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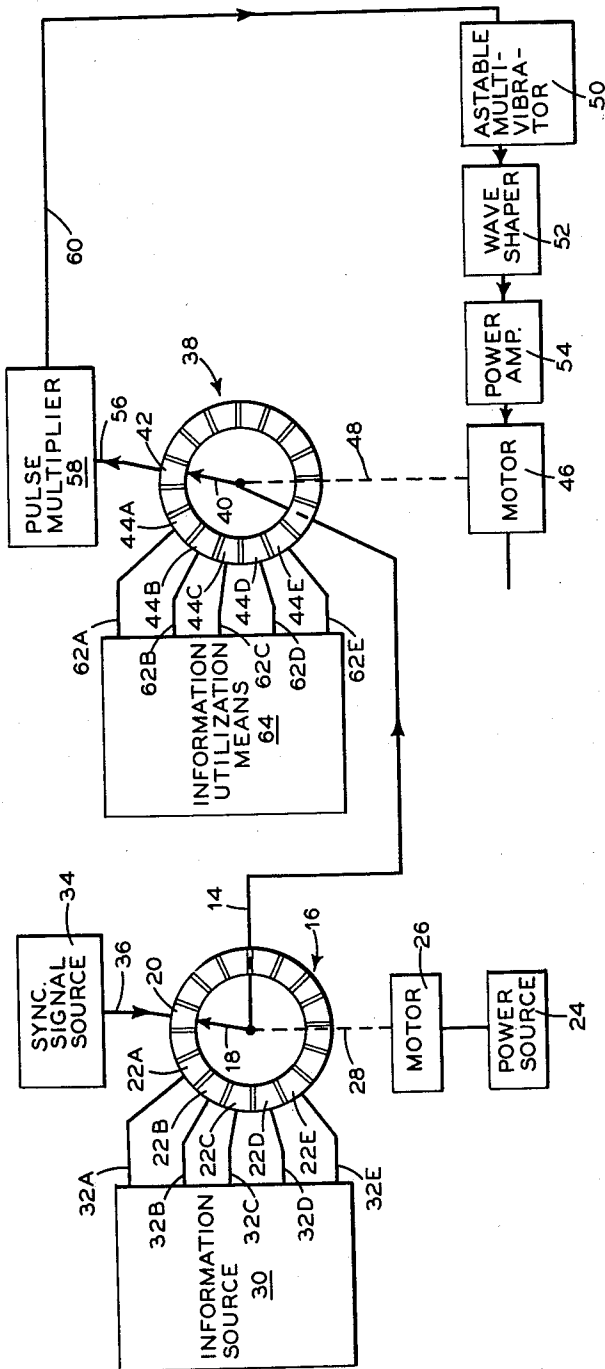
3,067,285

SYNCHRONIZATION SYSTEM

Filed Oct. 24, 1960

2 Sheets-Sheet 1

FIG. 1



RECEIVING STATION
12

TRANSMITTING STATION
10

COMMUNICATIONS SYSTEM
14

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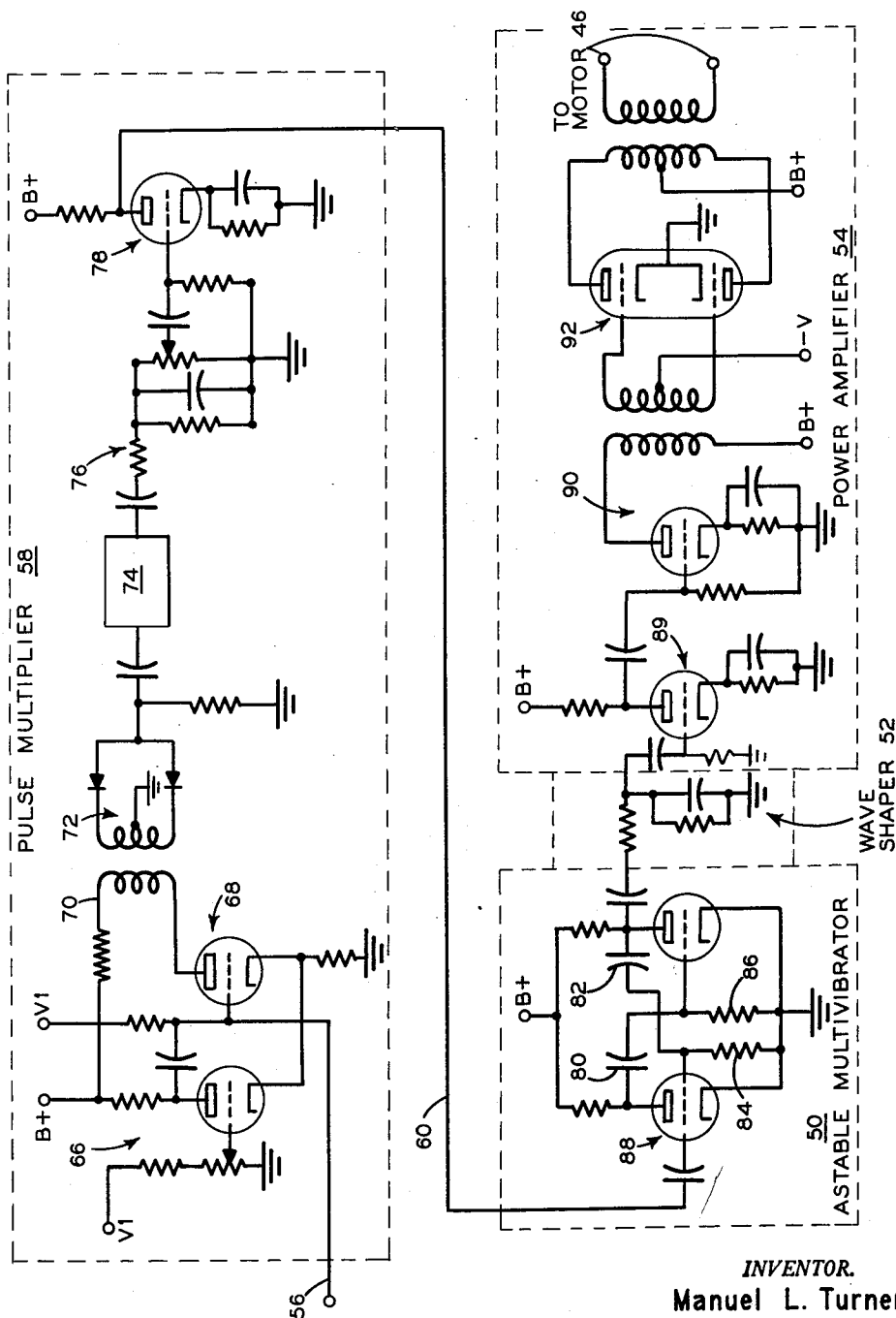
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FIG. 2



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SYNCHRONIZATION SYSTEM

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6 Claims. (Cl. 178—69.5)

This invention relates to phase and frequency synchronization between rotary elements, and more particularly, to communication systems requiring phase and frequency synchronization between rotary elements of the transmitting and receiving stations.

Such systems, of which present day Teletype systems are an example, often include a rotary signal collector at the transmitting station and a rotary signal distributor at the receiving station. A moving contact of the signal collector sequentially sweeps over a set of fixed contacts which are receiving information signals in parallel and transmits the signals serially. A moving contact of the rotary signal distributor at the receiving station receives the serially transmitted information signals and distributes these signals effectively in parallel to a set of fixed contacts swept by the moving contact.

There is a fixed one-to-one correspondence between a fixed contact of the rotary signal collector and a fixed contact of the rotary signal distributor so that the information signals received by a particular fixed contact of the signal collector are always transmitted to the same fixed contact of the signal distributor. If the moving contact of the signal distributor rotates at a different frequency or varies in phase with respect to the moving contact of the signal collector, the required one-to-one correspondence is not maintained and the information transmitted is usually unintelligible.

Many systems have been proposed to maintain the essential phase and frequency relationship between the signal collector and the signal distributor. Some of these systems sense for the lead or lag of one unit with respect to the other unit and generate slow down or speed up signals for the drive mechanism of one of the units. Other systems provide a master synchronizer to control all units. However, such systems are either slow in operation or economically impractical under certain conditions. For example, the lead and lag sensing systems have inherent time delays which cause intermittent periods of unreliable information transmission. Master synchronization is not practical when the units are at widely scattered points and when there are a plurality of receiving units.

It is accordingly an object of this invention to provide an improved means for synchronizing, in phase and frequency, remotely located rotary elements.

Another object of this invention is to provide improved means for synchronizing a rotary signal receiver to a rotary signal transmitter.

A further object of this invention is to provide improved means for maintaining a constant frequency and phase relation between a rotary signal collector and a rotary signal distributor.

Generally, the invention contemplates the provision of means for maintaining a constant speed and position relation between first and second rotary elements. Accordingly, means are provided for rotating the first rotary element at a given frequency. Means transmit a signal from the first rotary element to the second rotary element each time the first rotary element is at a particular angular position during each cycle of rotation. Means cause the second rotary element to rotate at a frequency slightly different from the given frequency. Further means transmits the received signals to the means for causing the rotation of the second rotary element only when the second rotary element is in a particular angular position

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when the signal is received, to cause the second rotary element to rotate at the given frequency.

Other objects of this invention will in part be obvious and in part hereinafter pointed out.

In the drawings,

FIG. 1 is a schematic block diagram of a communication system employing the synchronizing feature of the instant invention; and

FIG. 2 is a schematic diagram of portions of the synchronizing means shown in FIG. 1.

Referring to FIG. 1, the invention is shown, by way of example, as incorporated in a communication system which includes a transmitting station, generally designated at 10, which is coupled to a receiving station, generally designated at 12, by a loop 14.

Transmitting station 10 comprises a rotary signal collector 16 having a moving contact 18, a fixed contact 20 for receiving synchronizing signals, and a set of fixed contacts 22A to 22E for receiving information signals. A 60 cycle power source 24 energizes motor 26 having a stepdown gear ratio of 8 to 1, which is coupled by shaft 28 to the moving contact 18. Contact 18 sweeps over fixed contacts 20 and 22A to 22E at a frequency of $7\frac{1}{2}$ cycles per second.

Information represented by coded combinations of voltages is transmitted in parallel from an information source 30 via lines 32A to 32E respectively to contacts 22A to 22E. Moving contact 18 is coupled to loop 14. Therefore, as contact 18 is driven through a single rotation thereof, the coded combination of voltages on contacts 22A to 22E is converted to a serial array of time spaced voltage pulses or information signals that are transmitted to receiving station 12 by way of loop 14.

To insure phase and frequency synchronization, as hereinafter more fully described, a synchronizing signal source 34 transmits via line 36, a synchronizing signal to contact 20. The synchronizing signal must have a characteristic which is distinguishable from the information signals. A convenient characteristic may be the amplitude of the voltage of the signals or the length of pulse. Thus, the amplitude of the synchronizing signal may be twice as great as the amplitude of the information signals. Therefore, during each cycle of contact 18, a series of voltage pulses of a first amplitude (information signals) preceded by a voltage pulse of twice that amplitude (synchronizing signal) is transmitted from station 10 via loop 14 to station 12.

Receiving station 12 comprises a rotary signal distributor 38 having a moving contact 40, a fixed contact 42 for receiving synchronizing signals, and a set of fixed contacts 44A to 44E for receiving information signals. A synchronous motor 46 having an 8 to 1 stepdown ratio, is coupled by a shaft 48 to contact 40.

An oscillator means comprising astable multivibrator 50, wave shaper 52 and power amplifier 54, serially connected in that order, energizes motor 46. Multivibrator 50 has a free running frequency of slightly more or less than 60 cycles per second, but is susceptible to external triggering. Wave shaper 52 is basically a filter which transmits the fundamental frequency sinusoid of the square wave generated by astable multivibrator 50 to power amplifier 54 for energizing motor 46. Thus, contact 40 is rotated at one-eighth the frequency of multivibrator 50.

Contact 40 is electrically coupled to signal loop 14 for receiving information and synchronizing signals from station 10. Contact 42 is coupled via line 56 to pulse multiplier 58 which transmits 8 pulses via line 60 to multivibrator 50 for each pulse received that exceeds a given amplitude. Contacts 44A to 44E are respectively

coupled via lines 62A to 62E to information utilization means 64.

Under normal operating conditions, information signals received from information source 30 by fixed contact 22A via line 32A should be transmitted to information utilization means 64 from fixed contact 44A via line 62A. A similar relationship exists for the remaining paired fixed contacts. If the initial phase and frequency relationships between signal collector 16 and signal distributor 38 are such that contact 18 engages contact 22A when contact 40 engages contact 44A and both contacts 18, 40 rotate with the same speed, such relationship will be maintained.

However, such is not the case. It will be recalled that by virtue of the free running frequency of astable multivibrator 50, contact 40 is caused to rotate slightly faster or slower than contact 18, so that initially signal collector 16 and signal distributor 38 are out of synchronism. However, within a few seconds after warmup, a synchronizing signal transmitted from source 34 via line 36, contact 20, contact 18, loop 14 and contact 40 will be received by contact 42 and transmitted via line 56 to pulse multiplier 53. Since this is a synchronizing signal, its amplitude will exceed the threshold required by pulse multiplier 53, which accordingly generates 8 pulses that successively trigger multivibrator 50.

The leading edge of each of these pulses has a definite relation to the time of occurrence of the synchronizing signal and the square wave generated by the multivibrator 50 in response to these trigger pulses also has a definite relationship. Therefore, the sinusoidal signal which energizes motor 46 has a definite phase relation with the time of occurrence of the synchronizing signal. From this point on timewise, and in the manner described, the frequency and phase of rotation of contact 40 is synchronized to the rotation of contact 18. If, due to transient phenomena, there is a loss of synchronization, the above described action is automatically repeated until phase and frequency locking is attained.

It follows that multivibrator 50 is no longer triggered by pulses from multiplier 53 and contact 18 starts rotating faster or slower because the free running frequency of multivibrator 50 has taken over. When contact 40 has again caught up with contact 18, synchronizing signals are again received by multiplier 53 which will then transmit triggering pulses to multivibrator 50 to constrain the same to follow a frequency 8 times the frequency of the received synchronizing signals.

In FIG. 2 is shown the circuitry associated with receiving station 12. Since the circuits are generally known in the art, they will be described briefly. Pulse multiplier 53 includes a monostable multivibrator 66 of conventional design with the exception that the primary winding 70 of a transformer is in the anode circuit of the amplifier 68; and a full wave rectifier 72 of conventional design.

Unit 74 is three additional cascaded combinations of a monostable multivibrator similar to multivibrator 66, and a full wave rectifier similar to rectifier 72. During operation, a synchronizing signal is received as a pulse on line 56 to trigger multivibrator 66 to its "on" state, causing rectifier 72 to transmit a pulse to unit 74. When multivibrator 66 returns to its "off" state, a second pulse is transmitted by rectifier 72 to unit 74. Thus, for each pulse received, 2 pulses are transmitted by the combination of multivibrator 66 and rectifier 72. Of course, it is apparent that the time constants of the monostable multivibrators are chosen to provide the proper time spacing of the pulses. The pulses generated by unit 74 are fed after shaping by a conventional wave shaper 76, to voltage amplifier 78 of conventional design.

Astable multivibrator 50 is of conventional design with the time constants as determined by capacitors 80, 82 and resistors 84, 86 chosen to provide a symmetrical square wave with a frequency slightly greater or less than 60 cycles per second. It is noted that line 60 from

pulse multiplier 53 is coupled to the control grid of amplifier 88 to constrain multivibrator 50 to operate at the frequency of the pulses from multiplier 53. Wave shaper 52 is a conventional filter to select the fundamental frequency of the square wave generated by multivibrator 50 and accordingly transmits a substantially sinusoidal signal to power amplifier 54.

Amplifier 54 includes a conventional voltage amplifier 89 which drives transformer coupled amplifier 90, which in turn drives push-pull amplifier 92. The output of amplifier 92 is coupled to synchronous motor 46.

Changes might be made in embodiments of the invention herein disclosed without departing from the spirit thereof, and therefore it is understood that all matter herein disclosed is illustrative and not limiting except as set forth in the appended claims.

What is claimed is:

1. In a pulse communication system, the combination of a rotary signal collector, means for rotating said signal collector at a predetermined frequency, means for causing said signal collector to transmit a synchronizing signal each time said signal collector passes through a particular angular position, a rotary signal distributor, oscillator means for generating signals having a free running frequency slightly different from N times said predetermined frequency, means responsive to said oscillator means for rotating said signal distributor at 1/N times the frequency of the signals generated by said oscillator means, and means for receiving said synchronizing signals when said signal distributor is at a particular angular position and for frequency multiplying said synchronizing signals N times for causing said oscillator means to generate signals at N times the predetermined frequency.

2. In a communication system, the combination of a rotary signal collector having a moving contact and a plurality of fixed contacts, means for generating synchronizing signals coupled to one of said fixed contacts, means for generating information signals coupled to the remaining fixed contacts, means for rotating said moving contact at a predetermined frequency, a rotary signal distributor having a moving contact and a plurality of fixed contacts, means connected to one of the fixed contacts of said signal distributor for receiving said synchronizing signals, information signal utilization means coupled to the remaining fixed contacts of said signal distributor, means for providing signal coupling between said moving contacts, free running oscillator means for generating power signals having a natural frequency slightly different from N times said predetermined frequency, synchronous motor means responsive to said oscillator means for rotating the moving contact of said signal distributor at a submultiple N of the frequency of said power signals, frequency multiplying means coupled to said synchronizing signal receiving means for frequency multiplying the frequency of received synchronizing signals by a factor N, and means for coupling said frequency multiplying means to said oscillator means to constrain the frequency of the power signals to N times the frequency of the received synchronizing signals.

3. In a communication system, the combination of a rotary signal collector having a moving contact and a plurality of fixed contacts, means for generating synchronizing signals coupled to one of said fixed contacts, means for generating information signals coupled to the remaining fixed contacts, motor means for rotating said moving contact at a predetermined frequency, a rotary signal distributor having a moving contact and a plurality of fixed contacts, one of the fixed contacts of said signal distributor being adapted to receive synchronizing signals, information signal utilizing means coupled to the remaining fixed contacts of said signal distributor, means for providing signal coupling between said moving contacts, a free running relaxation oscillator means for generating pulses having a natural frequency slightly different from N times said predetermined frequency, wave

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shaping means for shaping said pulses to a substantially sinusoidal signal, power amplifying means for amplifying the sinusoidal signals, synchronous motor means responsive to said power amplifying means for rotating the moving contact of said signal distributor at a submultiple N of the frequency of said sinusoidal signals, signal frequency multiplying means coupled to said one fixed contact of said signal distributor for generating N pulses for each received synchronizing signal, and means coupling said signal frequency multiplying means to said oscillating means for causing said oscillator means to generate a pulse for each pulse received from said signal multiplying means.

4. The combination as in claim 3 wherein said free running relaxation oscillator means is an astable multivibrator.

5. In combination with first and second rotary elements, means for maintaining a constant speed and phase relation between said rotary elements comprising a first moving contact coupled to said first rotary element, a first fixed contact for engagement by said first moving contact, means for generating synchronizing signals coupled to said first fixed contact, motor means for rotating said first rotary element and said first moving contact at a predetermined frequency, a second moving contact coupled to said second rotary element and a second fixed contact for engagement by said second moving contact, means for providing signal coupling between said first and sec-

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ond moving contacts, a free running relaxation oscillator means for generating pulses having a natural frequency slightly different from N times said predetermined frequency, wave shaping means for shaping said pulses to a substantially sinusoidal signal, power amplifying means for amplifying the sinusoidal signal, synchronous motor means responsive to said power amplifying means for rotating said second rotary element and said second moving contact at a submultiple N of the frequency of said sinusoidal signal, signal frequency multiplying means coupled to said second fixed contact for generating N pulses for each received synchronizing signal, and means coupling said signal frequency multiplying means to said oscillator means for causing said oscillator means to generate a pulse for each pulse received from said signal multiplying means.

6. The combination of claim 5 wherein said free running relaxation oscillator means is an astable multivibrator.

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