April 6, 1948. H. R. MALLORY 2,439,050

VIBRATORY SWITCHING DEVICE FOR OSCILLOGRAPHS

Filed Sept. 2, 1944 2 Sheets-Sheet 1

Fig. 1

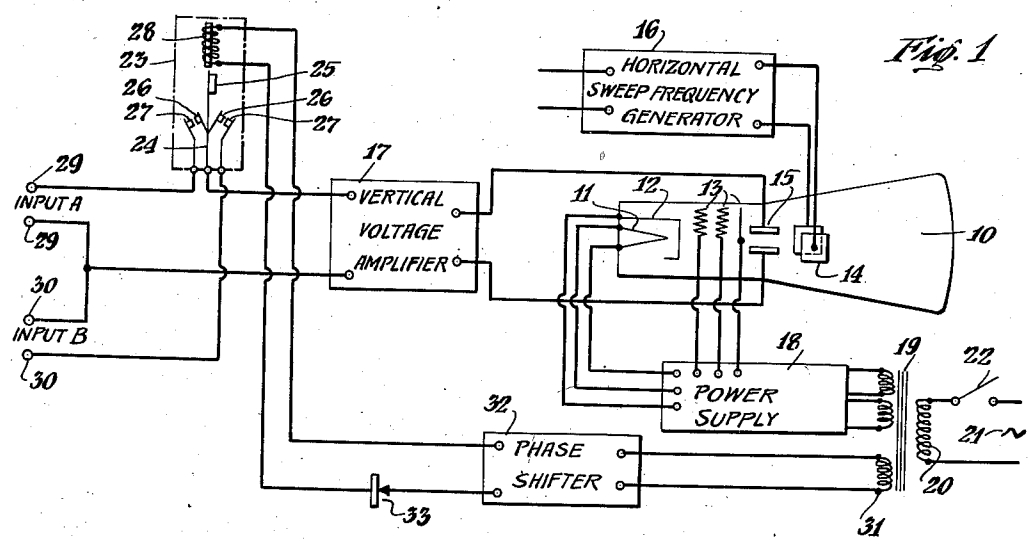


Fig. 2

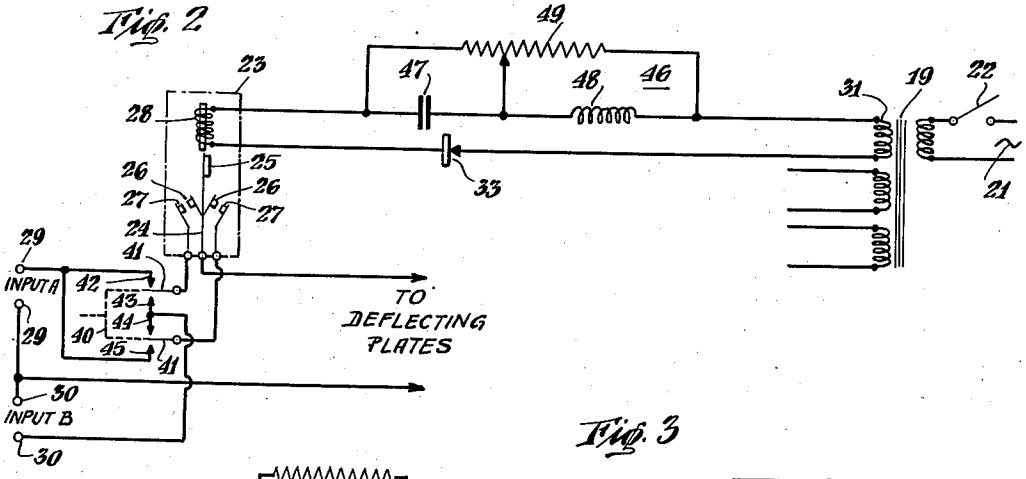
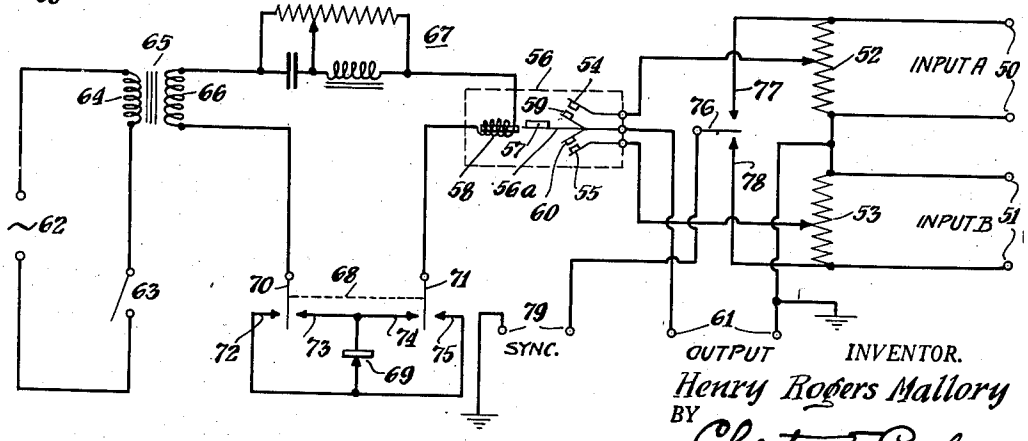


Fig. 3



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Filed Sept. 2, 1944 2 Sheets-Sheet 2

Fig. 4

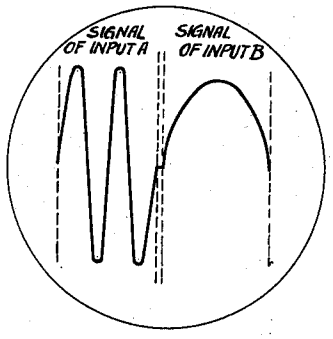


Fig. 5

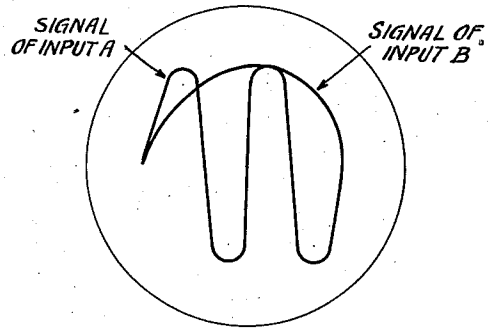


Fig. 6

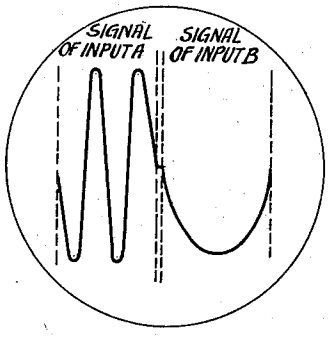
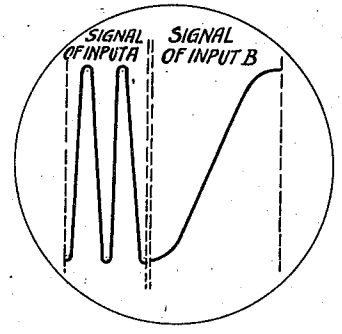


Fig. 7



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Patented Apr. 6, 1948

2,439,050

UNITED STATES PATENT OFFICE

2,439,050

VIBRATORY SWITCHING DEVICE FOR OSCILLOGRAPHS

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Application September 2, 1944, Serial No. 552,425

9 Claims. (Cl. 315—26)

1

The present invention relates to switching devices, and, more particularly, to a novel and improved vibratory switching device for cathode ray tube oscillographs, string oscillographs, and the like, whereby two traces corresponding to a pair of variable voltages may be simultaneously exhibited.

As those skilled in the art know, conventional cathode ray tubes are, essentially, single element indicators, and permit the visual observation of a single variable only at a time. There are many cases, however, where it is desirable to exhibit two or more unrelated phenomena at the same time, for example in electrical studies for the comparison of amplitude, wave-form, phase, and frequency relationships. The same applies to sound, light, mechanical vibrations and displacements and to other quantities which may be translated into electrical functions, and which may be visually represented and may be studied by means of corresponding traces on the screen of the oscillograph.

Heretofore, the device most commonly employed for this purpose was an electronic switch comprising two vacuum-tube amplifiers, to the grid circuits of which were connected the two signals to be investigated. A multivibrator generating a square-wave signal was employed to alternately bias the grids of the two amplifiers to cutoff. The plate circuits of these two amplifiers were combined to produce an output alternately constituted of first the one, then the other, signal. Provided that the rate of switching was fast enough, the output of the amplifiers when connected to one set of the deflecting elements would produce two traces, corresponding to the two signals, appear simultaneously on the screen of the oscillograph, due to the persistence of vision of the human eye.

Electronic switches of the described character had the disadvantage of being relatively complex electronic devices and of being rather expensive so that their use was restricted to well-equipped industrial and scientific laboratories where cost was not an important consideration. Also conventional electronic switches were quite bulky and heavy and in most cases were hardly smaller than the cathode ray oscillograph itself. These circumstances have considerably reduced their practical applications.

It has been already suggested to employ rotary commutators, self-interrupters, and relays operated by means of a low-frequency vacuum-tube oscillator for alternately switching two input signals to a common output connected to one set of deflecting elements of the oscillograph. These

2

prior switching devices were in general unreliable in operation and their cost and space requirements were not far below those of an electronic switch. Although various suggestions and proposals of this type have been made, as far as is known, none of these suggestions and proposals was completely satisfactory and successful when carried into practice on a practical and commercial scale.

It is an object of the present invention to provide a simple and completely satisfactory solution of the outstanding problem.

It is another object of the present invention to provide a vibratory switching device for cathode ray tube oscillographs in which a vibratory electromagnetic interrupter energized from a source of low-frequency alternating current is employed for alternately supplying signals from two independent sources to the same set of deflecting elements of the oscillograph.

It is a further object of the invention to provide a novel vibratory switching device comprising a vibratory interrupter operated from the alternating current power line, from which also the oscillograph is energized, said interrupter alternately closing a pair of input circuits at the rate of the power line frequency and thereby alternately applying voltages from two sources to the common output circuit for simultaneous visual observation of such voltages upon the screen of the cathode ray tube.

It is also within the contemplation of the invention to provide a vibratory switch energized from the alternating current mains and maintained in continuous vibratory motion of constant frequency for periodically and alternately impressing two different signals upon the deflecting system of the tube, means being provided for varying and adjusting the phase relation of vibrator operation with respect to the frequency of the mains.

The invention also contemplates a vibratory switching device for cathode ray tube oscillographs in the form of an independent unit directly energized from the alternating current mains which is extremely simple in character, small in size, may be readily placed in operative relation with any conventional cathode ray oscillograph, and which may be built on a practical and commercial scale at a low cost.

Other and further objects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings; in which:

Fig. 1 illustrates the circuit diagram of a vi-

bratory switching device embodying the principles of the present invention;

Fig. 2 depicts a similar circuit diagram of a modified embodiment of the invention in which provision is made for reversal of the connections of the two input circuits with respect to the vibratory switch;

Fig. 3 shows the circuit diagram of a vibratory switching device incorporating the invention and in the form of an independent unit energized from the alternating current mains; and

Figs. 4, 5, 6, and 7 show various wave patterns on the screen of the cathode ray tube oscillograph, obtained by the device of the invention, the traces corresponding to the two input signals being shown juxtaposed, rather than superposed upon one another, for greater clarity.

While a few preferred embodiments of the invention are described herein, it is contemplated that considerable variation may be made in the method of procedure and the construction of parts without departing from the spirit of the invention. In the following description, and in the claims, parts will be identified by specific names, for convenience, but they are intended to be as generic in their application to similar parts as the art will permit.

Referring now more particularly to Fig. 1 of the drawing, reference character 10 generally denotes a conventional cathode ray tube having a heater 11, a cathode 12, and a set of control electrodes 13 cooperating with each other for producing a cathode ray beam. Deflecting forces are applied to said beam by means of a pair of horizontal deflecting plates 14 and a pair of vertical deflecting plates 15, the horizontal deflecting voltage being obtained from a horizontal sweep frequency generator 16. The vertical deflecting voltage is amplified by means of a vertical voltage amplifier 17 prior to being applied to the corresponding deflecting plates 15. The various operating voltages for the oscillograph tube are obtained from a power supply 18 energized from the secondary windings of a transformer 19, the primary winding 20 of which may be connected to source of alternating current 21, by means of a switch 22. In view of the fact that the construction, circuit arrangement, and operation of the cathode ray tube oscillograph are along conventional lines and do not form part of the present invention, no detailed description thereof will be necessary.

The switching device of the invention is built around a vibratory electromagnetic interrupter generally denoted by reference character 23. This interrupter essentially comprises a vibratory reed 24 clamped at one end thereof and bearing a ferromagnetic armature or weight 25 at the other end thereof. The reed also carries a pair of reed arms or contact arms at the end of which there are mounted vibratory contacts 26. These vibratory contacts may cooperate with relatively fixed contacts 27 mounted at the ends of side arms or side springs of the usual type. Armature or weight 25 is under the control of a driver coil 28 so that upon said coil being energized from a source of alternating current or of intermittent direct current, the reed will be maintained in a continuous vibration and will alternately close contacts 26 and 27 on the two sides thereof.

To permit the alternate application of two signals to the same set of deflecting elements of the cathode ray tube, there are provided two pairs of input terminals of which 29 constitute the terminals of input circuit A and 30 constitute the terminals of input circuit B. One side of terminals 29 and 30 are connected together and to one terminal of vertical voltage amplifier 17 while the other, "hot," side of said terminals 29 and 30 are respectively connected to fixed contacts 27. Reed 24, bearing vibratory contacts 26, is connected to the other, "hot," terminal of the said vertical voltage amplifier 17.

The driver circuit of the vibratory interrupter is energized from the same source of alternating current 21, preferably the alternating current mains, as the cathode ray tube. For this purpose, transformer 19 is provided with an additional secondary winding 31, producing a relatively low alternating voltage, such as, for example, 12.6 volts, which through a phase shifter 32 and a half-wave rectifier 33 may be impressed upon the driver coil. Although in the illustrated embodiment of the invention a separate secondary winding has been shown for operating the vibratory interrupter, obviously any of the usual low-voltage windings of a conventional power transformer may be utilized for the same purpose.

From the foregoing description, the operation of the vibratory switching device of the invention will be readily understood by those skilled in the art. Upon closing main or power switch 22, power transformer 19 will be energized and the operation of the cathode ray tube will be initiated in the conventional manner. At the same time, however, an alternating voltage will be also developed across secondary winding 31 and through phase shifter 32 and half-wave rectifier 33, driver coil 28 will be periodically energized every other half-cycle. Reed 24 will be maintained in continuous vibration at the frequency of the power line and will alternately close contacts 26 and 27 on the left and the right side thereof. In this manner, input circuits A and B, connected to the two signals to be studied, will be alternately connected to the common output circuit represented by the input side of vertical voltage amplifier 17, and after amplification are impressed upon vertical deflecting plates 15. Thus, two traces, corresponding to the two signals to be studied, will simultaneously appear on the screen of the cathode ray tube and may be subjected to comparative study.

It has been found that a vibratory electromagnetic interrupter having a vibratory system normally tuned to an operating frequency of about 110 to 120 cycles per second will be positively locked into the 60 cycle power line frequency even though it is vibrating at double frequency. An interrupter tuned to a frequency of 55 to 60 cycles per second, however, will give somewhat more satisfactory results, particularly for the observation of 60-cycle phenomena, inasmuch as the switching rate is cut in half making it possible to observe approximately one-half of a 60-cycle alternation. The object of the provision of the half-wave rectifier in the driver circuit is to cut off every other half-cycle. The same result may be obtained by omitting the half-wave rectifier and replacing ferromagnetic weight 25, normally constituted of soft iron, with a permanent magnet of the same size and shape having North and South poles at the two sides thereof, to the right and to the left of the axial line of the driver coil, as those skilled in the art will readily understand. The phase shifter may be employed to adjust the phase of operation of interrupter 23 with respect to the phase of the power line, this

being particularly desirable when power line frequency phenomena are to be investigated.

The modification of the invention depicted in Fig. 2 is in most respects similar to the one described in the foregoing and similar reference characters have been used to denote corresponding parts. Also, illustration of the cathode ray tube and of its power supply have been to a large extent omitted for the sake of simplicity. The difference resides in the provision of a reversing switch 40 between the two input circuits and the vibratory switch 23. Reversing switch 40 is in the form of a double-pole, double-throw switch having two movable contact arms 41, respectively connected to the two fixed contacts 27 of the vibratory switch. The upper contact arm may selectively close contacts 42 or 43, while the lower contact arm may selectively close contacts 44 or 45. Contacts 42 and 45 are connected together and to one of terminals 29, and contacts 43 and 44 are likewise connected together and to one of the terminals 30. The other one of terminals 29 and 30 are connected together and to one of the vertical deflecting plates of the cathode ray tube (not shown), the other vertical deflecting plate being connected to reed 24. The driver circuit comprises secondary winding 31 of power transformer 19, half-wave rectifier 33, driver coil 28, and the phase shifter network generally denoted by reference character 46. The phase shifter network may take various convenient and well-known forms. Its illustrated form comprises a condenser 47 of about 50 microfarads connected in series with an inductance 48 of about 100 millihenries, a potentiometer 49 of about 200 ohms being connected across both, the sliding contact of which is connected to the common terminal of condenser and inductance. By means of a phase shifter of the described character the phase may be varied approximately between plus 45 degrees and minus 45 degrees in a manner well understood.

In view of the similarity of circuit arrangement the operation of this modified embodiment of the invention will be obvious. The purpose of the provision of polarity switch 40 is to invert the respective connections of inputs A and B to the fixed contacts 27 of the vibratory switch. This is particularly desirable when observing power line frequency phenomena as it permits, with the phase shifter 46, the investigation of any part of the cycle.

The further modified embodiment of the invention shown in Fig. 3 is in the form of an individual and independent unit which may be manufactured and sold as an accessory to conventional cathode ray oscillographs to permit the simultaneous observation of two oscillatory phenomena. It comprises input terminals 50 and input terminals 51 which are for connection of the two signals thereto. A potentiometer 52 is connected across terminals 50 and a similar potentiometer 53 is connected across terminals 51. The sliding contacts of potentiometers 52 and 53 are respectively connected to stationary contacts 54 and 55 of vibrator 56. One of input terminals 50 and input terminals 51 are connected together and to ground. In this manner the input voltage of both signals may be independently adjusted. Vibratory reed 56a is clamped at one end thereof and carries a soft iron armature 57 at the other end thereof under the control of a driver coil 58. The reed also supports vibratory contacts 59 and 60, respectively cooperating with stationary contacts 54 and 55 during vibrations of the reed. One of output terminals 61 is connected to reed 56a and the other to ground.

The driver circuit is energized from the alternating current power line 62 through a switch 63 and the primary winding 64 of a step-down transformer 65. The driver circuit proper comprises secondary winding 66, phase shifter network 67, driver coil 58, reversing switch 68 and half-wave rectifier 69. The reversing switch includes a pair of jointly operable contact arms 70 and 71. Of these, arm 70 may selectively close contacts 72 and 73, and arm 71 may selectively close contacts 74 and 75. Contacts 72 and 75 are connected together and also to one terminal of half-wave rectifier 69, while contacts 73 and 74 are likewise connected together and to the other terminal of said half-wave rectifier. From this circuit arrangement it obviously follows that by placing reversing switch 68 from one into the other of its positions, the direction of connecting the half-wave rectifier in the driver circuit will be reversed. Phase shifter 67 is identical with the corresponding element 46 of Fig. 2 so that it will not be necessary to repeat its description.

When it is desired to operate the vibratory switch of Fig. 3, the two signal sources to be investigated are respectively connected to terminals 50 and 51, the voltage of the sources being adjusted to the proper value by means of potentiometers 52 and 53. Output terminals 61 of the device are connected to the vertical deflection terminals of the cathode ray oscillograph. Reversing switch 68 is placed into one of its positions and main switch 63 is closed to energize driver coil 58. Upon said driver coil being energized every other half-cycle, reed 56a will be maintained in continuous vibration and contacts 54, 59, and 55, 60 will be alternately closed. Consequently, input circuits A and B will be alternately connected to the common output circuit. In this manner, traces corresponding to both signal inputs A and B will simultaneously appear upon the screen of the cathode ray oscillograph and may be readily compared with each other.

The phase of vibratory interrupter operation may be continuously adjusted by means of phase shifter 67. On the other hand, reversing the position of switch 68 will reverse the polarity of half-wave rectifier 69 whereby the said phase may be changed by 180 degrees. As it has been stated in the foregoing, this is of particular value when investigating power line frequency phenomena, as it permits with the phase shifter the investigation of any part of the cycle.

Reference character 76 denotes the contact arm of a single-pole double-throw switch adapted to selectively close contacts 77 and 78, respectively connected to the "hot" sides of inputs A and B. One of terminals 79 is connected to ground, and the other to contact arm 76, so that a synchronizing voltage connected between terminals 79 may be selectively impressed upon the one or the other of the two signal inputs.

Figures 4 to 7 are various cathode ray oscillograph traces, or patterns, obtained by the vibrator switch of the invention. In Figures 4, 6 and 7 the traces corresponding to the two inputs are shown juxtaposed for the sake of clarity, rather than superposed and each extending along the full width of the screen, as they actually appear. In Fig. 4, the horizontal sweep frequency generator has been adjusted to the fundamental power line frequency, the frequency applied to input B is at fundamental power line frequency, and the frequency of input A is four times the fun-

damental power line frequency. The pattern of Fig. 5 has been obtained under identical conditions, with the exception that the horizontal sweep frequency generator is set for a frequency twice the power line frequency. Fig. 6 shows a pattern obtained under the same conditions as that of Fig. 4 but the polarity reversing switch in its other position so that both signals are inverted. Fig. 7 illustrates a pattern corresponding to the same conditions as that of Fig. 4 with the exception that the phase shifter control has been operated so as to observe different parts of the signal.

It will be noted that the vibrator switch of the invention provides numerous important advantages. Thus, first of all, it may be employed for the complete observation of any two signals having a frequency of 60 cycles, or more, and for the partial observation of such signals having frequencies less than 60 cycles. The switch embodying the invention is particularly advantageous for the observation of power line frequency phenomena, such as, for instance, the output wave-form of a rectifier circuit, phase displacement of power line frequency equipment, etc. The rectifier reversing switch together with the phase shift control permits the complete observation of a power line frequency signal.

It is also to be observed that the operation of the switching device of the invention is not restricted to the observation of 60 cycle phenomena but extends at least throughout the audio-frequency range. Thus, it has been found that the device will faithfully compare signals of a frequency as high as 20,000 cycles per second. In addition, while the signal will be somewhat interrupted, it is perfectly feasible to investigate and to compare the phase relation between frequencies as low as 20 cycles per second. In other words, the device has a useful frequency range of approximately 20 to 20,000 cycles per second and provides particular advantages in observing power line frequency phenomena.

Moreover, the vibrator switch of the invention is extremely simple in construction, is very reliable in operation and may be manufactured in the form of a small and inexpensive unit, in general costing only a mere fraction of conventional electronic switches now used for substantially the same purpose. Due to the fact that no vacuum tubes or networks of any kind are employed in the switching circuit of the device, complete freedom from phase shift, as regards one signal to the other, is obtained. For this reason, the present device may be used to compare very accurately the exact phase relation between, for example, the current and voltage existing in a loudspeaker voice coil, while being driven by a test oscillator. These new results, particularly the freedom from phase shift, cannot be obtained by means of conventional electronic switches.

Although the present invention has been disclosed in connection with a few preferred embodiments thereof, variations and modifications may be resorted to by those skilled in the art without departing from the principles of the invention. For example, the principles of the invention are not restricted to cathode ray tube oscillographs but may be applied to practically any type of visual, photographic, or recording oscillograph, such as string oscillographs, crystal or electromagnetic recorders, and the like. All of these variations and modifications are considered to be within the true spirit and scope

of the present invention, as disclosed in the foregoing description and defined by the appended claims.

While the present invention, as to its objects and advantages, has been described herein as carried out in specific embodiments thereof, it is not desired to be limited thereby but it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. In a device for simultaneously exhibiting traces corresponding to a pair of variable voltages by means of an oscillograph, the combination which comprises a vibratory electromagnetic interrupter having a vibratory reed adapted to alternately actuate a pair of contacts and a driver coil therefor, an input circuit for each of said voltages respectively connected to said contacts, and a common output circuit connected to said reed and electrically associated with said oscillograph, said driver coil being energized at a constant low frequency rate from an external current source thereby to cause vibration of said reed and alternate connection of said input circuits to the common output circuit, the resonant frequency of said reed being substantially an integral multiple of the frequency of driver coil energization whereby the frequency of the vibratory interrupter is locked in with the frequency of said external current source.

2. In a switching device for cathode ray tube oscillographs energized from the alternating current mains whereby two independent variable voltages may be simultaneously exhibited on the screen of said tube; the combination which comprises a vibratory electromagnetic interrupter including a vibratory reed, a pair of contacts alternately operable during vibration of said reed, and a driver coil for said reed; an input circuit for each of said voltages respectively connected to said contacts; a common output circuit connected between said reed and one set of deflecting elements of the cathode ray tube; and connections between said driver coil and the alternating current mains to maintain said reed in vibration and to alternately apply said two variable voltages to said deflecting elements by said contacts, the resonant frequency of said reed being substantially an integral multiple of the frequency of the alternating current mains whereby the frequency of the vibratory interrupter is locked in with that of the alternating current mains.

3. In a vibratory switch for cathode ray tube oscillographs energized from the alternating current mains whereby two variable voltages may be exhibited on the screen of said tube at the same time; the combination which comprises a magnetically polarized vibratory interrupter having a vibratory reed, a driver coil therefor, and a pair of contacts alternately operable during vibration of said reed; an input circuit for each of said voltages respectively connected to said contacts; a common output circuit connected between said reed and one set of deflecting elements of the cathode ray tube; and connections between said driver coil and the alternating current mains whereby said reed will be caused to vibrate at the frequency of the mains and will alternately apply said two variable voltages to said deflecting elements by said contacts, the resonant frequency of said reed being substantially an integral multiple of the frequency of the alternating current mains whereby the frequency of the vibratory interrupter is locked in

with that of the alternating current mains.

4. In a switching device for cathode ray tube oscillographs operated from the alternating current power line to simultaneously exhibit two variable voltages on the screen of the tube; the combination which comprises an electromagnetic vibratory interrupter having a vibratory reed with a driver coil therefor and a pair of contacts alternately operable during vibrations thereof, an input circuit for each of said voltages respectively connected to said contacts, a common output circuit connected between said reed and one set of deflecting elements of the cathode ray tube, connections between said driver coil and the alternating current power line, and a half-wave rectifier interposed in said connections whereby said reed will be caused to vibrate at the power line frequency and will alternately apply said two variable voltages to said deflecting elements by said contacts.

5. In a switching device for cathode ray tube oscillographs operated from the alternating current power line to simultaneously exhibit two variable voltages on the screen of the tube, the combination which comprises an electromagnetic vibratory interrupter having a vibratory reed with a driver coil therefor and a pair of contacts alternately operable during vibrations thereof, an input circuit for each of said voltages respectively connected to said contacts, a common output circuit connected between said reed and one set of deflecting elements of the cathode ray tube, means including a half-wave rectifier for energizing said driver coil from the power line thereby to cause vibration of said reed at the power line frequency and alternate application of said two variable voltages to said deflecting elements by said contacts, and switching means for reversing the polarity of said rectifier to change the phase of operation of the vibratory interrupter substantially by 180 degrees.

6. In a switching device for cathode ray tube oscillographs operated from the alternating current power line to simultaneously exhibit two variable voltages on the screen of the tube; the combination which comprises a vibratory interrupter including a reed bearing vibratory contacts, relatively fixed contacts cooperating with said vibratory contacts, and a driver coil for said reed; an input circuit for each of said voltages respectively connected to said fixed contacts; a common output circuit forming a connection between said reed and one set of deflecting elements of the cathode ray tube; means for energizing said driver coil from the power line thereby to cause vibration of said reed at the power line frequency and alternate connection of said input circuits to said common output circuit by said contacts; and phase-shifting means interposed between the power line and the driver coil to continuously adjust the phase relation of vibrator operation with respect to the power line frequency.

7. In a switching device for alternating current power line-operated cathode ray tube oscillographs to simultaneously exhibit two variable voltages on the screen of the tube; the combination which comprises a vibratory interrupter including a reed bearing a vibratory contact on each side thereof, a relatively fixed contact for cooperation with each of said vibratory contacts, and a driver coil for said reed; a pair of input circuits and a common output circuit having one of their sides connected together; the other side of said input circuits being respectively connected to said fixed contacts and the other side of said output circuit being connected to said reed; means including a half-wave rectifier for energizing said driver coil from the power line thereby to cause vibration of said reed at power line frequency and alternate connection of said input circuits to the output circuit by said contacts; and switching means for reversing the connection of said input circuits with respect to the fixed contacts of the vibratory interrupter.

8. In a switching device for alternating current power line-operated cathode ray tube oscillographs to simultaneously exhibit two variable voltages on the screen of the tube; the combination which comprises a vibratory interrupter including a reed bearing vibratory contacts, relatively fixed contacts cooperating with said vibratory contacts, and a driver coil, an input circuit for each of said variable voltages respectively connected to said fixed contacts; means for individually adjusting the voltages applied to said input circuits; a common output circuit between said reed and one set of deflecting elements of the cathode ray tube; means including a half-wave rectifier for energizing said driver coil from the power line thereby to cause vibration of said reed at power line frequency and alternate connection of said input circuits to said common output circuit; and means for selectively impressing a synchronizing voltage upon one of the input circuits.

9. In a switching device for alternating current power line-operated cathode ray tube oscillographs to simultaneously exhibit two variable voltages on the screen of the tube; the combination which comprises a vibratory interrupter including a reed bearing vibratory contacts, fixed contacts cooperating with said vibratory contacts, and a driver coil; an input circuit for each of said variable voltages respectively connected to said fixed contacts; a common output circuit between said reed and one set of deflecting plates of the cathode ray tube; a driver circuit for energizing the driver coil from the power line thereby to cause vibration of the reed at power line frequency and alternate connection of the input circuits to the common output circuit; a half-wave rectifier in said driver circuit; phase shifter means in said driver circuit to continuously change the phase of operation of the vibratory interrupter; and switching means for reversing the connections of said rectifier to change the phase of operation of the vibratory interrupter by 180 degrees.

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