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PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION.

Improvements in Liquid Wave Transmission of Power.

We, GOGU CONSTANTINESCO, Engineer, of The Haddon Engineering Works, Honeypot Lane, Alperton, in the County of Middlesex, and WALTER HADDON, Engineer, of 132, Salisbury Square, Fleet Street, London, E.C., do hereby declare the nature of this invention to be as follows:—

The present invention relates to systems of transmitting power by mechanical wave transmission. In the Specifications of Letters Patent Nos. 9029 of 1913, 12,438 of 1914, methods are described whereby power can be transmitted by means of periodic variations of pressure and volume travelling along liquid columns.

The object of the present invention is to make it possible to change the number of phases in such mechanical wave transmission systems.

The invention consists in 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 differ in phase from each other by the same angle.

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

The invention also consists in a phase transformer in which the wave length from which the polyphase currents are derived is replaced by an equivalent system of inertias in series and condensers in parallel.

The invention also consists in the improved method and means for changing the number of phases hereinafter described.

In carrying the invention into effect according to one example, we may have a main pipe in which a water column is oscillating at a frequency of say 20 per second, the wave length being about 70 metres. The pipe for 36 metres may be made into a coil, and two branch pipes connected at the ends of this coil. There will then be produced in the branch pipes oscillations of the liquid column differing in phase by 180 degrees. It is thus possible to use the oscillations in the two branch pipes 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.

According to another example, three branches may be connected to the main pipe at distances of 23·33 metres apart. In these branch pipes, three phase oscillations of the same frequency as the main line will be produced. These branches may be connected to a motor formed with three pistons having their axes 120 degrees apart, and acting on a common crank. The crank is thus rotated at the frequency of the line.

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 travelling 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 $\frac{\lambda}{n}$ where λ is the wave length. If the frequency is low, and the wave length inconveniently long, the pipe can be built up as a charged line. In this way, the resulting wave length in the line may occupy as short a space as desired. 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 co-efficient 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.

According to another example of the invention, which gives a compact form of transformer from single phase to three phase current, a number of inertias, say nine, may be arranged in a pipe connecting two points on the monophase line. Between each pair of inertias there is a branch pipe in which is inserted a condenser, the ends of these branch pipes being connected to a common point. The polyphase lines in this arrangement are connected to points dividing the wave length in the transformer equally into three parts.

According to another form, the pipe may have a number of inertias inserted in it in series, capacities consisting of strong vessels filled with liquid being connected to the line alternately with the inertias, the three phase current being tapped off from points along the wave length differing in phase by 120 degrees.

Dated this 15th day of May, 1916.

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COMPLETE SPECIFICATION.

Improvements in Liquid Wave Transmission of Power.

We, GOGU CONSTANTINESCO, Engineer, of The Haddon Engineering Works, Honeypot Lane, Alperton, in the County of Middlesex, and WALTER HADDON, Engineer, of 132, Salisbury Square, Fleet Street, London, E.C., do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to systems of transmitting power by liquid wave transmission. In the Specifications of Letters Patent Nos. 9029 of 1913 and 12,438 of 1914, methods are described whereby power can be transmitted by means of periodic variations of pressure and volume travelling along liquid columns producing alternating liquid currents.

Alternating liquid or other fluid currents may be defined as follows:

For any flow of fluid in full pipes if

ω = the sectional area of the pipe in square centimetres,
v = the velocity of the fluid at any instant in centimetres per second,
and
i = the flow of liquid in cubic centimetres per second, we have,

$$i = v\omega$$

Suppose that the current is produced by a piston moving in a cylinder of section Ω sq.cm. with a simple harmonic motion.

Let
r = the equivalent length of the driving crank in centimetres,
a = the angular velocity of the crank or the pulsation in radians per second,
n = the number of revolutions of the crank per second,

Then the flow from the cylinder to the pipe at any instant will be

$$i = \mathrm{I} \sin(at + \phi) \quad \ldots\ldots\ldots \quad (1)$$

where
$\mathrm{I} = ra\Omega$ = the maximum alternating flow in cm.^{3}/sec., or the amplitude of the flow,
t = the time in seconds,
ϕ = the angle of phase,
and if
T = the period of one complete alternation, equal to the time of one complete revolution of the crank,
we have

$$a = 2\,\pi\,n,$$

$$n = \frac{1}{T}$$

Let us define the effective current $I_{eff.}$ by the equation

$$I^2_{eff.} = T\int_0^T i^2 dt = \frac{I^2}{2} \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

and the effective velocity

$$v_{eff.} = \frac{I_{eff.}}{\omega}$$

The stroke volume δ will be given by the relation—

$$\delta = 2r\Omega = 2\frac{I}{a}$$

This corresponds to the volume displaced by the piston in the cylinder during a single stroke and is measured in cubic centimetres. Thus the stroke f of the liquid in the pipe in the immediate neighbourhood of the piston will be—

$$f = \frac{\delta}{\omega} = \frac{2I}{a\omega}$$

Alternating Pressures.

The consideration of alternating pressures is similar to that of alternating currents. In a pipe in which the current is flowing the pressure p will be of similar form; and we have

$$p = P\sin(at \div \psi) \div p_m \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where
P = the maximum alternating pressure in kilogrammes per square centimetre,
ψ = the angle of phase,
and

$p_{m.}$ = the mean pressure in the pipe. The minimum pressure in the pipe will then be

$$p_{min.} = p_{m.} - P$$

and the maximum pressure will be

$$p_{max.} = p_{m.} + P.$$

If p^1 is the pressure at any point in the pipe and p^2 the pressure at another point,
the difference

$$h = p^1 - p^2 = H \sin(at \div \psi) \quad \ldots\ldots\ldots\ldots\ldots \quad (4)$$

will be defined as the instantaneous hydromotive force between the two points and H is its amplitude.

The effective hydromotive force will be

$$H_{eff.} = \frac{H}{\sqrt{2}}$$

The capacity C of a liquid may be defined by the relation

$$C = \frac{\triangle V}{\triangle p}$$

where $\triangle V$ is the change in the volume of the liquid under a change of pressure $\triangle p$.

If E is the coefficient of elasticity of the liquid we have

$$\triangle p = E \frac{\triangle V}{V}$$

so that

$$C = \frac{V}{E}$$

V being the volume of liquid in cubic centimetres.

The object of the present invention is to make it possible to change the number of phases in liquid wave transmission systems.

The invention consists in 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 differ in phase from each other by the same angle.

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

The invention also consists in a phase transformer in which the wave length from which the polyphase alternating liquid currents are derived is replaced by an equivalent system of inertias in series and condensers in parallel.

The invention also consists in the improved method and means for changing the number of phases hereinafter described.

In carrying the invention into effect according to one example, we may have main pipe in which a water column is oscillating at a frequency of, say, 20 per second, the wave length being about 70 metres. The pipe for 35 metres may be made into a coil, and two branch pipes connected at the ends of this coil. There will then be produced in the branch pipes oscillations of the liquid column differing in phase by 180 degrees. It is thus possible to use the oscillations in the two branch pipes 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.

According to another example, three branches may be connected to the main pipe at distances of 23.33 metres apart. In these branch pipes, three phase oscillations of the same frequency as the main line will be produced. These branches may be connected to a motor formed with three pistons having their axes 120 degrees apart, and acting on a common crank. The crank is thus rotated at the frequency of the line.

It will be seen that the method is quite general, and any number of phases can be otained. Further, the process may be reversed; a polyphase oscillation travelling 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 $\frac{\lambda}{n}$ where λ is the wave length. If the frequency is low, and the wave length is inconveniently long, the pipe can be built up as a charged line, by inserting additional inertias in series in the line or condensers in parallel on the line. In this way, the resulting wave length in the line may occupy as short a space as desired. 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.

According to another example of the invention, which gives a compact form of transformer from single phase to three phase current, a number of inertias, say nine, may be arranged in a pipe connecting two points on the monophase line. Between each pair of inertias there is a branch pipe in which is inserted a condenser, the ends of these branch pipes being connected to a common point. The polyphase lines in this arrangement are connected to points dividing the wave length in the transformer equally into three parts.

According to another form, the pipe may have a number of inertias inserted in it in series, capacities consisting of strong vessels filled with liquid being connected to the line alternately with the inertias, the three phase current being tapped off from the points along the wave length differing in phase by 120 degrees.

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

1. A method of and means for changing the number of phases in a liquid wave transmission system which consists in dividing one wave length of a vibrating column into equal lengths and tapping from the points of division an equal number of columns.

2. A phase transformer as claimed in Claim 1 in which the length of the line tapped required for a complete wave is artificially shortened by using in the line inertias in series or condensers in parallel or both.

3. A phase transformer as claimed in Claim 1 in which the wave length from which the polyphase currents are derived is replaced by an equivalent system of inertias in series and condensers in parallel.

4. The improved method of and means for changing the number of phases in a liquid wave transmission line hereinbefore described.

Dated this 19th day of October, 1916.

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