

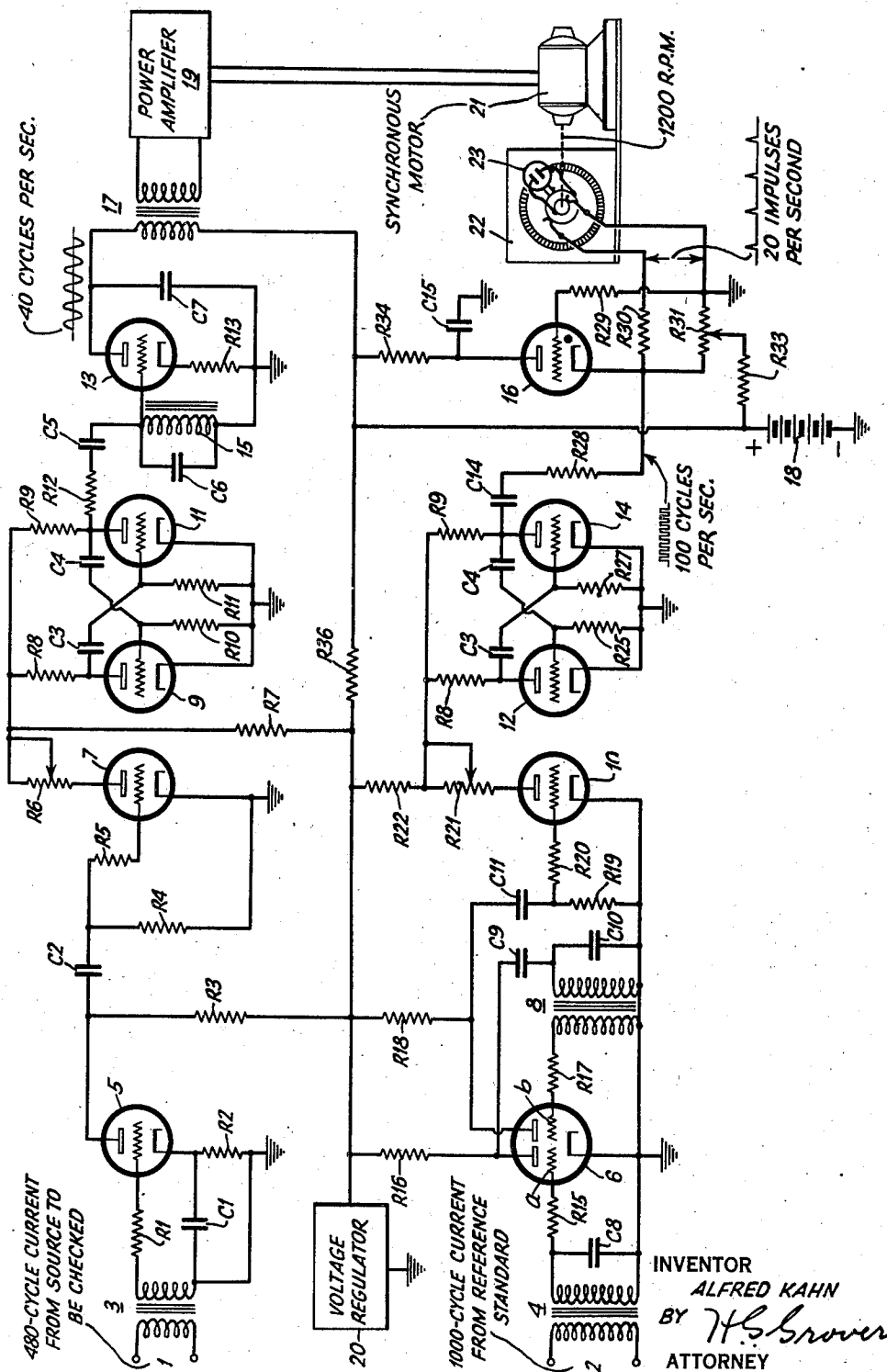
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SYSTEM FOR FREQUENCY CONVERSION AND COMPARISON OF FREQUENCIES

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SYSTEM FOR FREQUENCY CONVERSION
AND COMPARISON OF FREQUENCIES

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2 Claims. (Cl. 250—36)

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This invention relates to synchronizing systems and has particular reference to a device for synchronizing a given frequency source with a known standard frequency generator. The invention also comprehends means for multiplying or dividing either of two frequencies so that their derivatives may be compared and synchronized one with the other.

This application is a division of my copending application Serial No. 408,633, which was filed August 28, 1941, Patent No. 2,349,501, dated May 23, 1944.

In multiplex telegraph systems, it is common practice to maintain synchronism between local and remote apparatus by means of tuning forks and phase correction devices. Usually, the transmitting station is provided with a tuning fork control for the distributor speed. It is also a common practice to generate an alternating current, the frequency of which is maintained substantially constant by means of a tuning fork. When telegraph signals are transmitted through a multiplex distributor, the speed of which is thus controlled, it is possible, by well-known means, to maintain the speed of a distributor at a receiving station in synchronism with the received signals.

In some of the more extended communications systems, it has been found that a number of different tuning forks are necessary in order to provide all the frequency controls that are necessary. It is desirable to check the frequency of these tuning forks from time to time with an even better standard of frequency. Such a standard is one which is quite costly to build and maintain and, therefore, precautions are taken to operate the standard itself under ideal conditions such as would minimize the frequency drift therein.

It is an object of this invention to provide convenient means for checking certain practically operable frequency control devices with the frequency of a known standard that may be reserved merely for checking purposes.

It is another object of my invention to provide a convenient arrangement for dividing the frequencies from two different sources, each of a different fundamental frequency, so that a comparison may be made between two sub-harmonic frequencies common to the two sources.

In carrying out my invention, I preferably use electronic circuits for deriving the common sub-harmonic frequency. I then compare the sub-harmonics obtained from two different sources by means of a stroboscope. The stroboscope may

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be of the type which embodies a gaseous glow tube rotating on the shaft of a synchronous motor. The speed of the motor may be determined by the frequency of the alternating current derived from the tuning fork. On the other hand, the flashing of the glow tube may be made by means of short, sharp impulses derived from a laboratory frequency standard.

My invention will now be described in more detail, reference being made to the accompanying drawing, the sole figure of which represents diagrammatically a typical embodiment.

Referring to the drawing, I show a pair of input terminals 1 on which may be impressed, for example, an alternating current of 480 cycles per second, representing the output from a tuning fork generator the frequency of which is to be compared with that of a laboratory standard.

The 480-cycle frequency is fed across transformer 3 to the input circuit of a discharge tube 5. This tube is self-biased by means of cathode resistor R2, which is shunted by capacitor C1. The input circuit includes a grid resistor R1 and the secondary of transformer 3.

A limiter stage comprising discharge tube 7 is controlled by output from tube 5. The control potential is developed across resistor R3 the anode-connected end of which is coupled through capacitor C2 and resistor R5 to the control grid of tube 7. Grid leak resistor R4 is connected to the grounded cathode of tube 7.

The output from tube 7 is a square wave which serves to synchronize a multivibrator comprising discharge tubes 9 and 11. The circuit constants of these tubes are preferably selected to produce a 40-cycle frequency, thus dividing the 480-cycle synchronizing frequency by 12. For tuning the multivibrator the values of resistors R6, R8, R9, R10, and R11, and of capacitors C3 and C4 may be determined empirically. Care should be taken that resistors R10 and R11 are not subject to ohmic variations due to temperature or humidity. The values of capacitors C3 and C4 should also be substantially independent of temperature and humidity variations. A critical tuning adjustment of the multivibrator is made by fixing the value of resistor R6 so that the multivibrator will keep in step with the twelfth sub-harmonic of the 480-cycle output from tube 7. The anode voltages in tubes 7, 9, and 11 are adjusted by means of resistor R7.

The grid of tube 11 is coupled to the anode of tube 9, and the grid of tube 9 is coupled to the anode of tube 11. This cross-coupling of the input and output electrodes in the two tubes provides

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the well-known multivibrator action which is desired in order to produce a 40-cycle output which is synchronized with the 12th sub-harmonic of the 480-cycle tuning-fork generator.

The square-wave output from tube 11 is applied across resistor R12 and capacitor C5 to the grid of an amplifier tube 13. This tube is self-biased by means of a cathode resistor R13. The resonant circuit consisting of inductance 15 and capacitor C6 is connected between the grid of tube 13 and ground, thus providing a smoothing action which results in the output from tube 13 of a 40-cycle current of essentially sine-wave formation. This current is further smoothed by means of the inductance of an output transformer 17 and a capacitor C7, the latter being connected between the anode of tube 13 and ground.

The secondary of transformer 17 is connected to input terminals of a power amplifier 19, which may be of a type commonly used to deliver frequency-controlled power to one or more synchronous motors. Such motors are, in turn, used to drive telegraph distributors, and the like. In this case, however, the operation of my invention is best explained by showing output leads from the amplifier 19 connected to a synchronous motor 21, the shaft of which carries a small neon lamp 23. The excitation of this lamp is made intermittent by means of short sharp pulses at a frequency of 20 cycles per second, which corresponds with the nominal shaft rotation speed of the motor 21. The derivation of the pulses for excitation of the lamp 23 will now be explained.

Assuming that a 1000-cycle source is available for reference purposes and that this source is maintained within very close limits of variation, according to laboratory standards, then output energy from such a source will be applied to input terminals 2 and impressed across transformer 4 upon a first stage input circuit of a twin triode discharge tube 6. This input circuit is tuned by a capacitor C8 in shunt with the secondary of transformer 4. Resistor R15 also forms part of the same input circuit.

The first and second discharge zones of tube 6 are controlled respectively by grids a and b. The output circuits of the first and second zones are cascaded. Grid b is in circuit with resistor R17 and with the secondary of transformer 8. The primary of this transformer is tuned by capacitor C10 and is fed with an alternating potential developed across resistor R16 which is disposed in the output circuit of the first discharge zone in tube 6. Capacitor C9 isolates the direct current anode potential in the first discharge zone of tube 6 from the grounded primary of transformer 8.

Discharge tube 10 has input and output circuits which are similar to those of tube 7. Its input circuit includes resistors R19 and R20, and the junction between these resistors is coupled across capacitor C11 to the anode of the second discharge zone in tube 6. A load resistor R18 is provided in the output circuit of this discharge zone. The output circuit of tube 10 includes resistor R21 across which potentials are developed suitable for controlling the frequency of a multivibrator, the latter comprising discharge tubes 12 and 14. The combined action of tubes 6 and 10 is that of amplification and limiting, and the product is a 1000-cycle square wave.

The circuit components for the multivibrator tubes 12 and 14 are similar to those of tubes 9 and 11 except for certain constants which are chosen to produce frequency division by 10 of the 1000-cycle synchronizing frequency. The operation of

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this multivibrator will, therefore, be understood without further description, except to point out that the values of resistors R25 and R27 are suitably differentiated for the purpose of providing such compensation for unbalance as will cause the multivibrator to be maintained in step with an even sub-harmonic (the tenth) of the 1000-cycle control frequency. Resistor R22 determines the anode potentials applied in tubes 10, 12, and 14.

Output impulses from the multivibrator described in the preceding paragraph are fed through capacitor C14 and resistor R28 to the input circuit of a succeeding stage comprising a gaseous discharge tube 16. To ignite this tube, such impulses are applied negatively to the cathode. The control grid is connected to the cathode through resistors R29 and R31, the junction between these two resistors being grounded. Anode potential is supplied to the tube from a direct current source 18 through resistor R34. In order to adjust the ignition and extinction potentials, resistor R31 is constituted as a variable potentiometer, the movable tap on which is connected to one end of resistor R33 for feeding a suitable positive potential thereto with respect to ground. An appreciable time is required for capacitor C15 to be charged through resistor R34. During this time, the anode potential in tube 16 builds up gradually to a value such that the next succeeding negative impulse applied to the cathode will produce an ionization discharge. This charge, however, is of only momentary duration since the sudden discharge of capacitor C15 again reduces the anode potential to a value below that which will sustain ionization. The short sharp discharges in tube 16 result in the delivery of momentary excitation potentials to a neon lamp 23 used for purposes of indicating the frequency drift.

The values of resistor R34 and capacitor C15 are so determined, therefore, that the tube 16 acts as a frequency divider and its periodicity is preferably such as to divide the control impulses by 5, thus producing an output of 20 cycles per second, whereas the output from the multivibrator tubes 12, 14 was stated to be 100 cycles per second.

One electrode of the lamp 23 is connected through a collector ring and brush and through resistor R30 to the cathode of tube 16, and the other electrode of the lamp 23 is grounded.

The lamp 23 constitutes an indicating element for a stroboscope, other portions of which include a stationary translucent disc 22 on which there appears a circular scale suitably divided for observing the angle of drift of the neon lamp flashes within a given period of time. The lamp 23 is mounted for rotation on the shaft of motor 21. The flashes appear through the translucent disc 22. The disc 22 may be graduated in degrees, or, as an alternative, may be graduated in terms of percentage deviation of the frequency of the tuning fork source with respect to a corresponding fixed standard of the same frequency.

It will be clear from the above description that the flashing of the lamp 23 once per revolution around the scale of the disc 22 can be observed as an indication of frequency drift with respect to the 480-cycle fork frequency in relation to the 1000-cycle laboratory standard.

The motor 21 is mounted on a chassis behind a stationary calibrated translucent disc 22. A neon lamp 23 mounted on the motor shaft is excited by pulses generated from the 1000-cycle standard and is viewed through the aforementioned

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disc, which may be calibrated in degrees. With the motor operating at a shaft speed of 20 R. P. S. and the neon lamp flashing once per revolution, a convenient means is thus afforded for reading fork generator accuracy directly from the calibrated dial 22. Furthermore, a short time observation will indicate to the operator whether the working standard is slow or fast and to what degree. The change in fork speed caused by adjustment can be observed immediately so that a more accurate setting can be made in a brief space of time. The last statement refers to normal operating adjustments made by means of a fork drive potentiometer (not shown) and does not, of course, include major thermostat readjustments which may be found necessary from time to time.

The advantage to be derived from my improved frequency drift indicator will be better understood from the following discussion of the theory of operation.

By observing the amount of drift in degrees for a given period of time, the speed difference in parts in 100,000 can be readily determined. For example, in one second, the motor rotation is 20 revolutions, during which time the neon lamp 23 sweeps through 7200 degrees, provided the fork generator frequency is exactly what it should be. The relation between x degrees of drift per second and the frequency error in parts per 100,000 is shown by the equation

$$\frac{x}{7200} = \frac{1}{100,000}$$

or $x = .072^\circ$ per part in 100,000 cycles per second.

Thus a shift of .072° per second is equivalent to an accuracy of one part in 100,000. Because of the difficulty of reading so small an angle, it is preferable to check for 100 seconds, during which the drift would be 7.2° per part in 100,000.

If "R" is the observed difference in degrees in 100 seconds, then the frequency drift may be expressed as

$$\frac{R}{7.2} = \text{parts in 100,000}$$

It is perhaps preferable to divide the circumference of the scale on the disc 22 in 50 divisions. Each division will then be 7.2°, so that the frequency drift in parts in 100,000 will correspond with the number of scale divisions through which the neon flash drifts in 100 seconds.

The operator by observing the direction of drift of the neon flash can tell whether the 480-cycle fork generator is slow or fast. If the drift is clockwise, this standard is fast; if counter-clockwise, it is slow.

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The foregoing description may suggest modifications of my invention, particularly to those skilled in the art, but such modifications should be considered comprehended within the scope of the invention itself.

I claim:

1. In combination with a source of recurring wave trains, a frequency divider comprising a gaseous discharge tube having a cathode, an anode, and a control electrode, means for applying potential variations from said source to one electrode of said tube, a direct current source having its positive terminal connected through a resistor to the anode of said tube and through a tap on a voltage divider to the cathode thereof, a resistive connection from the negative terminal of said direct current source to said control electrode, another connection from the negative terminal of said direct current source to the end of said voltage divider remote from said cathode, a capacitor connected between the anode of said tube and the negative terminal of said direct current source, said resistor and said capacitor constituting a time constant circuit whereby the ignition voltage in said tube is gradually built up during the occurrence of a predetermined number of waves in one of said trains, and means for so adjusting the tap on said voltage divider that said tube is caused to strike only in response to the final wave of each recurring wave train.

2. Apparatus for deriving a succession of discrete impulses of relatively brief duration from a source of sine waves of a frequency harmonically related to the periodicity of said impulses, said apparatus comprising means for limiting the amplitude of said sine waves to produce relatively square waves, means including a multivibrator for generating oscillations at a frequency which is controlled by said square waves, a direct current source, a capacitor and resistor for storing electrical energy from said source at a constant rate during the generation of recurring oscillatory trains, each train possessing a predetermined number of waves, a gaseous discharge device through which said energy is caused to be suddenly released under control of the terminating oscillation in each said train, and adjustable potentiometric means having impedance connections across the terminals of said source and to the cathode of said gaseous discharge device for applying a suitable marginal voltage across the discharge path in the latter, whereby said terminating oscillation is rendered effective to fix the sub-harmonic frequency of said discrete impulses in relation to the frequency of said sine wave source.

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