Dec. 9, 1941. H. C. RESSLER 2,265,779

FACSIMILE SYNCHRONIZING DEVICE

Filed Sept. 14, 1939 2 Sheets-Sheet 1

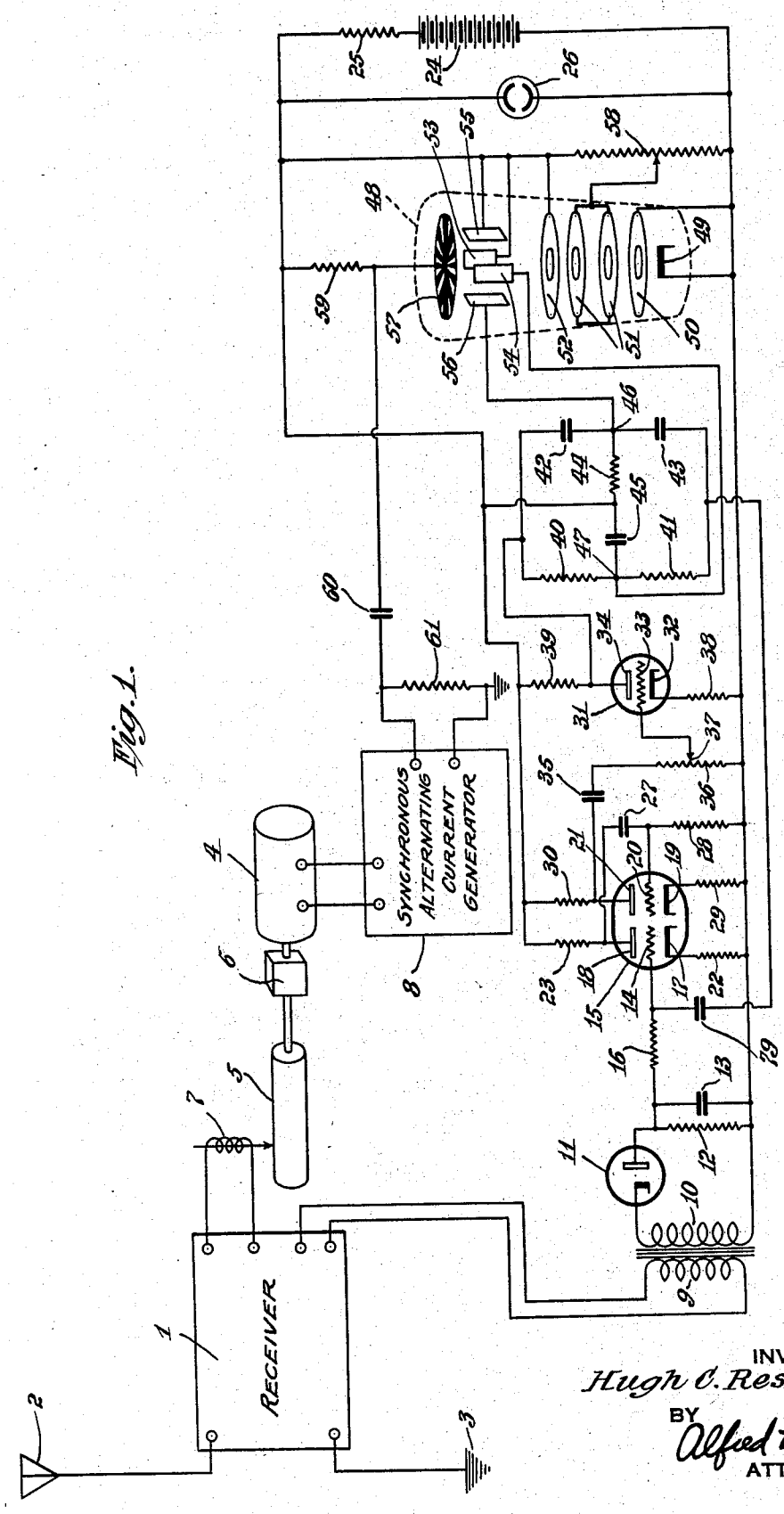


Fig. 1.

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Fig. 2.

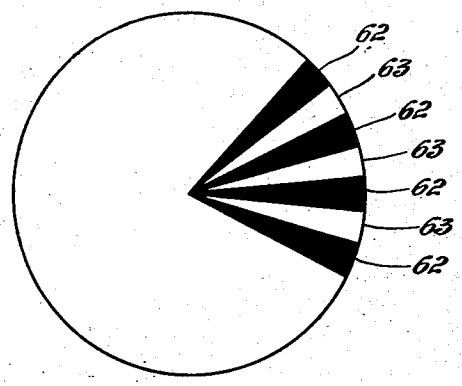


Fig. 3.

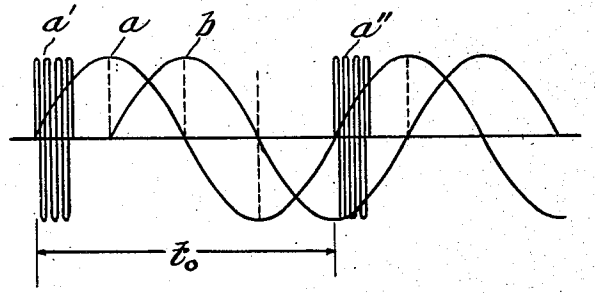


Fig. 4.

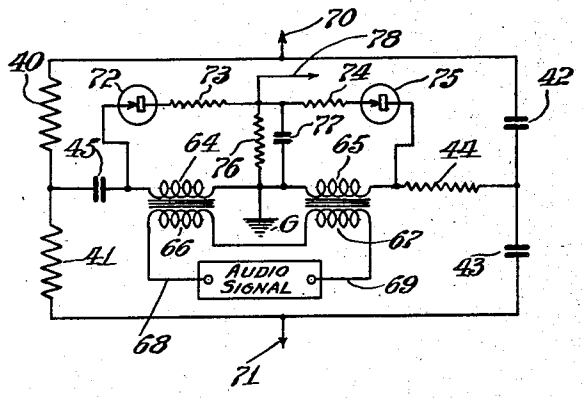
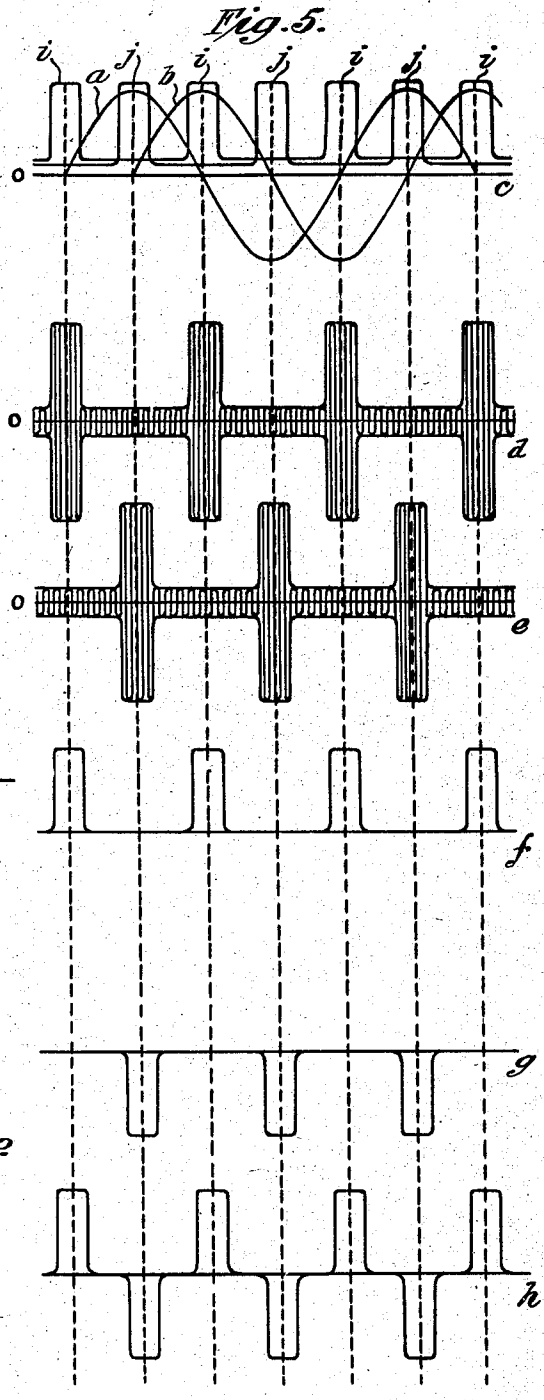


Fig. 5.



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FACSIMILE SYNCHRONIZING DEVICE

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Application September 14, 1939, Serial No. 294,868

5 Claims. (Cl. 178—69.5)

The present invention concerns electrical synchronizing systems and, in particular, electrical synchronizing embodying a novel method of frequency multiplication.

One object of the present invention is to provide methods of and means for deriving essentially sine wave synchronizing signals of harmonic frequency from lower frequency signals.

Another object is to derive these harmonic frequency signals by methods and means which eliminate the fundamental without the use of conventional filters or oscillators at the harmonic frequency.

A further object is to derive harmonic signals in which any residual undesired component is spaced at least twice the fundamental frequency away from the desired harmonic.

A still further object is to derive substantially pure harmonic signals of any desired order and with simple changes to vary the order of the harmonic at will without altering the efficiency of the system or the purity of the resulting signal.

In facsimile, television and similar systems, synchronism must be maintained between the transmitter and receiver in order to be able to accurately record or reproduce the transmitted material. Economic considerations, in general, require that synchronizing signals be transmitted during short intervals interposed with the marking or picture signals. Since it is desirable to apply a continuous signal to the synchronizing means, especially if the latter comprises an electric motor, the spaces between the intervals of synchronizing signal transmission must be filled in. One method of filling in the spaces is to generate trains of damped oscillations by "shocking" an oscillatory circuit, resonant at the desired synchronous frequency, by means of the transmitted synchronizing signal. Final smoothing and elimination of harmonics may be accomplished by resonant filters tuned to the desired harmonic. This method becomes increasingly inefficient as the order of the harmonic increases and as the frequency decreases. Practical systems also leave some harmonics, especially those adjacent to the desired harmonic, which may be a source of disturbance in the synchronizing system. The present invention concerns a system which approaches an ideal system and completely eliminates the difficulties pointed out above.

In the present system, low frequency impulses are transmitted interposed with facsimile or other signals. Electrical waves having the fundamental frequency of these impulses are produced by means of a highly regenerative circuit or by synchronizing an oscillator. Two components of this low frequency, 90° out of phase, may be applied to deflecting means of an electron stream device sweeping the stream over a segmented target. The number of segments in the target corresponds to the order of harmonic which is desired. The stream sweeping the target generates the desired harmonic frequency signal which is amplified and applied to the recorder or other synchronizing means. Alternately the low frequency signal may be multiplied to a higher frequency by one or more frequency multiplying circuits consisting of single or multiple phase rectifiers. The multiplied frequency may be applied directly to the synchronizing means or it may be further multiplied by applying it to the target multiplier.

The invention may be more fully understood and further objects will be evident from the following detailed description when taken in conjunction with the various figures of the drawings.

In the drawings:

Fig. 1 shows one form of the present invention applied to a facsimile receiver.

Fig. 2 shows an enlarged diagram of one part of the apparatus shown in Fig. 1.

Fig. 3 shows diagrams of signals useful in explaining the operation of Fig. 1.

Fig. 4 shows a modified portion of the circuit of Fig. 1.

Fig. 5 shows diagrams of signals associated with the operation of Fig. 4.

Fig. 1 shows a facsimile receiver 1 attached to an antenna 2 and ground 3. A recorder consisting of a synchronous motor 4 driving a recording drum 5 thru suitable reducing gears 6 is shown receiving its power from a source of synchronous alternating current 8. Recordings are made by means of a stylus 7 energized from receiver 1. Synchronizing signals, which will usually be of the form a' and a'' in Fig. 3, are fed from receiver 1 to primary 9 of transformer 9—10. The spaces between a' and a'' will usually be occupied by picture signals. The synchronizing signals a' a'' from the receiver consist of a number of essentially constant amplitude cycles of sub-carrier frequency voltage, the envelope of which is essentially rectangular. These signals induce similar signals in secondary 10 of the coupling transformer and this secondary voltage is applied across rectifier 11 in series with load 12—13 thereby removing the sub-carrier component and leaving rectangular unidirectional impulses across load resistor 12 shunted by condenser 13.

These rectangular impulses are applied to grid 14 of a double tube 15 thru resistor 16. Tube 15 includes two sets of elements and may be replaced by two separate tubes. One set of elements includes cathode 17, control grid 14 and plate 18, while the other set includes cathode 19, control grid 20 and plate 21. Each set of elements forms an amplifier stage. Cathode 17 receives a bias from current thru resistor 22 and plate 18 is loaded by resistor 23 and is energized from a source of direct current 24 having an internal resistance 25 and regulated by a voltage regulator 26. The second amplifier stage is connected in cascade by feeding grid 20 from plate 18 thru coupling condenser 27 and across grid leak 28. Cathode 19 receives its bias from the cathode current drop in resistor 29 and plate 21 is loaded by resistor 30 and is energized from direct current source 24. A third stage of amplification is provided by tube 31 having cathode 32, control grid 33 and plate 34. Grid 33 receives an adjustable portion of the output of plate 21 thru coupling condenser 35 across gain control 36 from the adjustable tap 37. Cathode 32 is connected to bias resistor 38 and plate 34 is loaded with resistor 39 and energized from source 24. Calling plate 34 the output of the three stage amplifier and grid 14 its input, a bridge network consisting of resistors 40, 41 and 44 and condensers 42, 43 and 45 is connected between output and input. Resistor 40 in series with resistor 41, is connected in parallel with condenser 42 in series with condenser 43, resistor 44 is connected in series with condenser 45 and the two are connected between the junction between condensers 42 and 43 and the junction between resistors 40 and 41 to complete the bridge network. The input is fed directly from plate 34 to the junction between resistor 40 and condenser 42 and the output from the junction between resistor 41 and condenser 43 is fed to grid 14 thru blocking condenser 79. Since the bridge network passes currents of all frequencies, except those at the balance frequency, and there are an odd number of stages in the amplifier, the amplifier will degenerate and the amplification thru the system will be low except for the balance frequency. It is convenient, although other combinations may be used, to make condenser 43 equal to condenser 42 equal to one-half condenser 45 and resistor 41 equal to resistor 40 equal to twice resistor 44. Under these conditions, the balance frequency is equal to one divided by 2π times the resistance of resistor 41 times the capacity of condenser 43. Thus, the amplifying system is responsive to one frequency, the balance frequency, and if this is made to be f_0, the f_0 component of rectified impulses a' and a'' will be selected. The rectangular impulses produced by rectifying a' and a'' may be represented mathematically by a series of terms consisting of f_0 and many harmonics due to the fact that a' and a'' are spaced a distance t_0 apart.

Also, in Fig. 1 is shown a special cathode ray tube 48 including a cathode 49, control grid 50, first anode 51, second anode 52, deflecting plates 53, 54, 55 and 56 and a special target 57. The second anode 52 is energized from direct current source 24 and first anode 51 is supplied with current from a tap on resistor 58 also supplied from source 24. This tube produces an electron beam directed on to target 57, and may be made to be sharply defined by proper adjustment of the focus control voltage on anode 51. This beam is deflected by deflecting plates 54 and 56 in perpendicular directions. Target 57 acts as a signal anode and output voltage is taken off across load resistor 59 connected between target 57 and source 24.

An enlarged view of the surface of target or anode 57 is shown in Fig. 2. The target is shown for a multiplication factor of 18 with 18 non-emitting segments 62 and 18 emitting segments 63. The target may be made of aluminum foil on which are formed carbonized segments 62 leaving the aluminum exposed in segments 63. The electron beam striking target 57 generates a large number of secondary electrons when the beam strikes the emitting segments 63 and a very few secondary electrons when it strikes the non-emitting segments 62. Thus, the beam in passing over the segments generates an alternating current having a maximum when it is on the emitting segments and a minimum when on the non-emitting segments.

Fig. 3 shows the modulated sub-carrier synchronizing impulses a' and a'' fed into the transformer 9—10. Rectifier 11 and its associated load 12—13 remove the sub-carrier and produce rectangular impulses equivalent to one-half of the envelope of impulses a' and a''. The three stage bridge-controlled amplifier sharply selects the fundamental frequency component having a period t_0 as shown at a. At points 46 and 47 of the bridge circuit of Fig. 1 there will exist two substantially pure sine wave voltages having periods t_0 but having a phase difference of 90° as represented by a and b. When the beam of cathode ray tube 48 is deflected by applying these 90° out of phase voltages to the perpendicular deflecting plates 54 and 56, it traces a circular pattern on target 57. The beam passing over the segments of target 57 generates in load resistor 59 a substantially pure sine wave voltage of a frequency nf_0 where n is the number of emitting or non-emitting segments and f_0 is the frequency of the waves a and b having the period t_0. If f_0 is for instance 3⅓ cycles and n is 18, then the generated frequency nf_0 will be 60 cycles. This 60 cycle signal is fed thru coupling condenser 60 across resistor 61 to the synchronous alternating current generator 8 for purposes of synchronizing to 60 cycles the alternating current generated by this unit. This generated synchronous alternating current is applied to motor 4. If motor 4 is a two pole synchronous motor, it will run at 60 revolutions per second and if gear 6 reduces this speed 18—1, drum 5 will revolve 3⅓ times per second and t_0 will represent one scanning line. The synchronizing impulses will then be interspaced with lines of facsimile picture signal.

Briefly, the process just described in detail consists in recapturing, in substantially pure sine form, the fundamental frequency component of the synchronizing impulses and multiplying this fundamental by a desired factor to produce an essentially pure harmonic frequency of the fundamental. This harmonic frequency is used to synchronize an alternating current generator or is amplified to produce alternating current of sufficient power to drive a motor or other recorder driving means.

In Fig. 4 is shown a modified bridge circuit for generating a synchronizing signal in which the harmonic components are more widely spaced than if the fundamental frequency were distorted to produce the harmonic component desired. Distortion of the fundamental as by an overloaded amplifier produces undesired harmonic

components spaced by a frequency difference equal to the fundamental frequency away from the desired harmonic. The system to be described yields undesired components spaced two or more times the fundamental away from the desired harmonic frequency.

Fig. 4 shows a circuit which may be used with the circuit of Fig. 1 by connecting lead 79 to plate 34 and lead 71 to one side of condenser 79 and produces an output at lead 78 which may be used as a synchronizing signal. Tubes 11, 15 and 31 of Fig. 1 may be used with the circuit of Fig. 4, but tube 48 will not ordinarily be required. The circuit includes the balanced feedback circuit of Fig. 1 employing resistors 40, 41 and condensers 42, 43 and 45. The balanced feed-back, when attached to the three stage amplifier shown in Fig. 1, serves to recapture the fundamental of the synchronizing impulses, as shown at *a* and *b* of Fig. 5*c*. In Fig. 4 secondary 64 of transformer 64—66 is connected between condenser 45 and ground G and secondary 65 is connected between resistor 44 and ground G. Secondaries 64 and 65 and their associated magnetic circuits are so proportioned that the transformer cores are well saturated by signals *a* and *b*, except near zero instantaneous value. Under these conditions the apparent inductance of primaries 66 and 67 will be small except for intervals near zero fundamental voltage. If *a* represents the voltage across resistor 44 and secondary 65, the apparent inductance of primary 67 will have the form shown at *i*. Similarly, if *b* represents the voltage across secondary 64, the apparent inductance of primary 66 will have the form shown at *j*. Now, if an audio frequency signal is applied from the "audio signal" source through leads 68 and 69 to primaries 66 and 67 connected in series, these signals will be passed by transformer 65—67 during interval *i* and by transformer 64—66 during interval *j*. Thus, the voltage across secondary 65 will be of the form shown by Fig. 5*d* and the voltage across secondary 64 will be of the form shown by Fig. 5*e*. The envelopes of these signals have been drawn in on Fig. 5*d* and *e* to emphasize the fact that they consist of impulses of audio frequency voltage and are spaced by one-half the period of the fundamental *a* or *b*. Voltages across secondaries 64 and 65 are combined and impressed on rectifiers 72 and 75 in series with resistors 73 and 74. A bridge rectifier circuit is completed by connecting a load consisting of resistor 76 shunted by condenser 77 from the junction between resistors 73 and 74 to ground G. The audio frequency signals across secondaries 64 and 65 are rectified and waves *d* produce rectified current impulses *f* while waves *e* produce rectified current impulses *g*. Impulses *f* and *g* are produced in the common load 76—77 and hence appear together at output point 78 to form a series of impulses as shown at *h*. A comparison of *h* with *a* shows that *h* has twice as many positive and negative peaks as *a*, or a multiplication of the fundamental frequency by two. This frequency multiplied output at point 78 may be applied to the synchronous alternating current generator 8 (Fig. 1) for synchronizing purposes, or it may be operated on again to multiply the frequency to a still higher fundamental.

It will be seen that the action of the systems described is to recapture the fundamental frequency of synchronizing impulses in essentially pure sine form and then to multiply the frequency to produce synchronizing signals. While two methods of accomplishing this result have been shown and described, many modifications will be evident to those skilled in the art within the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. In a synchronizing system, the combination of, a, source of impulses comprising a fundamental frequency wave and large components of harmonics of said fundamental, a selective circuit for separating said fundamental frequency wave from said harmonics to provide a substantially pure sine wave of fundamental frequency, a frequency multiplier responsive to said fundamental for producing a wave having a predominant component harmonically related to said fundamental frequency, and a device to be synchronized responsive to said predominant harmonic component.

2. In a device for synchronizing a facsimile recorder with a predetermined series of synchronizing impulses, the combination of, a rectifier for deriving unidirectional impulses from said synchronizing impulses, a selective feedback amplifier for generating from said unidirectional impulses a substantially pure sine wave signal having a period equal to the period of said impulses, a cathode ray tube having a segmented target for multiplying the frequency of said sine wave signal to produce a signal of predetermined higher frequency, a recorder driven by a synchronous motor, and means for generating an alternating current to operate said motor controlled by said higher frequency.

3. In a device for synchronizing a facsimile recorder in accordance with a series of substantially equally spaced impulses, the combination of, a selective feed-back amplifier for generating from said impulses a substantially pure sine wave signal having a period equal to the period of said impulses, means for multiplying the frequency of said sine wave signal to produce a second signal of a predetermined higher frequency, a recorder driven by a synchronous motor, and means for operating said motor in synchronism with said second signal.

4. In a device for operating a facsimile recorder under control of a series of substantially equally spaced impulses, the combination of, a selective circuit for deriving from said impulses a substantially pure sine wave signal having a period equal to the period of said impulses, means for multiplying the frequency of said sine wave signal to produce a second signal having a predetermined higher frequency, a recorder driven by a synchronous type motor, and means for operating said motor in synchronism with said second signal.

5. In a device for operating a facsimile recorder under control of a series of substantially equally spaced impulses, the combination of, a selective aperiodic circuit for deriving from said impulses a substantially pure sine wave signal having a period integrally related to the period of said impulses, means for multiplying the frequency of said sine wave signal to produce a second signal having a predetermined higher frequency, a recorder driven by a synchronous motor, and means for operating said motor from an alternating current derived from said second signal.

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