Feb. 18, 1941. G. GUANELLA 2,231,998

SYNCHRONIZING SYSTEM

Filed Feb. 10, 1939 5 Sheets-Sheet 1

Fig. 1a.

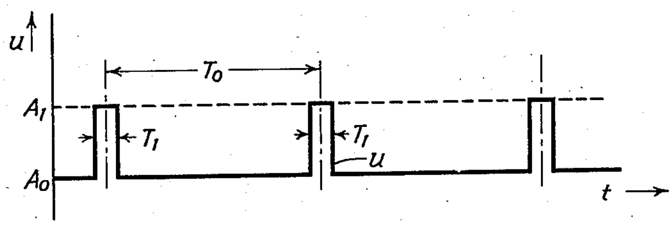


Fig. 1b.

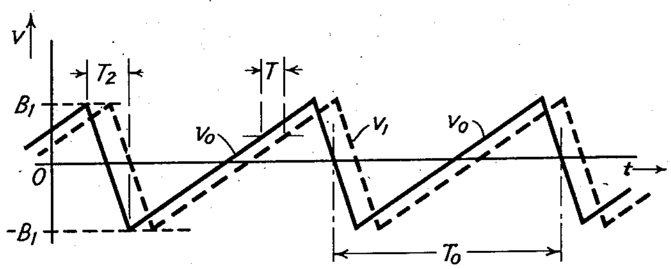


Fig. 1c.

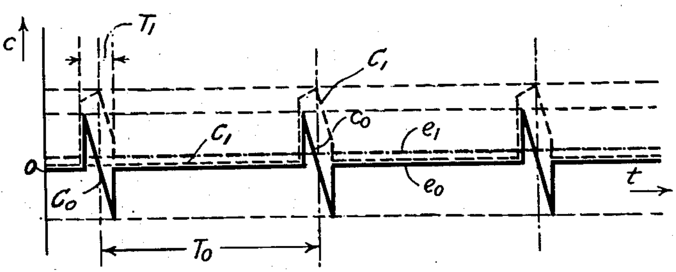
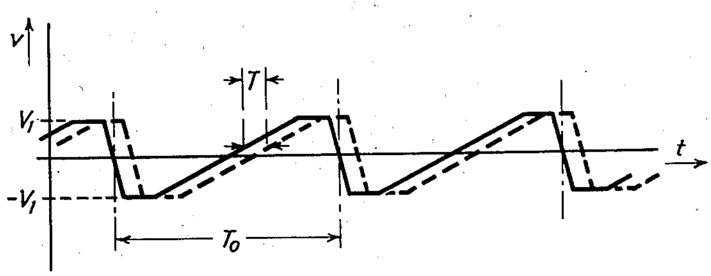


Fig. 1d.



INVENTOR.
Gustav Guanella

BY

ATTORNEY

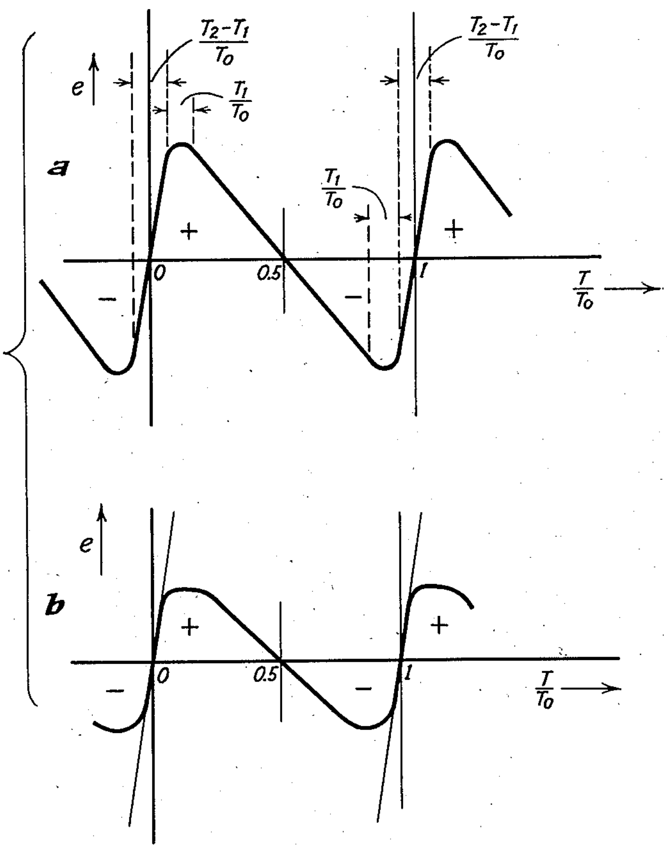


Fig. 2

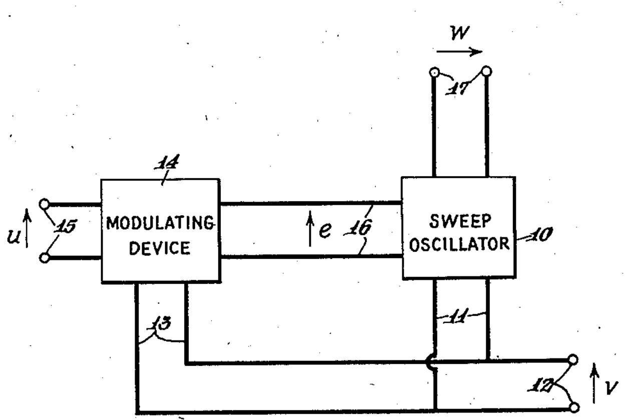


Fig. 3

INVENTOR.
Gustav Guanella
BY
Karl Mau
ATTORNEY.

SYNCHRONIZING SYSTEM

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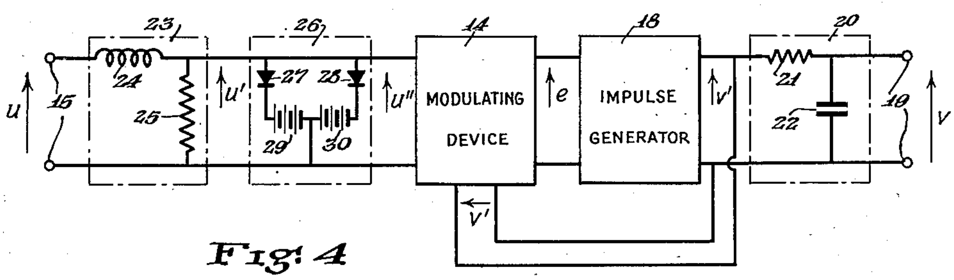

Fig: 4

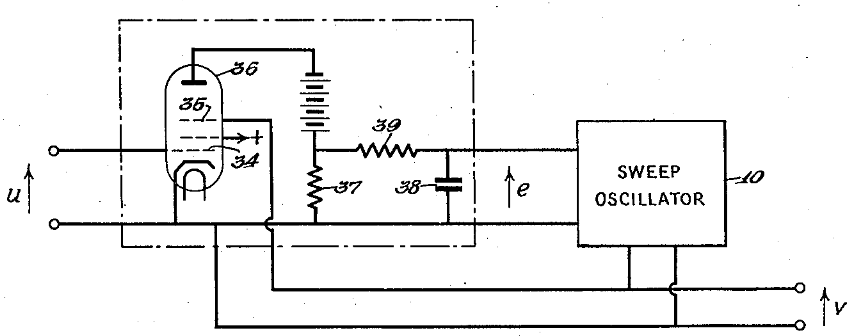

Fig: 5

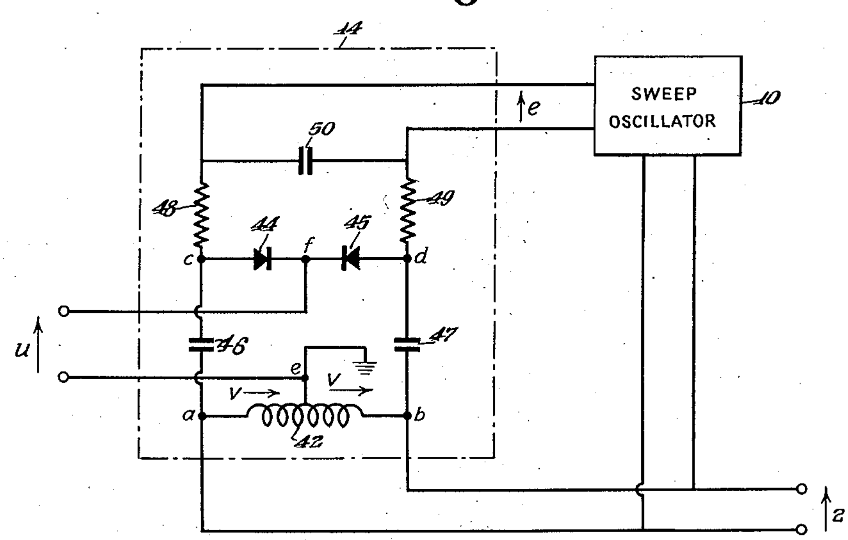

Fig: 6

INVENTOR.
Gustav Guanella

BY Karl Nau

ATTORNEY.

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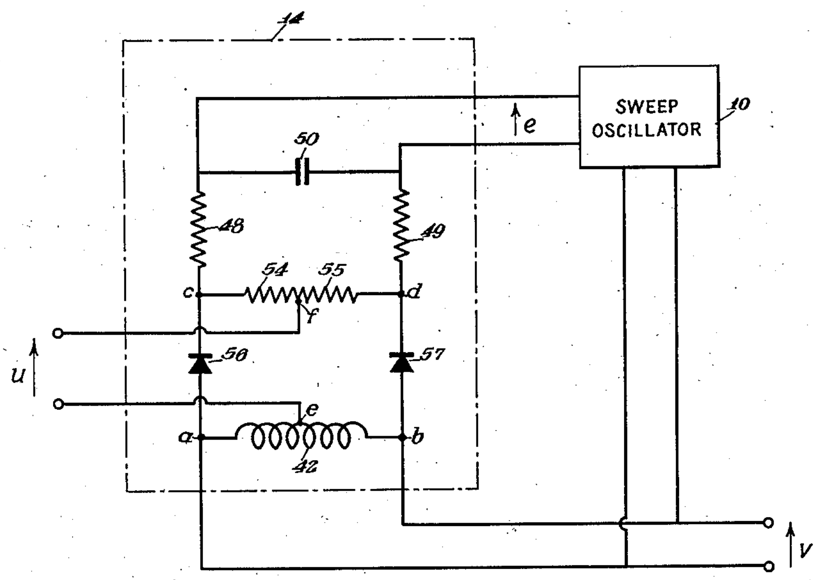

Fig. 7

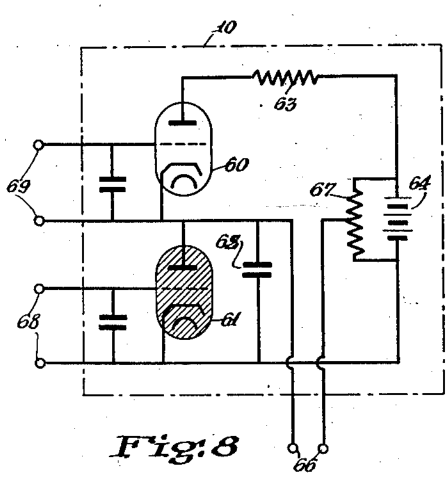

Fig. 8

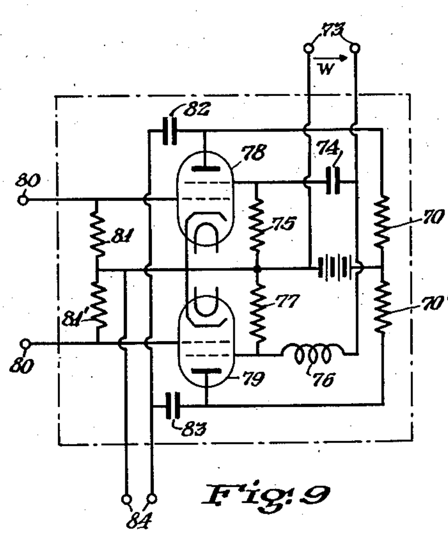

Fig. 9

INVENTOR.
Gustav Guanella
BY Karl Nau
ATTORNEY.

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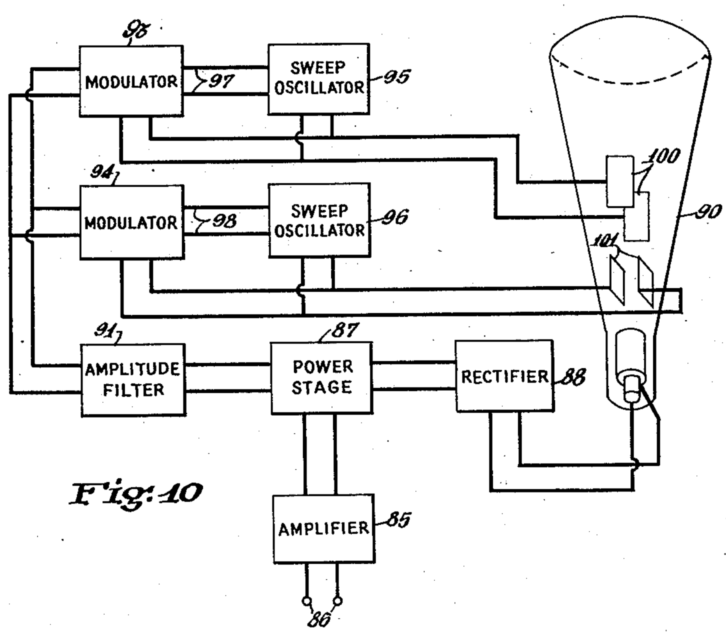

Fig: 10

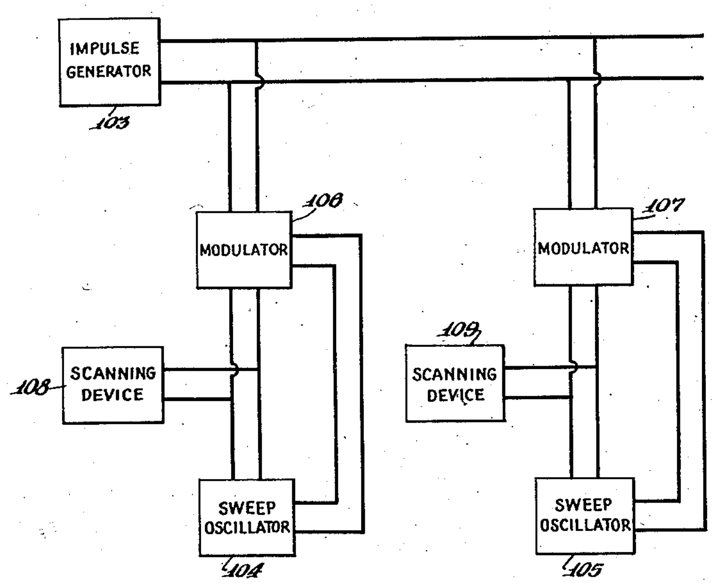

Fig: 11

INVENTOR.
Gustav Guanella

BY [signature]

ATTORNEY.

Patented Feb. 18, 1941 2,231,998

UNITED STATES PATENT OFFICE

2,231,998

SYNCHRONIZING SYSTEM

Gustav Guanella, Zurich, Switzerland, assignor to Radio Patents Corporation, a corporation of New York

Application February 10, 1939, Serial No. 255,608
In Switzerland February 17, 1938

10 Claims. (Cl. 178—69.5)

The present invention relates to novel means for and a method of maintaining synchronism between transmitting and receiving apparatus in telegraphy, television and the similar transmission systems.

In the transmission of television signals it is customary to apply a special control potential to the devices for scanning and reproducing a picture, such potential determining at each instant the position of the image point within the total image area being transmitted.

Usually there is provided for this purpose an image sweep or deflecting potential determining the position of each line of the image being scanned and a line sweep potential to determine the position of each image point within the individual scanning lines. These sweep potentials are produced either by special relaxation oscillators or by converting or distorting a determined control potential which latter may be derived by stepping up or down a fundamental frequency.

In order to ensure satisfactory transmission, equality of both frequency and phase known as locked synchronism between corresponding sweep potentials at the transmitter and receiver is required. This synchronism is usually obtained by controlling the sweep potential generated at the receiver by special synchronising impulses received together with the image signals or alternatively by deriving the sweep potentials at the transmitting and receiving stations from equal alternating control potentials.

The known methods of synchronization have many drawbacks due primarily among other reasons to frequent disturbances and impairment of the synchronism by short momentary interfering impulses especially when using relaxation or saw-tooth type sweep oscillations. There are other difficulties in ensuring synchronous operation when employing control potentials produced by multiplication from a lower fundamental frequency.

According to the present invention, the difficulties and drawbacks inherent in the known synchronizing systems are substantially overcome by the provision of a novel method and system based on the principle of mutual modulation of a pair of electrical signals one of which corresponds to or is derived from the synchronizing signals while the other corresponds to the deflecting or sweep potential to be synchronized. After sufficient filtering of the modulation product or output potential obtained in this manner, there may be derived from the latter a control potential varying in proportion to small deviations from the synchronism between the transmitting and receiving devices both as to magnitude and sign. This control potential is utilized to govern an element determinative of the frequency and/or phase of the deflecting potential produced by the sweep oscillator in such a manner as to counteract the initial tendency to deviate from the synchronous condition. By sufficient filtering of the control potential obtained in this manner the effect of momentary disturbances liable to impair or interfere with the fidelity of the image transmission may be substantially eliminated in practice. As a result there is obtained a highly steady and stable synchronization substantially independent of momentary disturbances in the transmission such as occasioned by distorted or mutilated synchronizing impulses and due to other causes.

The novel method to be described in detail hereafter is suited in general for maintaining synchronism between a pair of sweep potential generators in television apparatus by the aid of synchronizing signals or impulses transmitted during interrupting pauses between the image signals or superimposed upon or otherwise combined with the image signals for simultaneous transmission. The inventive method however has many other uses such as for maintaining the synchronism between a plurality of scanning arrangements by the aid of a common timing signal or standard controlling frequency. In this manner it is possible to operate in synchronism several scanning devices which may be arranged at distant places either simultaneously or in succession. As is understood, the inventive method is not limited to the use in television but applies with equal advantage to the transmission of single or "still" pictures such as in the case of facsimile transmission or picture telegraphy.

The invention will become more apparent from the following detailed description taken with reference to the accompanying drawings forming part of this specification and wherein:

Figures 1 and 2 represent theoretical diagrams and graphs, respectively, explanatory of the basic principle and function of the invention,

Figure 3 is a block diagram illustrating a basic synchronizing system in accordance with the invention,

Figure 4 is a more detailed diagram showing a modification of a synchronizing system according to the invention,

Figure 5 is similar to Figure 3 illustrating the employment of a multi-grid electron tube for producing a potential for controlling the synchronism,

Figure 6 shows a further modification embodying a balanced modulator for producing the control potential,

Figure 7 illustrates a further modification employing an interrupting system for generating the control potential,

Figure 8 illustrates a method of varying the frequency of a relaxation sweep oscillator embodying a gaseous triode suited for controlling synchronism in accordance with the invention,

Figure 9 illustrates an arrangement for regulating the phase of a sweep or deflecting potential generator in dependence upon a control potential suited for the invention,

Figure 10 shows in block diagram form a complete television receiving system embodying the improvements of the invention,

Figure 11 is illustrative of a system for simultaneously synchronizing a plurality of devices by the method and arrangements according to the invention.

Similar reference characters identify similar elements throughout the different views of the drawings.

Referring to Figure 1*a*, there are shown synchronizing impulses u varying between amplitude levels A_0 and A_1 and having a length T_1 and spacing intervals T_0. The impulses u constitute synchronizing signals which may be transmitted to the receiver during special interrupting pauses of the picture signals such as at the end of each line or image and are segregated at the receiver from the image signals by means of amplitude filters or in any other suitable manner. In Figure 1*b* there is shown a saw-tooth type deflecting potential v of the type usually employed in cathode ray scanners although not limited thereto and varying between amplitudes $-B_1$ and $+B_1$. The frequency or phase of this potential is to be adjusted in dependence upon an electric controlling potential or current in a manner to maintain absolute or locked synchronism with the impulses u, Figure 1. There is indicated by the dotted curve v_1 in Figure 1*b* a slight deviation from synchronism, the curve v_1 lagging the curve v_0 which latter corresponds to the condition of synchronism by a definite phase difference T between the fundamental frequency components of the curves.

The generation of a potential for controlling the synchronism is effected according to the invention by mutually inter-modulating the deflecting potential shown in Figure 1*b* with the synchronizing or impulse potential, Figure 1*a*, and subsequent filtering of the resultant or product obtained by such modulation. As a result, there is obtained a direct potential varying in both magnitude and sign in dependence upon deviations from synchronism between the component potentials u and v applied to the modulating device. By intermodulation of the impulse potential u (Figure 1*a*) and the saw-tooth potential v (Figure 1*b*) there is obtained, when neglecting a constant factor, a product $c=u.v$ as shown in Figure 1*c*. In case of synchronism, the modulation product has a shape as shown at c_0 resulting from the impulses u and the saw-tooth voltage v_0. This product is zero as long as the amplitude A_0 of the synchronizing impulses u is zero; i. e. during the spacing intervals between the impulses. During the impulse periods, however, c_0 equals $A_1.v_0$; that is, the product c_0 is proportional to v_0 and passes through zero simultaneously with the latter.

If, now for instance, the saw-tooth voltage, in case of disturbed synchronism, lags the synchronizing impulses as shown by the dashed line v_1 in Figure 1*b*, there is produced by the intermodulation process between u and v_1, a modulation product $c_1=u.v_1$. This product is also zero during the spacing intervals between the synchronizing signals. During the impulse periods, however, this modulation product deviates from c_0 due to the fact that v_1 assumes higher values than v_0. After adequate filtering of the modulation products c_0 or c_1 there are obtained average or direct current components e_0 or e_1, respectively. Due to the symmetrical shape of the product potential c_0 with respect to the zero line, the component e_0 is equal to zero. On the other hand, since the product c_1 is predominantly positive, the mean value e_1 will also be positive. If the saw-tooth voltage v leads the impulses u, the product c_1 will be predominantly negative and accordingly its mean value will also be negative. Thus, the filtered intermodulation product e_1 varies both in sign and magnitude proportionately to relative phase deviations between the saw-tooth voltage and the time spaced synchronizing impulses.

In accordance with the present invention the controlling magnitude e_1 is utilized to control a device adapted to accelerate or decelerate the saw-tooth voltage in proportion to and depending on the polarity of the controlling magnitude. In this manner an initial phase deviation between the impulse and saw-tooth voltages from a normal phase difference will effect a change in the saw-tooth generator in such a manner as to counteract the initial phase deviation; that is, any disturbance of the synchronism will result in reduction of the disturbance.

The control of the saw-tooth voltage generator by the magnitude e_1 is effected by controlling a frequency or phase determining element associated with the generator and adapted to be regulated by the control current or potential e_1 as will be described in further detail with reference to Figures 8 and 9.

An essential feature of the invention is the fact that the same does not propose to excite or accelerate a relaxation discharge directly by the synchronizing impulses, but involves the generation of a separate controlling or synchronizing current or potential produced by intermodulation of a pair of potentials having a predetermined relation to the synchronizing impulses and to the saw-tooth voltage to be maintained in locked synchronism. The process of intermodulation of the magnitudes u and v for generating a modulation product c will be explained further in connection with Figures 5 and 7 of the drawings.

Depending on the particular kind of modulation used there are obtained additional components in the modulation product c_1 which however results in a mean value or direct current of constant value so that its effect on the control may be disregarded or eliminated.

The potentials u and v to be modulated may also contain a determined additional direct current component in which case the modulation product will include only additional alternating potentials and in some cases a direct current component of constant magnitude. The relation of the filtered control potential to the deviations from synchronism will remain substantially the same except for a displacement of the zero operating point. This will be further understood from the following.

The synchronizing impulses u may be decomposed according to Fourier's theory into the following frequency components, assuming the center of an impulse as the starting point:

$$u=a_0+a_1 \cos wt+a_2 \cos 2wt+a_3 \cos 3wt+ \ldots \quad (1)$$

The sweep potential v on the other hand is composed of component frequencies as follows:

$$v=b_0-b_1 \sin w(t-T)-b_2 \sin 2w(t-T) -b_3 \sin 3w(t-T)- \ldots \quad (2)$$

In the above equations w represents the fundamental frequency of both signals, T the phase displacement of the deflecting potential v relative to its normal phase position as determined by the synchronizing impulses u. The positive coefficients a_n and b_n represent the amplitudes of the individual components whose magnitudes decrease as the order of n increases.

The direct current component c of the modulation product uv includes only portions derived from components of like frequency of the original signals u and v, since as is well understood no direct current component or beat frequency zero may be generated by modulating currents of unlike frequency:

$$c=a_0 . b_0+\tfrac{1}{2}a_1 b_1 \sin wT+\tfrac{1}{2}a_2 b_2 \sin 2wT +\tfrac{1}{2}a_3 b_3 \sin 3wT+ \ldots \quad (3)$$

Furthermore, the direct current components a_0 and b_0 of the original signals produce a constant factor $a_0\, b_0$ of the controlling potential c which, if desired, may be eliminated by suitable compensating means.

For small deviations of synchronism or phase differences T the sign nwT may be replaced in a known manner by the arc or angle nwT. From this it follows that the controlling potential c is directly proportional to small phase deviations T both as regards its magnitude and sign. This relationship is maintained also in the case that all or some of the amplitudes a_n and b_n of the individual components are modified prior to the modulation. In case of greater phase deviations, a proportional relationship no longer exists since in this case the sign is no longer equal to the corresponding arc or angle.

In the known modulation devices or circuits there are obtained additional potentials besides the modulation product uv. Thus, the output potential may contain the squares of the input potentials being modulated. These potentials u^2 and v^2 contain direct current components a_0^2, a_1^2, . . . b_0^2, b_1^2 which latter, however, are independent of the phase deviations T so that their effect may be eliminated.

Referring to Figure 2*a* there is shown the relation between the controlling potential c obtained from the signals u and v by mutual modulation and subsequent filtering in dependence upon relative phase variations between these potentials. The phase differences are measured as fractions T/T_0 of an entire period T_0 of the potentials. From this diagram it is evident that small deviations from synchronism result in the production of a large controlling potential due to the great slope of the curve for small values of T/T_0. However, a suitable control potential may also be obtained with larger phase deviations up to T/T_0=to ½. In case of still greater deviations, the phase of the controlling potential is reversed, that is the synchronism is controlled with a phase difference of one or more periods.

In practice it is possible to pass either or both of the potentials to be modulated through non-linear or distorting circuits or devices prior to their application to the modulating device or circuit. Thus for instance the signal according to Figure 1*b* may be converted by means of an amplitude limiting device into a signal according to Figure 1*d* from which there is also obtained by modulation with the signal according to Figure 1*a* and subsequent filtering a controlling potential varying in direct proportion to small phase differences both as to its magnitude and sign as shown by the graph according to Figure 2*b*. The modulation of the potentials may be effected by applying them to a device or circuit whose transmission factor or electrical conductivity may be controlled in linear dependence upon a further potential such as is the case in the known amplitude modulation devices or circuits. However, it is also possible for the purpose of this invention to employ a modulating system producing a more or less distorted output potential. Thus, a satisfactory controlling potential may be obtained by the use of circuits including elements having non-linear impedance characteristics or whose transmission factor or conductivity varies in non-linear dependence upon an impressed controlling potential.

According to a further embodiment, the sum and difference of the two potentials u and v may be formed in a push-pull or balanced modulating circuit by means of rectifiers of the square law or any other type whereupon by sufficient filtering of the differential of the rectified potentials a satisfactory direct current component for controlling the synchronism may be obtained. Furthermore, the controlling potential may be produced by an inertialess switching device or circuit interrupting or reversing the signal v in the rhythm of the synchronizing impulses u. Such an inertialess switch may have the form of a chopping circuit composed of rectifiers whose conductivity is controlled in accordance with the impulses u.

The potentials to be modulated may also be modified prior to the modulation in such a manner that individual components thereof are phase rotated by a predetermined angle. In this manner potentials may be formed which are specifically suited for the particular type of modulation being used. In many cases potentials having phase rotated components may be directly derived from existing circuits resulting in substantial simplification and saving of apparatus. This will be further understood from the following.

Let it be assumed that the nth component c* the impulse signal u is rotated in phase by an amount p_n and that the nth component of the sweep potential v is phase rotated by an angle q_n. The potentials obtained after such phase rotation may be represented by the following expressions:

$$u_1=a_0+a_1 \cos (wt-p_1)+a_2 \cos (2wt-p_2) +a_3 \cos (3wt-p_3)+ \ldots \quad (4)$$

$$r_1=b_0-b_1 \sin (w(t-T)-q_1)-b_2 \sin (2w(t-T)-q_2) -b_3 \sin (3w(t-T)-q_3) \ldots \quad (5)$$

from which the direct current component of the modulation product is obtained as follows:

$$c=a_0 b_0+\tfrac{1}{2} a_1 b_1 \sin (wT+q_1-p_1)+\tfrac{1}{2} a_2 b_2 \sin (2wT+q_2-p_2) +\tfrac{1}{2} a_3 b_3 \sin (3wT+q_3-p_3)+ \ldots \quad (6)$$

This component is characteristic of the phase deviations T/T_0 if it can be replaced by the expression (3) that is if the difference between the phase displacements q_n-p_n disappears for all frequency components or if this difference for all the components is divisible by 360°. In all these cases the phase difference between components of like frequency of the two potentials remains unchanged relative to the phase difference between components of like frequency of the synchronizing impulses resulting in a controlling potential c as represented by the expression (3) eventually with changed amplitudes a_n, b_n.

The expression (6) will also remain characteristic of the phase deviations if the differences between the phase displacements $q_n—p_n$ are an uneven multiple of 180°. This corresponds to a reversal of the polarity of all components of c excepting the constant factor a_o b_o. After considering this phase reversal there is obtained a controlling potential varying in direct proportion to small phase deviations both as to its magnitude and sign. As is understood it is immaterial whether the above phase displacement by 180° or a multiple thereof is due to a rotation of the components of the synchronizing impulses or of the sweep potential and whether the components of like frequency of both potentials are rotated by amounts equal to zero or 180°. The latter case prevails for instance if all the components are shifted by 90°. Such a phase rotation may be effected by using phase shifting networks as shown at 20 and 23 in Figure 4 to be described hereafter. Moreover, a change of the amplitudes of the individual components may take place simultaneously with their phase rotation.

According to a further feature of the invention it is possible to utilize the fundamental components of the signals to be modulated by suitable filtering or elimination of higher harmonics thereof. Thus, the modulating circuit may be controlled by a sinusoidal potential derived from the sweep potential v by sufficient filtering, or alternatively a sinusoidal potential from which the sweep potential is produced by distortion in a known manner may be applied to the modulating device or circuit.

Several practical embodiments of modulating arrangements suited for the purpose of the invention are illustrated in Figures 3 to 9 of the drawings.

Referring to Figure 3, there is shown in block diagram form a basic synchronizing arrangement constructed in accordance with the invention. There is indicated by 10 a sweep potential generator which may be a relaxation oscillator of known type or any other suitable arrangement for generating a saw-tooth shaped deflecting potential v of the type as shown in Figure 1b. This deflecting potential is applied through lines 11 upon a scanning device or image reproducer to be connected to terminals 12. The same potential is applied through lines 13 to the modulation device or circuit 14 which in addition is controlled by a further input potential corresponding to the synchronizing signals u according to Figure 1a and applied to terminals 15. The potential obtained by mutual modulation of these two potentials is filtered by a suitable arrangement embodied in 14 whereupon the filtered potential e deprived of all higher harmonics is impressed upon the sweep oscillator 10 through lines or circuit 16. The sweep oscillator is affected by this control potential in such a manner as to vary the frequency of the sweep voltage v impressed upon the output 12 in dependence upon variations of the controlling potential e in such a manner as to maintain synchronism between the potentials v and u in the manner described and understood from the foregoing. If at a definite instant the sweep potential v leads the synchronizing impulses u a controlling potential is produced by the modulation of the two potentials in 14 acting to influence the sweep oscillator in a manner to retard v and to restore the synchronism. In an analogous manner a control takes place in the reverse sense if the sweep potential v lags the synchronizing potential u.

The sweep oscillator 10 in Figure 3 may also be of the type functioning by converting an alternating potential w of standard frequency applied thereto through terminals 17 into the desired saw-tooth potential v. In the latter case, the frequency of v is determined by the frequency of w, the ratio between them being a whole number if frequency transformation is employed. Thus, the potential w may be a low frequency potential sent to the image transmitter and receiver through special lines such as the alternating potential derived from a standard power or lighting system. In the latter case, the frequencies of the synchronizing impulses u and of the deflecting signals v are alike, but a considerable phase difference may exist therebetween d' e to unequal phase rotation caused by the lighting circuits. These deviations or phase differences may be eliminated by utilizing a system according to the invention whereby the phase of the potential received from a power line and converted in 10 is controlled by the potential e in a manner to reduce or eliminate the phase shift effected by the line. Experiments have shown that small phase shifts of the potential w result in comparatively large phase rotations of the output potential v of higher frequency. For this reason it is advisable to pass the input potential w prior to its stepping up to a higher frequency through a circuit whose phase characteristic is varied by the controlling potential e.

The time constant of the filtering devices embodied in 14 should be adapted as far as possible to the frequency or phase variations to be expected in practice. If the relative frequency variations between u and v are of a slow character, a large time constant should be employed. In this manner the frequency or phase of v is prevented from being subject to rapid variations by momentary disturbances or mutilations of the synchronizing signals. On the other hand, in case of a less stable frequency of the sweep or synchronizing potentials considerable deviations from synchronism may occur by excessive filtering of the controlling potential which may be reduced or eliminated by use of a decreased time constant.

Referring to Figure 4 there is shown an embodiment for modulating two potentials which have been changed previously by means of non-linear or phase shifting elements. The impulse generator 18 may be a relaxation oscillator producing an impulse potential v' of the type shown in Figure 1a. From this impulse potential there is derived a saw-tooth shape deflecting potential v, Figure 1b, by the aid of a phase shifting or delay network 20 comprising a large resistance 21 and large capacity 22 in series and connected across the output of the generator 18. The capacity 22 is charged through the resistance 21 whereby there is obtained at the terminals 19 of the former a saw-tooth potential of the type shown in Figure 1b. The synchronizing impulses u are impressed across terminals 15 upon a further phase shifting or delay network 23 comprising a large inductance 24 in series with a small ohmic resistance 25, whereby the potential at the latter will assume a saw-tooth shape of the type shown in Figure 1b.

In an arrangement of the type described in the preceding paragraph, the controlling potential e may be obtained by modulating the synchronizing potential u with the deflecting potential v in the manner described hereinabove. Alternatively, the control potential may be derived by modulation of the two potentials u' and v', due to the fact that the respective components of these potentials comply with the above requirement as regards their phase and since one of these potentials has the form of impulses according to Figure 1*a* and the other is of saw-tooth shape according to Figure 1*b*.

Moreover, the saw-tooth potential u' may be modified by an amplitude limiting circuit **26** restricting its amplitudes by shunting through a pair of rectifiers **27** and **28** in series with counter biasing batteries **29** and **30**, respectively. In this case, there are applied to the modulating device **14** potentials u'' and v' of the type shown in Figures 1*a* and 1*d*, respectively, resulting in the generation of a controlling potential e varying in dependence upon deviations from the synchronism in the manner shown in Figure 2*b*.

In Figures 5, 6 and 7 there are shown by way of example various modulating arrangements suited for the purpose of the invention. According to Figure 5 the potentials u and v are applied to separate grids **34** and **35**, respectively, of a multi-grid electron tube **36**, the grids being preferably separated by a positively biased screen, whereby in a known manner a product output potential may be derived from the resistance **37** connected in the plate output circuit. This output potential in the example shown is impressed upon a smoothing filter network comprising a series resistance **39** and a parallel capacity **38** to obtain potential e for controlling the synchronism of the sweep oscillator **10** in a manner described hereinbefore.

According to the embodiment shown in Figure 6 modulation of the potentials u and v is effected by separate rectification of the sum and difference thereof and utilization of the differential of the rectified potentials. There is provided for this purpose a balanced modulator comprising in the example shown an induction coil **42**, the opposite halves of which form a Wheatstone bridge circuit together with a pair of rectifiers **44** and **45** each of the latter being provided with a series condenser **46** and **47**, respectively. The deflecting potential $2v$ of twice the amplitude is impressed upon terminals a, b of the inductance **42** while the synchronizing potential u is applied to the center e of the inductance **42** on the one hand and to the junction point f of the rectifiers **44** and **45**. The remaining terminals of the rectifiers c, d are connected to the sweep oscillator **10** through a filter network comprising series resistances **48** and **49** and a shunt capacity **50**. In an arrangement of this type there is produced between the terminals a and f the sum potential $u+v$ and between terminals b and f the difference potential $u-v$. These sum and difference potentials are rectified by the rectifiers **44** and **45**, respectively, thereby charging the condensers **46** and **47**. The differential between the rectified potentials appearing between c and d is impressed upon the filter **48**, **49**, **50**, obtaining in this manner a direct output potential e varying both as to sign and magnitude in dependence upon deviations from synchronism between the potentials u and v in the manner understood from the above.

In a circuit of the foregoing type the position of the rectifiers **44**, **45** and the condensers **46**, **47** may be exchanged without affecting the function and operation.

Referring to Figure 7 there is shown a modulating system of the interrupting type comprising inductance **42** similar to Figure 6 forming a bridge circuit together with a pair of resistances **54** and **55**, the latter having in series therewith rectifiers **56** and **57**, respectively. The deflecting potential v is again applied to the terminals a, b of the inductance **42** while the synchronizing signals are impressed upon the center point e of the inductance **42** on the one hand and upon the junction f between the resistances **54** and **55**. The rest of the circuit is substantially similar to the circuit according to Figure 6. During the interval between the impulses u, a negative impulse potential is impressed through impedances **54**, **55** in the blocking direction of the rectifiers **56**, **57**, whereby the latter prevent passage of the sweep or saw-tooth potential v. During the impulse periods on the other hand, a corresponding impulse current will flow through the rectifiers, whereby the potential v is passed to terminals c, d. The function of the rectifiers is therefore to periodically interrupt the saw-tooth signal v in the rhythm of the synchronizing impulses u. After adequate filtering in **48**, **49**, **50** of the interrupted output there is obtained a control potential e adapted to maintain the synchronism of the oscillator **10** in substantially the same manner as described hereinbefore.

The control of the sweep or deflecting potential oscillator by the synchronizing potential may be effected in various manners. When using a relaxation oscillator the frequency of the relaxation oscillations is dependent upon the values of the various impedances and operating voltages as is well known. It is possible therefore to control the frequency of such an oscillator by varying a suitable impedance or operating voltage in dependence upon the synchronizing potential in such a manner as to restore synchronous frequency or phase conditions. Thus, for instance a non-linear impedance may be provided in the oscillator circuit capable of being controlled by a biasing potential or current such as a vacuum tube impedance or the like. Practical embodiments of such arrangements are shown by way of example in Figures 8 and 9.

Referring to Figure 8, there is shown a relaxation oscillator of known type comprising a gaseous triode shunted by a condenser **62** and connected in series with a source of potential **64**, an impedance such as a resistance **63** and the anode-cathode path of further triode **60** which may be of the high vacuum type. Disregarding the triode **60** for the moment, this arrangement constitutes a known relaxation oscillator in that the condenser **62** is charged through impedance **63** gradually until the gas discharge through tube **61** is initiated, whereby the potential at the condenser is suddenly decreased to a value corresponding to the extinguishing potential of the tube. This phenomenon is repeated periodically whereby there is obtained at the output terminal **66** a saw-tooth shaped relaxation potential, the D. C. component of which may be adjusted by means of a potentiometer **67** in shunt to the source **64**. The initiation of the discharge may be controlled within substantial limits by varying the grid potential of the tube **61** applied through input terminals **68**. It is furthermore possible to vary the charging period by an adjustment of the charging resistance such as the impedance of the triode **60** in the example illustrated. The triode **60** constitutes a variable impedance which may be controlled by varying its grid potential applied through input terminals **69**. It is thus possible to control the frequency of the relaxation oscillations by the synchronizing potential *e* by impressing the latter upon the grid of either the tube 60 or 61.

If the sweep potential is generated by converting a local sinusoidal potential the former may be regulated by controlling the frequency of this local potential. This may be effected by varying the tuning of an alternating current generator such as by varying an adjustable reactive impedance associated with a tuning element. Such a reactive impedance may have the form of an electron tube constituting an adjustable inductive and capacitative reactance in a suitable circuit of well known design such as commonly used in automatic frequency or tuning control systems (AFC).

According to a further embodiment, the phase position of an alternating potential controlling a sweep oscillator from the outside may be controlled in dependence upon the synchronizing potential *e* by suitable phase shifting networks or devices. A suitable arrangement of this type is shown in Figure 9. In the latter the alternating potential *w* whose phase is to be controlled is impressed through terminals 73 upon a pair of phase rotating networks the first of which comprises a condenser 74 in series with a resistance 75, while the second network comprises an inductance 76 in series with a resistance 77. The junction points between the inductive and reactive impedances of these networks are connected to the outer grids of a pair of electron tubes 78 and 79, respectively, whereby the alternating potentials impressed upon these grids are either lagging or leading relative to the input potential *w*. The amplification of the tubes 78 and 79 is furthermore controlled by the potential *e* impressed upon a pair of further grids of the tubes in phase opposition through input terminals 80 in such a manner that an increase of the amplification of one tube corresponds to a decrease of the amplification of the other tube. As a result, the output or plate potentials derived at terminals 84 through coupling condensers 82 and 83 is composed of adjustable components of the leading or lagging input potentials, whereby the phase of the resultant output potential at 84 relative to the input potential applied at 73 is proportional to the synchronizing potential *e* impressed upon terminals 80. The phase adjusted output potential may serve to control the deflecting or sweep potential of a sweep oscillator either directly or after frequency multiplication and non-linear distortion in a manner well understood. Alternatively, the phase shift may be effected by mechanical means actuated in accordance with the potential *e* such as a variable plate of a condenser operated by a moving coil type instrument or actuator.

As is obvious from the above, in an arrangement according to Figure 9 the frequency of the control potential may not be varied if the phase rotation is effective within narrow limits only. For this reason, arrangements of this type may be used only if equal control frequencies are employed for generating the sweep potentials at the transmitter and at the receiver, whereby the synchronizing system merely serves to correct phase deviations between the controlling frequencies such as due to unequal impedance characteristics of the lines or networks transmitting the controlling frequency to the transmitter and receiver, respectively.

In Figure 10 there is shown in block diagram form a complete television receiving system embodying the improvement according to the invention. Item 85 represents the amplifier having input terminals 86 to which are fed the received image signals in the form of a modulated carrier wave transmitted through a line or through space after previous amplification at RF and IF frequency. From the power or output stage 87 of the amplifier 85 the modulated intermediate frequency signals are fed to a rectifier 88 serving to segregate the image signals which latter are applied to an intensity controlling element of a scanning device such as a cathode ray tube 90 in the example shown. A portion of the output energy is further fed from the power stage 87 to an amplitude filter 91 serving to segregate the synchronizing impulses *u* (line and image sweep impulses) in a manner well known. These impulses are applied to a pair of modulators 93 and 94 serving to produce controlling potentials *e* for maintaining the synchronism of the sweep oscillator 95 and 96, respectively, as described by the present invention. Oscillator 95 may serve to produce the image sweep potential and oscillator 96 may serve for producing the line sweep potential applied to two pairs of deflecting plates 100 and 101, respectively, of the cathode ray tube 90 in a manner well understood. Thus, modulator 93 serves for modulating the image sweep potential with the image sweep impulses resulting in a controlling potential at the output 97 applied to the image sweep oscillator 95 to control the synchronism thereof. The line sweep impulses simultaneously applied to the modulator 93 will have no effect upon the synchronism due to the fact that the controlling output potential is sufficiently filtered thereby preventing momentary disturbances from affecting the sweep oscillator 95. In a similar manner the modulator 94 serves to produce a controlling potential for maintaining the synchronism of the line sweep oscillator 96. This controlling potential is unaffected by the image sweep impulses simultaneously applied to the modulator 94 due to the fact that the resulting disturbing potentials caused by these impulses whose direct current component taken over a long time and period is equal to zero may be substantially suppressed by sufficient filtering of the controlling potential.

Referring to Figure 11, there is shown an embodiment for simultaneously controlling the synchronism of several scanning devices by the aid of a controlling or timing frequency. There is provided for this purpose an impulse generator 103 the output of which is applied to a pair of modulators 106 and 107 each of which serves to control the synchronism of an associated scanning device 108 and 109 by influencing the respective sweep oscillators 104 and 105 in a manner readily understood from the foregoing.

It will be evident from the above that the invention is not limited to the specific arrangements and steps described herein for illustration, but that the underlying thought and inventive principle are susceptible of numerous embodiments and modifications coming within the broad scope of the invention as defined in the appended claims. The specification and drawings are to be regarded, therefore, in an illustrative rather than a limiting sense.

I claim:

1. In television, the method of synchronizing a saw-tooth scanning potential by means of periodic synchronizing impulses, comprising the steps of intermodulating said saw-tooth potential with said impulses to produce a product function resultant potential, deriving from said product po-

tential a direct component varying in magnitude and sign in proportion to deviations of said saw-tooth potential from synchronism with said direct impulses, and utilizing said component to control said saw-tooth potential to maintain the same in locked synchronism with said impulses.

2. In television, the method of synchronizing a saw-tooth shaped scanning potential by means of periodic synchronizing impulses, comprising the steps of intermodulating said saw-tooth potential with said impulses to produce a resultant product function potential, deriving from said product potential a direct component varying in sign and magnitude in proportion to deviations of said saw-tooth potential from synchronism with said impulses, and utilizing said direct component to control said saw-tooth potential to maintain the same in locked synchronism with said impulses.

3. In a television system, a saw-tooth scanning oscillator, a source of synchronizing impulses, means for maintaining locked synchronism between said oscillator and said impulses comprising a modulating device adapted to produce a product function potential from potentials derived from said oscillator and said synchronizing impulses, filter means for deriving a direct component from said product potential varying in sign and magnitude in dependence upon deviations of the oscillator frequency from synchronism with said impulses, and means for impressing said direct component upon a frequency determining element of said oscillator to compensate for deviations from synchronism with said impulses.

4. In a system as claimed in claim 3 including means to limit the amplitude of said derived potential to a predetermined value.

5. In a system as claimed in claim 3 wherein said modulating means is comprised of a multi-grid electronic device, said derived potential and said synchronizing impulses being impressed upon different grids of said tube.

6. In a television system, a saw-tooth scanning oscillator comprising a charging impedance in series with a condenser shunted by a gaseous discharge device, a grid for said device, a source of synchronizing impulses, means for maintaining locked synchronism between said oscillator and said impulses, said means comprising a modulating device for producing a product function potential from potentials derived from said oscillator and said synchronizing impulses, further means including filter means for deriving a direct potential from said product potential varying in magnitude and sign in dependence upon deviations of the oscillator frequency from synchronism with said impulses, and means for impressing said direct potential upon said grid electrode to control the frequency of said oscillator to compensate for deviations from synchronism with said impulses.

7. In an electrical system, a saw-tooth signal generator, a source of time spaced periodic impulse signals, means for maintaining said generator in locked synchronism with said impulse signals, said means comprising a modulating device, means for applying to said modulating device a pair of potentials derived from said saw-tooth and impulse signals, respectively, means including filter means for deriving from the intermodulation product of said device control energy varying in sense and magnitude proportionately to deviations of the saw-tooth signals from synchronism with said impulse signals, and means for controlling said saw-tooth generator by said control energy to restore the synchronism thereof with said impulse signals.

8. In an electrical system, a saw-tooth signal generator comprising a resistance, a condenser in series with said resistance and a gaseous discharge device shunting said condenser, a control grid for said discharge device, a source of time spaced periodic impulse signals, means for maintaining said saw-tooth generator in locked synchronism with said impulse signals, said means comprising a modulating device, means for applying to said modulating device a pair of potentials derived from said saw-tooth signals and said impulse signals, respectively, means including filter means for deriving from the intermodulation product produced by said device control potential varying in sense and magnitude proportionately to deviations of the saw-tooth signals from synchronism with said impulse signals, and means for applying said control potential to said grid to control said generator to restore the synchronism of the saw-tooth signals with said impulse signals.

9. In an electrical system, a saw-tooth signal generator comprising an impedance, a condenser in series with said impedance and a gaseous discharge device shunting said condenser, at least part of said impedance being constituted by an electron discharge tube having a control electrode, a source of time spaced periodic impulse signals, means for maintaining said saw-tooth generator in locked synchronism with said impulse signals, said means comprising a modulating device, means for applying to said modulating device a pair of potentials derived from the saw-tooth signals and said impulse signals, respectively, means including filter means for deriving from the intermodulation product produced by said device a control potential varying in sense and magnitude proportionately to deviations of the saw-tooth signals from synchronism with said impulse signals, and means for impressing said control potential upon said control electrode to control said saw-tooth generator to restore the synchronism of the saw-tooth signals produced with said signal impulse signals.

10. In an electrical system, a generator for signal waves constituted substantially by a sine term Fourier series, a source of periodic signals constituted substantially by a cosine term Fourier series, means for maintaining said waves in locked synchronism with said signals, said means comprising a modulating device, means for applying to said modulating device a pair of potentials derived from said waves and said signals, respectively, means including filter means for deriving from the intermodulating product produced by said device control energy varying in sense and magnitude proportionately to deviations of said waves from synchronism with said signals, and means for controlling said generator by said control energy to restore the synchronism with said periodic signals.

GUSTAV GUANELLA.