The generator in this case consists of a reciprocating pump having three, or a multiple of three, cylinders with pistons working in these cylinders so that the three pistons or sets of pistons are reciprocated with a phase difference between them of 120°. Each of the three cylinders or sets of cylinders communicates with a pipe, one of the pipes leading to the receiver which may be of exactly similar form to the generator. The result of this is that as the generator is actuated, causing the piston to reciprocate, in each liquid column there is transmitted a series of periodic variations of pressure and volume which travel along the liquid column with substantially the velocity with which sound would travel along the column. In a case in which there are three liquid columns, and in which the generator and the receiver are exactly similar, it will be seen that the receiver pistons, supposing that there is a single cylinder connected to each liquid column, will be actuated once during each revolution of the generator and that the phase difference between the motion of the three pistons of the receiver will be the same as that between the three pistons of the generator, namely, 120°.

It will be readily seen that by the use of a generator having a single piston reciprocated once during each revolution of a cam or eccentric with a single pipe connected to such a generator containing liquid, a series of variations of pressure and volume can be transmitted along a single liquid column in an exactly similar manner to that in which the three series of waves are transmitted along the three liquid columns in the system above described, which may be termed a three-phase system. A system having a single liquid column may be termed a single phase system.

The object of the present invention is to obtain from such a single phase system a three-phase system or a system having other number of phases so that by tapping off subsidiary columns at different points of the single column leading from the generator, a two, three, or other number of phase systems, can be obtained capable of actuating a receiver suitable for any desired number of phases, that is to say, in a receiver—to take the case in which rotation is required—there may be any number of cylinders and pistons giving impulses to a crank or eccentric at any desired number of points in a single revolution. For example, to actuate a three-phase receiver it would be necessary to have three liquid columns, the impulses in these liquid columns differing in phase by 120°.

It will be seen from the analogy of the transmission of sound through liquids that in wave transmission of power by the method above described there will occur in the liquid column or columns a series of periodic variations of pressure and volume which will travel along the column and for each speed of revolution of the generating crank there will be a definite wave length in the liquid column, that is to say, if the column is sufficiently long, there will at any instant be a number of points along the column where the pressure is a maximum. Half way between these points there will be points at which the pressure is a minimum: and, with a piston reciprocating harmonically, that is, driven by a rotating crank with a connecting rod whose eccentricity can be neglected, the pressure along the pipe between two points at maximum pressure will follow a harmonic law. The result of this is that at any instant the pressure in the pipe may be represented by the ordinates of a sine curve whose abscissæ represent distances along the pipe. The points where this curve crosses the zero line, that is, the points where the pressure is zero or equivalent to the mean pressure, will be at a distance apart equal to the wave length of the waves generated in the pipe. It will be seen, therefore, that in order to obtain three liquid columns in which the variations of pressure and volume differ in phase by 120°, it is only necessary to tap off from the main column subsidiary columns at intervals of 120°, the wave length in the main column being represented by 360°.

The present invention, therefore, consists in obtaining any number of phases from an oscillating liquid column by dividing one wave length of the vibrating column into equal lengths and tapping from the points of division an equal number of columns. The columns thus derived from the main oscillating column will then differ in phase from each other by the same angle.

The invention conversely consists in obtaining a single phase column from two or more columns differing in phase by connecting such two or more columns leading from the generator to the single column at suitable points of the latter.

Owing to the comparatively low elasticity of liquids such as water, the wave length of the waves in the liquid column, unless the periodicity is extremely high, will be inconveniently long and in some cases it is desirable to utilize a phase transformer occupying a smaller space than the single wave length.

It can be shown mathematically that the effect of decreased elasticity in series in a liquid column is to shorten the wave length, while the effect of inertia in the liquid column is to lengthen the wave length. By utilizing this phenomenon it is possible to construct a charged liquid column having less elasticity than that due to the liquid alone and to utilize such a liquid column for the purpose of shortening the length of column required to give the requisite length for the complete wave length, and this length of charged line may be considerably less than the length required for a wave length in a column containing liquid alone and carrying impulses produced with the same frequency.

The present invention, therefore, further consists in a phase transformer in which the wave length of the line is artificially shortened by using inertias in series, or condensers in parallel, or both.

In carrying the invention into effect according to one example, we may have a main pipe in which a water column is transmitting oscillations at a frequency of, say, 20 per second. The wave length with water at this number of oscillations per second will be about 70 meters, the velocity of the wave in the liquid being about 1400 meters per second. The pipe for 35 meters may be made into a coil and two branch pipes may be connected at the ends of this coil. There will thus be produced in the branch pipes oscillations in the liquid columns which will differ in phase by 180°. The oscillations in the two branch pipes may thus be used to act on the two sides of a moving piston or diaphragm which would thus be set in motion and would vibrate at the same frequency. Similarly, according to another example, three branch pipes might be connected to the main pipe at distances of 23.33 meters apart and in these branch pipes oscillations differing in phase by 120° would be produced of the same frequency as the oscillations in the main line. These three branch pipes may be connected to a motor formed with three pistons having their axes 120° apart and acting on a common crank, thus rotating the crank at the frequency of the main water column.

Referring to the accompanying drawings:—

Figure 1 is a diagram illustrating one method of carrying out the invention in which a three-phase system is derived from oscillations in a single pipe.

Fig. 2 shows a further method of obtaining a three-phase system from a single phase system.

In carrying the invention into effect as shown by the diagram in Fig. 1, the generator *a* consists of a reciprocating piston working in a cylinder which is directly connected to a pipe *b* full of liquid. The reciprocations of the piston produce periodic variations of volume which travel along the liquid column with substantially the speed of sound. The ordinates of the dotted curve *c*, *d*, *e*, *f*, *g*, may be taken to represent the pressure in the liquid column at any particular instant, the distance between *c* and *g* being the wave length. Points *l*, *m*, along the pipe are selected such that *c l* equals *l m* and *l m* equals *m g*, and three pipes are connected, one at *l*, one at *m*, and one at *g*. The result of this will be that impulses will be produced in the liquid columns in the branch pipes leading from *l*, *m* and *g* which will differ in phase by 120° so that a three-phase alternating liquid current is obtained from the single phase current in the main pipe *b*.

Fig. 2 shows diagrammatically how the distance between the points at which the three-phase current is drawn off may be shortened so that the actual length required between the points of tapping may be made much less for the same periodicity than is the case with a single line. Although the length as illustrated between the tapping points is the same, by suitably varying the elasticity by means of capacities and inertias, the distance between the actual points of tapping of the pipe may be very much reduced, and it will be understood that the scale of Figs. 1 and 2 does not represent the difference which may be obtained.

In Fig. 2 the wave length in the line *b* is automatically shortened by inserting inertias *o o* in series in the line and capacities *p p p* in parallel. The wave length in this case will be very much less than in the case where liquid alone is used in the pipe, and if on the scale of the figure the distance *r s* represents the full wave length the branch lines can be tapped at the points *r u* and *v*, the actual distance between these points depending on the values of capacity and inertia with which the line is charged.

It will be seen that the method is quite general, and any number of phases can be obtained. Further, the process may be reversed: a polyphase oscillation traveling in *n* pipes can be transformed to a single phase oscillation by connecting the *n* pipes to a main line, and keeping the connecting pipes at a distance of λ where λ is the wave length. The wave length which is to be used in the transformer may be reduced simply to a succession of inertias in series, and condensers in parallel, the charged line comprising for example at least nine groups of condensers and inertias for a complete wave length. The phase transformer may thus be constructed in a very compact form.

According to another example, a short wave may be readily obtained by using a flexible tube, for example, a rubber tube, in which the capacity coefficient is very small. In such tube the wave length will be very short. A simple method of obtaining the necessary wave in a short length, if a fairly high frequency is employed, is to make the wave length of a metal tube coiled like a spring, so as to keep the branch pipes close together.

It will be readily understood that instead of a condenser, a capacity may be employed, that is to say, a strong vessel completely filled with liquid. Such a capacity will take the place of a condenser and will operate in an exactly similar manner. The inertia devices according to the invention consist merely of pistons placed in the wave transmission pipe, these pistons supporting heavy weights so as to present considerable inertia to the movement of the liquid in the column. These devices are fully described in the patent specifications above referred to.

What I claim is:—

1. In a system of liquid wave transmission of power in which a liquid column is subjected to variations, that travel along the liquid column, in the pressure and volume of it, means for obtaining a plurality of columns, whose wave lengths differ in phase, from a single phase column, or vice versa, comprising: a main pipe and a plurality of subsidiary pipes connected to the main pipe at equidistant points within the compass of a single wave length in the main pipe.

2. In a system of liquid wave transmission of power in which a liquid column is subjected to variations, that travel along the liquid column, in the pressure and volume of it, means for obtaining a plurality of columns, whose wave lengths differ in phase, from a single phase column, or vice versa, comprising: a main pipe and a plurality of subsidiary pipes connected to the main pipe at equidistant points within the compass of a single wave length in the main pipe and means for artificially shortening the wave length of the liquid column in the main pipe.

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

GOGU CONSTANTINESCO.