Feb. 22, 1955

E. F. KUBLER

2,702,881

REFERENCE VOLTAGE UNIT

Filed Dec. 15, 1953

Fig. 1.

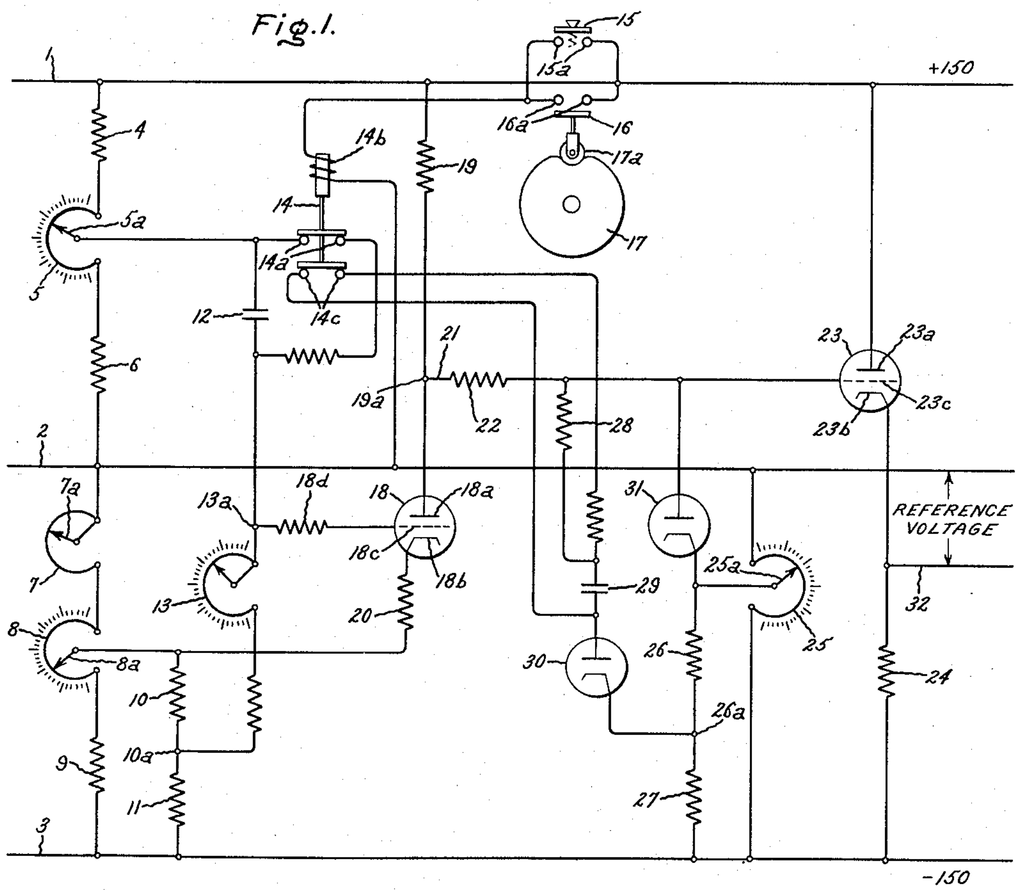


Fig. 2.

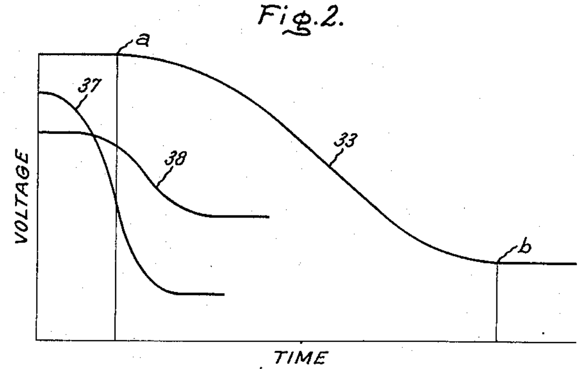
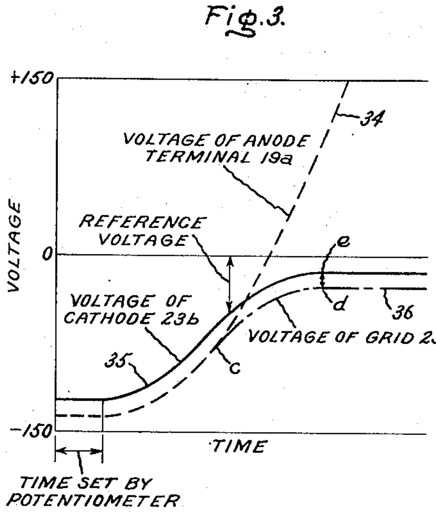


Fig. 3.



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2,702,881

REFERENCE VOLTAGE UNIT

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Application December 15, 1953, Serial No. 398,260

9 Claims. (Cl. 323—100)

This invention relates to reference voltage units, more particularly to adjustable reference voltage units and it has for an object the provision of a simple, reliable and improved unit of this character.

More specifically, the invention relates to reference voltage units for use in control systems or regulating systems in which the magnitude with respect to time of a controlled quantity such, for example, as the speed of a motor or the voltage of a generator is to be varied according to a predetermined pattern or program, and accordingly a further object of the invention is the provision of a unit that produces a reference voltage which varies according to such pattern. For example, it may be required to vary the magnitude of the controlled quantity at different rates during different portions of the program and to adjust the initial and final values of such controlled quantity to any one of a wide range of values and also to adjust the length of time at which such quantity is maintained at such initial and final values, and thus a further object of the invention is the provision of a reference voltage unit which produces a reference voltage of which the rates of change in different portions of its characteristic variation with respect to time are different and the initial and final values may be varied within wide limits.

In carrying the invention into effect in one form thereof, a source of direct voltage is provided together with an electric valve supplied from such source and having an input circuit and an output circuit. Also provided is a resistance capacitance timing circuit having connections to the input circuit of such valve for supplying thereto a control voltage varying with respect to time in accordance with the rate of change of voltage across a portion of such resistance capacitance circuit to produce an output voltage varying in a corresponding manner. The rate of change of the output voltage may be varied within wide limits by adjusting the relative values of the resistance and capacitance. Connections are provided for deriving from the output voltage a control voltage which varies in accordance with the output voltage throughout an initial portion of its range. A second resistance capacitance circuit connected to these voltage deriving connections is provided which becomes active at a predetermined but adjustable value of the derived voltage to modify such derived voltage by causing it to vary throughout a subsequent portion of its range at an entirely different rate which different rate may itself be adjusted by varying the resistance and capacitance of the resistance and capacitance components.

For a better and more complete understanding of the invention, reference should now be had to the following specification and to the accompanying drawing of which:

Fig. 1 is a simple diagrammatical representation of an embodiment of the invention and Figs. 2 and 3 are charts of characteristic curves which facilitate an understanding of the invention and its operation.

Referring now to the drawing, a direct voltage source having three different levels of voltage is represented by the supply conductors **1**, **2** and **3**. The value of the voltage of supply conductor **2** may be assumed to be 0 or ground level voltage, that of conductor **1** to be 150 volts positive and that of conductor **3** to be 150 volts negative with respect to conductor **2**. The values of voltage chosen for illustration are not critical or unique. Any other suitable values may be used.

Across the supply conductors **1** and **2** is connected a

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voltage divider comprising fixed resistor **4**, adjustable potentiometer **5** and fixed resistor **6** connected in series relationship. Another voltage divider comprising adjustable potentiometers **7** and **8** and fixed resistor **9** is connected across supply conductors **2** and **3**. The potentiometers **7** and **8** are provided with sliding contacts **7*a*** and **8*a*** respectively. Potentiometer **8** serves to adjust the initial value of the variable reference voltage and is referred to as the starting value potentiometer. Potentiometer **7** serves to adjust the minimum initial value of the reference voltage. In other words, it imposes an adjustable limitation on the minimum value to which the reference voltage may be adjusted by the starting value potentiometer and is referred to as the minimum starting value potentiometer.

Between the sliding contact **8*a*** of the starting value potentiometer and the negative supply conductor **3** is connected a third voltage divider which comprises fixed resistors **10** and **11** connected in series relationship. A capacitor **12** and an adjustable resistor **13** are connected in series relationship between a sliding contact **5*a*** of potentiometer **5** and the junction point **10*a*** of resistors **10** and **11**. The resistor **4**, potentiometer **5**, capacitor **12**, adjustable resistor **13** and fixed resistor **11** constitute an adjustable resistance-capacitance timing circuit. Adjustment of the resistor **13** serves to vary the rate of charge of the capacitor **12** and thus to vary the time constant of the timing circuit.

As shown, the capacitor **12** is normally short-circuited by the normally closed contacts **14*a*** of a relay **14** of which the operating coil **14*b*** is arranged to be connected across the supply source conductors **1** and **2** by means of a suitable switching device such for example as the pushbutton switch **15**. This switch **15** is provided with normally open contacts **15*a*** which are bridged by a movable contact member when depressed. In parallel with contacts **15*a*** are connected the normally open contacts **16*a*** of a cam switch **16** which is driven by the controlled machine. The controlled machine may be any machine of which the speed or other operating characteristics or controlled quantity is to be varied in accordance with a predetermined program. For example, it may be and in the following specification it is considered to be a cam grinding machine driven by a variable speed motor of which the speed is made to vary throughout the complete grinding operation in accordance with a predetermined program of speed with respect to time. The cam **17** has a circular equal radius cam face except for a single depression into which the cam follower **17*a*** descends at the end of a complete cycle of operation of the controlled machine.

Between the positive supply conductor **1** and the sliding contact **8*a*** of potentiometer **8** is connected an electric valve which may be of any suitable type. For example, it may be one of the triodes of a 6SN7 high vacuum valve **18**. Its anode **18*a*** is connected through an anode resistor **19** to supply conductor **1**. For the purpose of improving linearity of the characteristic of the valve throughout its entire range, its cathode is connected degeneratively through a resistor **20** to the slider **8*a*** of potentiometer **8**. Its control electrode **18*c*** is connected through a resistor **18*d*** to the junction point **13*a*** of capacitor **12** and adjustable resistor **13**.

A conductor **21** which is connected to the anode terminal **19*a*** of valve **18** together with the negative supply conductor **3** serves as a connection for deriving a control voltage from the output circuit of valve **18**. Conductor **21** is connected through a resistor **22** to the control electrode **23*c*** of a second electric valve **23** of which its anode **23*a*** is direct connected to the positive supply conductor **1** and its cathode **23*b*** is connected through a cathode follower resistor **24** to the negative supply conductor **3**. This valve may be of any suitable type such for example as the other triode of the 6SN7 high vacuum valve **18**.

Across supply conductors **2** and **3** is connected a potentiometer **25**. It is provided with a sliding contact **25*a*** between which and the negative supply conductor **3** resistors **26** and **27** are connected in series relationship to constitute a voltage divider. Between the control electrode **23*c*** of valve **23** and the junction point **26*a*** of resistors 26 and 27, a resistor 28, capacitor 29 and diode electric valve 30 are connected in series relationship. The diode valve 30 may be of any suitable type. For example, it may be one of the two conducting paths of a 6H6 double diode valve. Together with resistors 22 and 27 these elements constitute a second resistance capacitance timing circuit which serves to modify the control voltage which is derived between conductors 21 and 3 from the output circuit of the second stage valve 18.

The capacitor 29 is normally short circuited by means of a second pair of normally closed contacts 14c on the relay 14. Between the slider 25a and the control electrode 23c is connected a second diode valve 31 which is preferably the other half of the 6H6 valve of which the diode 30 constitutes the first half.

The output of the second stage valve is taken at the cathode 23b of valve 23. The voltage which appears between the ground voltage conductor 2 and the conductor 32, which is connected to the cathode, is the reference voltage.

With the foregoing understanding of the elements and their organization, the operation of the system to produce a reference voltage having a desired program of variation of magnitude with respect to time will readily be understood from the following description. In general, the shape of the reference voltage characteristic which it is desired to obtain is represented by the curve 33 which approximates the region between 90° and 270° of a sine wave curve.

Assuming that the initial value of the reference voltage is to be relatively high as indicated by the ordinate of the curve 33 at zero time, the slider 8a of potentiometer 8 is moved in a counterclockwise direction to a point which corresponds to the desired initial value of the reference voltage. To facilitate the setting, the potentiometer is preferably provided with a calibrated indicating scale as illustrated on the drawing.

The length of time which the reference voltage is to remain constant at the initial value is determined by the setting of potentiometer 5. This time is maximum when the slider 5a is in its extreme clockwise position and is zero or minimum when it is in its extreme counterclockwise position. A calibrated scale is provided to facilitate this setting. Assuming that the period of time during which the reference voltage is to remain constant at its initial value is represented by the abscissa of the point *a* on curve 33, the slider 5a is rotated to a corresponding position on the scale as indicated by the calibrated scale markings.

The final or finishing value of the reference voltage is determined by the setting of the potentiometer 25, and to facilitate the setting the potentiometer is provided with a cooperating scale. With the slider 25a in its extreme counterclockwise position, the minimum final value of the reference voltage is obtained. Conversely, in the extreme clockwise position of the slider, the final value of the reference voltage is maximum. Assuming that it is desired that the reference voltage shall have a final value such as represented by the ordinate of the point *b* of curve 33, the slider 25a is adjusted to a corresponding position on its cooperating scale.

Adjustment of the time required for the reference voltage to vary from its initial value to its final value is accomplished by the adjustment of the timing resistor 13 in the resistance capacitance timing circuit.

Depression of the start button switch 15 completes an energizing circuit for the operating coil 14b of relay 14. Responsively to its energization, the relay picks up to open its normally closed contacts 14a and 14c thereby to remove the short circuit from the capacitors 12 and 29. The previously existing short circuit about capacitors 12 and 29 prevented any charge from remaining on these capacitors prior to the actual start of the program. Owing to the adjustment of slider 8a to the point near its extreme counterclockwise position on potentiometer 8, the voltage of cathode 18b is relatively low and consequently, the value of the current conducted by valve 18 is relatively high. The resulting voltage drop across anode resistor 19 is correspondingly large and the voltage at anode terminal 19a with respect to the voltage of negative conductor 3 is positive but of relatively low value. This initial condition is illustrated graphically in Fig. 3 by the curve 34 of which ordinates represent voltage of anode terminal 19a and abscissae represent time. The zero horizontal axis represents the voltage of the conductors 2, the positive 150 volt axis represents the voltage of the positive supply conductor 1 and the negative 150 volt axis represents the voltage of the negative supply conductor 3. Thus at the instant of contact opening or zero time, the voltage of anode terminal 19a is slightly positive with respect to the negative conductor 3 as represented by the zero time ordinate of curve 34 in Fig. 3. Since this voltage derived between conductor 3 and anode terminal 19a is supplied to the control electrode 23c of second stage valve 23, the valve 23 is conducting. Owing to the degenerative effect of the cathode follower resistor 24, however, the value of the anode-cathode current of valve 23 is relatively low. The actual value of the voltage of the cathode 23b is positive with respect to the voltage of the control electrode by the amount of the negative bias as illustrated by curve 35 of which ordinates represent cathode voltage and abscissae represent time. Since the anode-cathode circuit current is relatively small, the voltage drop across cathode follower resistor 24 is correspondingly small. The result is that the reference voltage, which is derived between conductor 32 and the zero voltage supply conductor 2 is relatively high as represented by the ordinate value of curve 33 on the zero time axis of Fig. 2 and also by the zero time ordinate of the curve 35 of Fig. 3.

In response to the establishment of a reference voltage between the conductors 2 and 32, the machine which is controlled by the reference voltage is started and accelerated to a speed corresponding in magnitude to the value of the reference voltage. The operation of the controlled machine causes the cam 17, which is driven thereby, to move the cam follower 17a upwardly thereby to cause the movable switch contact 16 to bridge the normally open contacts 16a. The bridging of contacts 16a completes a circuit in parallel with the contacts 15a of the push button switch 15 which may now be released.

In response to the removal of its short circuit by the opening of contacts 14a, the capacitor 12 begins to charge at a rate that is determined by the setting of adjustable resistor 13 and consequently the voltage of control electrode 18c of the first stage valve becomes progressively less positive or more negative as the charge increases. During the time interval required for the voltage of control electrode 18c to decrease to the value of the cathode voltage, the conduction of valve 18 remains unchanged and consequently during this period the anode voltage of valve 18 and the value of the reference voltage across conductors 2 and 32 remain constant at the initial values as illustrated by the initial horizontal portions of curves 33 and 35. As the charge on capacitor 12 continues to increase, the voltage of control electrode 18c becomes progressively more negative. As a result, the anode current decreases and the voltage of anode terminal 19a begins to rise in accordance with the diminishing voltage drop across resistor 19. This is illustrated graphically by curve 34 in Fig. 3. This increasingly positive voltage which is supplied to the control electrode 23c of the second stage valve 23 causes its anode cathode current to increase correspondingly, and consequently the voltage drop across resistor 24 increases progressively so that the reference voltage between conductor 32 and supply conductor 2 decreases in accordance with the sloping portions of curves 33 and 35.

When the voltage of anode terminal 19a becomes more positive than the voltage at the junction point 26a of voltage divider resistors 26 and 27, the diode valve 30 breaks down and becomes conducting and the capacitor 29 begins to charge. The value of voltage of anode terminal 19a at which the diode becomes conducting is represented by the ordinate of the point *c* on curve 34.

As a result of the charging current flowing through resistor 22 and the increasing charge on capacitor 29, the voltage at the control electrode 23c no longer closely follows the curve 35. Instead, it diverges from curve 35 as indicated by the branch curve 36. Owing to the cathode follower operation of valve 23, the reference voltage between conductors 2 and 32 follows the pattern of the control electrode voltage as represented by curves 33 and 35. The slope of this portion of the reference voltage characteristic is determined by the combined effect of the first and second stage timing circuits, i. e., the resistance capacitance circuits in which are included the capacitors **12** and **29**.

When the voltage of control electrode **23***c* equals or slightly exceeds the voltage at the sliding contact **25***a*, the diode valve **31** breaks down and becomes conducting. The value of control electrode voltage at which the diode becomes conducting is represented by the ordinate of point *d* of curve **36**. In consequence of the diode becoming conducting, the control electrode is effectively tied directly to the slider **25***a* and thereafter its voltage remains essentially constant at the voltage of the slider. Likewise the cathode voltage and consequently the reference voltage remain constant at the final value which is represented by the ordinate of the point *b* of curve **33** of Fig. 2 and also by the ordinate of the point *e* of curve **35** of Fig. 3.

The reference voltage characteristic may be altered within rather wide limits by adjustment of the resistors **5**, **8**, **13** and **25**. For example, by adjustment of the resistor **8**, the reference voltage may be given initial values such as represented by the ordinates of the initial horizontal portions of curves **37** and **38**. The period of time during which the reference voltage remains constant at such initial values may, by adjustment of resistor **5**, be altered to conform to the period of time represented by the initial horizontal portions of curves **37** and **38**. The final values of the reference voltage may, by adjustment of resistor **25**, be adjusted to values such as represented by the ordinates of the final horizontal portions of curves **37** and **38**. Likewise by adjustment of resistor **13**, the rate of change of the reference voltage may be varied as represented by the different slopes of curves **37** and **38**.

The values of the resistances and capacitances employed in the unit are not critical but are subject to considerable variation. The values appearing in the following tabulation are illustrative of values which have been found to provide satisfactory operation.

Capacitors:	Capacitance
12	mfd__ 50
29	mfd__ 50

Resistor:	Resistance in thousands of ohms
4	31
5	50
6	1.8
7	10
8	10
9	2.7
10	24
11	1000
13	5000
19	240
20	3.9
21	482
22	510
25	50
26	12
27	240
28	300

Although in accordance with the provisions of the patent statutes this invention has been described as embodied in concrete form and the principle thereof has been explained together with the best mode in which it is now contemplated applying that principle, it will be understood that the structure shown and described is merely illustrative and that the invention is not limited thereto since alterations and modifications will readily suggest themselves to persons skilled in the art without departing from the true spirit of the invention or from the scope of the annexed claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An adjustable reference voltage unit for providing a reference voltage varying in time according to a predetermined pattern comprising a source of direct voltage, an electric valve supplied from said source and having an input circuit and an output circuit, a resistance-capacitance circuit connected to said input circuit for supplying thereto a control voltage varying with time to produce a corresponding variable voltage across a portion of said output circuit, electrical connections for deriving from said output circuit a second control voltage varying with said first control voltage through a portion of its range, and means for modifying said derived voltage in an adjoining portion of its range comprising a second resistance-capacitance circuit connected across said voltage deriving connections and responsive to a predetermined value of said output circuit voltage for initiating its action.

2. An adjustable reference voltage unit for producing a direct reference voltage varying in magnitude with respect to time according to a predetermined pattern comprising a source of direct voltage, a resistance-capacitance circuit and means for initiating a timed variation in the charge on the capacitor of said circuit, an electric valve supplied from said source and having an input circuit connected across a portion of said resistance-capacitance circuit and having an output circuit controlled thereby to provide an output voltage which varies in accordance with the voltage across said portion of said resistance-capacitance circuit, electrical connections for deriving from said output voltage a control voltage varying with said output voltage during an initial portion of its range, and means for modifying said derived voltage in an adjoining subsequent portion of its range comprising a second resistance-capacitance circuit connected to said electrical connections, and an electric valve electrically connected to said second resistance-capacitance circuit and responsive to a predetermined value of said derived voltage for initiating the modifying action of said second resistance-capacitance circuit.

3. An adjustable reference voltage unit for producing a direct reference voltage varying in magnitude with respect to time according to a predetermined pattern comprising a source of direct voltage, a resistance-capacitance circuit and means for initiating a timed variation in the charge on the capacitor of said circuit, an electric valve supplied from said source and having an input circuit connected across a portion of said resistance-capacitance circuit and having an output circuit controlled thereby to provide an output voltage which varies in accordance with the voltage across said portion of said resistance-capacitance circuit, electrical connections for deriving from said output voltage a control voltage varying with said output voltage during an initial portion of its range, and means for modifying said derived voltage in an adjoining subsequent portion of its range comprising a second resistance-capacitance circuit connected to said electrical connections, and means for initiating the modifying action of said second resistance-capacitance circuit comprising a source of direct voltage having a voltage divider connected thereacross and an electric valve having one of its main discharge supporting electrodes connected to said second resistance-capacitance circuit and the other connected to a point of predetermined voltage on said divider.

4. An adjustable reference voltage unit for producing a direct reference voltage varying in magnitude with respect to time according to a predetermined pattern comprising a source of direct voltage, a resistance-capacitance circuit and means for initiating a timed variation in the charge on the capacitor of said circuit, an electric valve supplied from said source and having an input circuit connected across a portion of said resistance-capacitance circuit and having an output circuit controlled thereby to provide an output voltage which varies in accordance with the voltage across said portion of said resistance-capacitance circuit, electrical connections for deriving from said output voltage a control voltage varying with said output voltage during an initial portion of its range, and means for modifying said derived voltage in an adjoining subsequent portion of its range comprising a voltage divider connected across said source, a second resistance-capacitance circuit connected from a point on said electrical connections to a predetermined intermediate voltage point on said divider, and an electric valve included in said second circuit between the capacitor thereof and said intermediate voltage point for initiating the modifying action of said second circuit at a value of said derived voltage exceeding the voltage of said intermediate point.

5. An adjustable reference voltage unit for producing a direct reference voltage varying in magnitude with respect to time according to a predetermined pattern comprising a source of direct voltage, a circuit connected across said source comprising a capacitor and a resistor connected in series relationship, means for initiating a variation in the charge on said capacitor, a first electric

valve having an anode, a cathode and a control electrode, input connections for connecting said cathode and control electrode across a portion of said resistor-capacitor circuit and having an output circuit controlled by the voltage of said control electrode to provide an output voltage which varies in accordance with the voltage across a portion of said resistor-capacitor circuit, electrical connections for deriving from said output voltage a control voltage varying in proportion to said output voltage during an initial portion of its range, means for modifying said derived control voltage in an adjoining subsequent portion of its range comprising a second resistor-capacitor circuit connected to said voltage deriving connections, means responsive to a predetermined value of said output voltage for initiating the voltage modifying action of said second circuit, and a potentiometer supplied from said direct voltage source and having an adjustable contact connected to said input connections for adjusting the initial values of said output voltage and said control voltage derived therefrom.

6. An adjustable reference voltage unit for producing a direct reference voltage varying in magnitude with respect to time according to predetermined pattern comprising a source of direct voltage, a circuit connected across said source comprising a capacitor and a resistor connected in series relationship, means for initiating a variation in the charge on said capacitor, a first electric valve having an anode, a cathode and a control electrode, input connections for connecting said cathode and control electrode across a portion of said resistor-capacitor circuit and having an output circuit controlled by the voltage of said control electrode to provide an output voltage which varies in accordance with the voltage across a portion of said resistor-capacitor circuit, electrical connections for deriving from said output voltage a control voltage varying in proportion to said output voltage during an initial portion of its range, means for modifying said derived control voltage in an adjoining subsequent portion of its range comprising a second resistor-capacitor circuit connected to said voltage deriving connections, means responsive to a predetermined value of said output voltage for initiating the voltage modifying action of said second circuit, a potentiometer supplied from said direct voltage source and having an adjustable contact connected to said cathode for adjusting the initial values of said output and derived control voltages, and a second potentiometer energized from said direct voltage source and having an adjustable contact connected to said resistor-capacitor circuit for adjusting the time interval after said initiation of the variation of said charge during which said output and derived voltages remain constant at said initial values.

7. An adjustable reference voltage unit for producing a direct reference voltage varying in magnitude with respect to time according to a predetermined pattern comprising a source of direct voltage, a circuit connected across said source comprising a capacitor and a resistor connected in series relationship, means for initiating a variation in the charge on said capacitor, a first electric valve having an anode, a cathode and a control electrode, input connections for connecting said cathode and control electrode across a portion of said resistor-capacitor circuit and having an output circuit controlled by the voltage of said control electrode to provide an output voltage which varies in accordance with the voltage across a portion of said resistor-capacitor circuit, electrical connections for deriving from said output voltage a control voltage varying in proportion to said output voltage during an initial portion of its range, means for modifying said derived control voltage in an adjoining subsequent portion of its range comprising a second resistor-capacitor circuit connected to said voltage deriving connections, means responsive to a predetermined value of said output voltage for initiating the voltage modifying action of said second circuit, a potentiometer supplied from said direct voltage source and having an adjustable contact connected to said cathode for adjusting the initial values of said output and derived voltages, and a second potentiometer energized from said direct voltage source and having an adjustable contact connected to said control electrode for including in said input connections an adjustable amount of said second potentiometer thereby to adjust the length of the time interval after said initiation of the variation of said charge during which said output and derived voltages remain constant at said initial values.

8. An adjustable reference voltage unit for producing a direct reference voltage varying in magnitude with respect to time according to a predetermined pattern comprising a source of direct voltage, a circuit connected across said source comprising a capacitor and a resistor connected in series relationship, means for initiating a variation in the charge on said capacitor, a first electric valve having an anode, a cathode and a control electrode, input connections for connecting said cathode and control electrode across a portion of said resistor-capacitor circuit and having an output circuit controlled by the voltage of said control electrode to provide an output voltage which varies in accordance with the voltage across a portion of said resistor-capacitor circuit, electrical connections for deriving from said output voltage a control voltage varying in proportion to said output voltage during an initial portion of its range, means for modifying said derived control voltage in an adjoining subsequent portion of its range comprising a voltage divider supplied from said source, a circuit including a second resistor and a second capacitor connected in series relationship between one of said voltage deriving connections and a predetermined intermediate voltage point on said divider, a second electric valve included in said second circuit and responsive to a predetermined value of said derived voltage for initiating the modifying action of said second resistor-capacitor circuit, a potentiometer supplied from said direct voltage source and having an adjustable contact connected to said input connections for adjusting the initial values of said output voltage and said control voltage derived therefrom, and means for adjusting the final value of said voltages comprising a second potentiometer supplied from said source and having an adjustable contact and a third electric valve having its discharge supporting electrodes connected between said voltage deriving connections and said adjustable contact of said second potentiometer.

9. An adjustable reference voltage unit for producing a direct reference voltage varying in magnitude with respect to time according to a predetermined pattern comprising a source of direct voltage, a first control circuit having connections to said source, a capacitor and an adjustable resistor connected in series in said circuit for controlling the rate of change of voltage across said capacitor, means for initiating a change in the charge on said capacitor, an electric valve supplied from said source having an input circuit connected across a portion of said control circuit and having an output circuit controlled thereby to provide an output voltage having a rate of change substantially equal to the rate of change of voltage across said capacitor, electrical connections for deriving from said output voltage a control voltage having a rate of change equal to the rate of change of said output voltage throughout an initial portion of its range, and means for modifying the rate of change of said derived voltage in an adjoining subsequent portion of its range comprising a source of substantially constant direct voltage, a voltage divider connected across said constant voltage source, a second control circuit connected between a first of said voltage deriving connections and a point of predetermined voltage on said divider, a second capacitor and a second adjustable resistor connected in series relationship in said second control circuit for controlling the rate of change of voltage across said second capacitor, and means for initiating the modifying action of said second circuit comprising an electric valve having its anode cathode circuit connected in series in said second circuit to become conducting at a value of said derived voltage substantially equal to said predetermined voltage.

No references cited.