

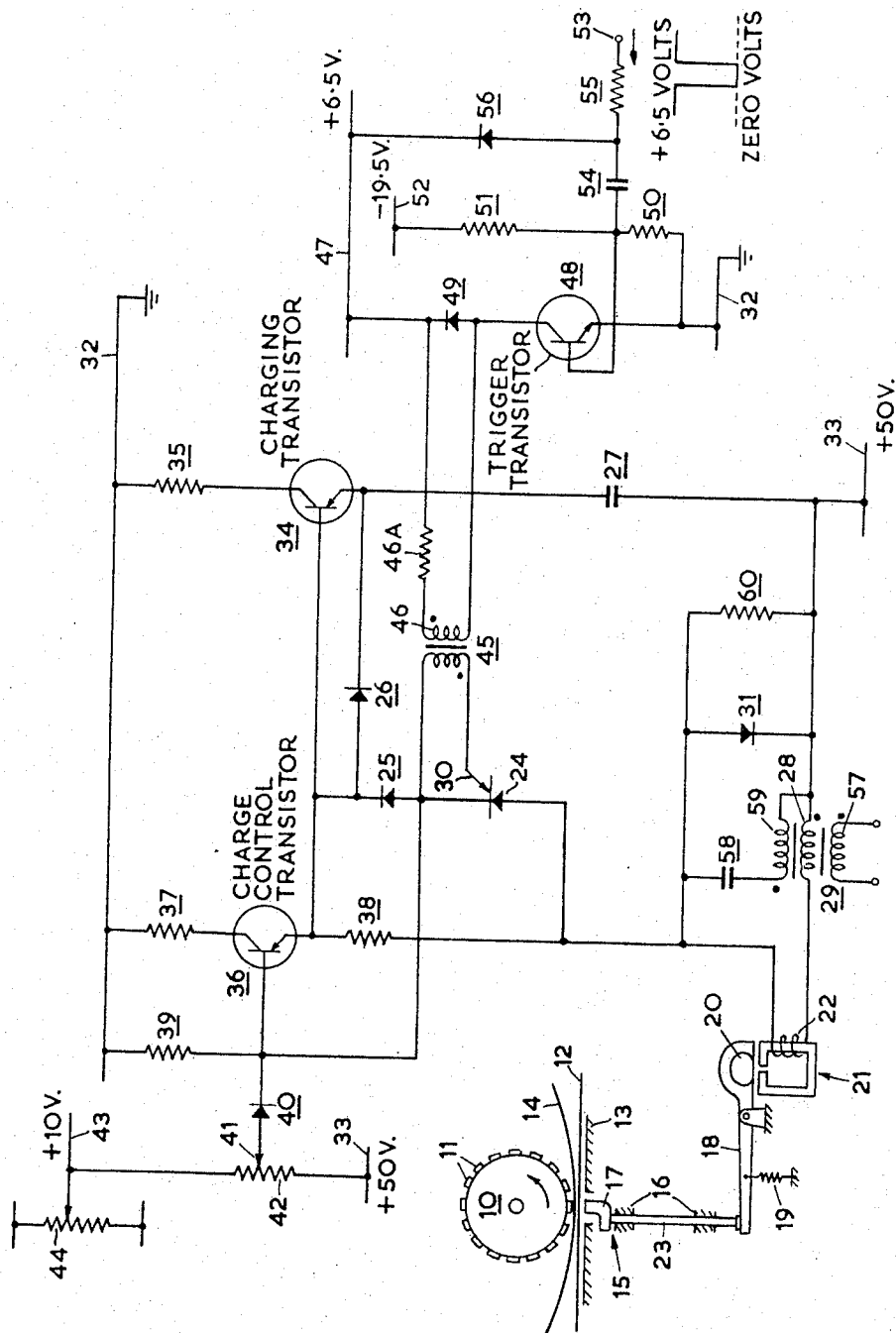
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DATA PRINTING APPARATUS

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1

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DATA PRINTING APPARATUS

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ABSTRACT OF THE DISCLOSURE

This invention relates to solenoid drive circuits for high speed printers and includes a capacitor which is connected on the one hand through a charging impedance to a power supply and on the other hand through an SCR to the solenoid. The present invention provides a charging transistor as the charging impedance. The charging transistor is controlled in cooperation with a variable bias supply whereby said charging transistor can be turned off when the voltage on the capacitor reaches an adjustable predetermined value; also said charging transistor is maintained in an off condition during discharge of the capacitor.

This invention relates to data printing apparatus for use, for example, with electronic computers and other data processing equipment, and to operating means for data printing hammers of such data printing apparatus.

According to one feature of the present invention in a data printing apparatus each hammer for causing a character impression to be made on a paper or like sheet is moved from a non-printing position to a printing position, when required, whereby to make such a character impression, by an electro-magnetic device having a movable armature member for impulsing the hammer on electrical energization of the device, and means are provided for effecting energization of the device by connecting an electrical winding thereof in circuit with a charged capacitor for discharge of the capacitor through the electrical winding.

Means are also provided for automatically recharging the capacitor to a desired potential immediately after a character impression has been made.

Preferably, adjustment means are provided for adjusting the desired potential to which the capacitor can be charged, whereby to enable adjustment of the quantity of energy to be supplied by the electro-magnetic device to the printing hammer, and any associated mechanism, during the discharge of the capacitor, and thereby to effect adjustment of the strength of the character impression to be made by the hammer on discharging the capacitor.

The several adjustment means associated with the several hammers respectively of the printing apparatus may be supplied from a common electrical supply source, and a further adjustment means may be provided for adjusting the voltage of this common supply source whereby to effect simultaneous and like adjustment of the individual potentials to which the several capacitors shall be charged, and thereby to effect a simultaneous and like adjustment of the strengths of the several character impressions to be made by the several hammers respectively of the printing apparatus.

Preferably, each capacitor is charged through a charging transistor which is controlled differentially in dependence upon a reference voltage supplied as the output of the associated adjustment means and a feedback voltage dependent upon the voltage developed across the capacitor.

2

Each capacitor may be connected when required with its associated electrical winding by means of a controllable switching means, for example, a silicon-controlled rectifier, arranged to prevent discharge of the capacitor except when, on receipt of a trigger signal, the controllable switching means is rendered conductive. Preferably, the resulting flow of current when discharging the capacitor is employed to automatically render non-conductive the transistor through which the capacitor is charged, and to activate means for checking, by comparing together a signal dependent upon the discharge current and a signal dependent on the input signal which initiated the printing of the character impression, that the desired character has been impressed by the apparatus.

Associated with the several controllable switching means are several electrical trigger circuit arrangements, each of which is arranged to respond to the trailing edge only of input pulses supplied thereto.

One printing apparatus according to the present invention for use with an electronic digital computer will now be described by way of example and with reference to the accompanying drawing, which shows diagrammatically the relevant circuit connections and mechanical parts of the apparatus.

Referring now to the drawing, the printing apparatus includes a character shaft 10 bearing around its periphery a plurality of axial parallel rows of character type 11, each such row extending across the length of the shaft and comprising a plurality of spaced identical type. The shaft is driven by means not shown at constant speed, and paper 12 on which it is desired to print data (from the computer directly, or indirectly through a magnetic tape) is supported beneath the character shaft 10 on a fixed support member 13 mounted below the shaft. Means not shown are provided for moving the paper intermittently as required for printing the data line by line. An inked ribbon extending across the full width of the character shaft is disposed between the paper and the character shaft, and is moved continuously by driving means not shown so as to make use of as much of the ribbon surface as possible.

A single row of printing hammers 15 is mounted beneath the fixed support member, there being one hammer for each character type in a row. The hammers project through apertures in the support member, and are biased by means not shown to a lower or non-printing position as shown in the drawing. Each hammer is guided for vertical movement in spaced bearings 16, and is moved from its non-printing position to an upper or printing position, in which the hammer head 17 holds the paper and ribbon hard against the corresponding character type on the character shaft, by a pivoted lever 18. This lever, which is biased by a spring 19 to the position shown, includes a ferro-magnetic armature 20 which co-operates with the poles of an electro-magnet 21. The magnet has an electrical winding 22 which on energization is effective to cause the armature 20 to be magnetically attracted rapidly towards the poles.

It will be appreciated that the consequent movement of the armature results in the application of an impulse by the free end of the lever to the hammer shaft 23, and in the consequent rapid movement of the hammer to the printing position whereby to print a character impression on the paper sheet.

The winding 22 is connected in a closed electrical circuit which includes in series relationship a silicon-controlled rectifier 24, two diodes 25, 26, a capacitor 27 and a primary winding 28 of a sensing transformer 29, and the winding 22 is energised by applying a trigger signal to a trigger electrode 30 of the silicon-controlled rectifier, whereby to render it conductive and thereby enable the

capacitor 27 to discharge itself through the said aforesaid closed electrical circuit. A diode 31 is shunted across the winding 22 so as to limit the back E.M.F. induced in the winding, and thereby prevent such back E.M.F. adversely affecting the capacitor 27.

The capacitor 27 is connected in a charging circuit which is connected between an earth line 32 and a 50 volt line 33, and which includes a first or charging transistor 34 of the p-n-p type and a collector load resistor 35, the emitter of this transistor being connected to the capacitor 27 adjacent the diode 26.

The base of the charging transistor is controlled by a second or charge control transistor 36 of the p-n-p type which has its collector connected with the earth line 32 through a load resistor 37, and its emitter connected with the 50 volt line 33 through a circuit which includes in series relationship an emitter load resistor 38, the winding 22 of the electro-magnet, and the sensing transformer primary winding 28.

The base of the control transistor is connected through a resistor 39 of high ohmic value with the earth line 32, through a diode 40 with an adjustable tapping 41 of a reference potentiometer 42 which is itself connected between the 50 volt line 33 and a 10 volt line 43, and through the diode 25 with the emitter of the control transistor. The supply line 43 is itself connected to a source of adjustable stabilised voltage which is represented for simplicity only as a potentiometer 44.

Trigger pulses for the silicon-controlled rectifier 24 are derived through an isolating transformer 45 whose primary winding 46 is connected for energization, from a +6.5 volt line 47, in the collector circuit of a third or trigger transistor 48 of the n-p-n type. A current-limiting resistor 46A is also connected in this collector circuit, and the primary winding 46 and resistor 46A are shunted by a diode 49 for limiting the back E.M.F. induced in the primary winding, and the emitter of the trigger transistor is connected directly with the earth line 32, and through a resistor 50 with the base of the trigger transistor. The base of the trigger transistor is also connected through a resistor 51 of very high ohmic value to a -19.5 volt line 52, and to an input circuit terminal 53 through a circuit which includes in series relationship a capacitor 54 and a resistor 55. A diode 56 connected on one side to the +6.5 volt line 47 and on the other side to a point between the capacitor 54 and the resistor 55 limits the positive potential of this point to +6.5 volts.

With the exception of the stabilized voltage source 44 the circuit described above is repeated for each hammer of the printing apparatus, and the source 44 serves to provide a common adjustable control voltage for all of the several circuits provided for the respective hammers. Thus by variation of the voltage appearing at the line 43 the control voltage for all of the control transistors is varied simultaneously and by the same proportion.

The operation of the circuit is as follows. Consider the circuit at the instant when the silicon-controlled rectifier 24 has ceased to conduct a discharge current from the capacitor 27. In the absence of a current flow through the diodes 25 and 26, these diodes no longer limit the base emitter potentials of the control and charging transistors 36 and 34 to low positive values such as to prevent conduction by these transistors, so that a control current is immediately reestablished in the control transistor emitter-collector circuit. The magnitude of this control current is limited by the feedback action of the high potential drop developed across the emitter resistor 38, so that the potential of the emitter of the control transistor, and hence of the base of the charging transistor, is held at a value dependent upon the reference potential appearing at the tapping 41.

Under this condition, when the capacitor 27 is in a discharged condition, the potential of the emitter of the charging transistor 34 is greater than that of the base of that transistor, and a charging current therefore flows in

the capacitor 27 and emitter-collector circuit of the charging transistor. As the potential developed across the capacitor 27 rises with increase in stored energy, the magnitude of the charging current is progressively reduced by the progressively decreasing emitter-base potential of the charging transistor, with the result that the charging transistor ceases to carry an emitter current when the potential developed across the capacitor 27 has risen to a value dependent upon the emitter potential of the control transistor, and hence upon the potential of the tapping 41 of the potentiometer 42.

It will thus be understood that the energy stored in the capacitor when charged can be accurately controlled in accordance with the setting of the reference potentiometer tapping 41, and that after the capacitor has been charged the charging transistor ceases to conduct further charging current.

When it is desired to imprint a character on the paper 12 a trigger impulse is applied to the primary winding 46 of the trigger transformer 45, so as to develop a trigger signal at the control gate 30 of the silicon-controlled rectifier 24. This rectifier is thereupon rendered conductive, and current flows in the rectifier by discharge of the voltage appearing across the charged capacitor 27. This discharge current flows in the electro-magnet winding 22 and in the diodes 25 and 26, and the consequent potentials developed across these diodes are sufficient to reverse bias the base electrodes of the control and charging transistors 36 and 34 and thereby immediately render them non-conductive. Thus during the discharge of the capacitor 27 no charging current is delivered by the charging transistor 32.

The discharge of the capacitor through the winding 22 results in the energization of the electromagnet 21, the consequent attraction of the armature 20, the angular movement of the pivoted lever 18, the impulsing of the hammer shaft, and the consequent pressure of the paper and inked ribbon against the character type on the character shaft.

Since when discharging the capacitor 27, the discharge current is of a maximum value at the beginning of discharge, and subsequently decays exponentially, the energization of the winding 22 is likewise of a maximum value initially and subsequently decays to a low value. Thus the armature, pivoted lever and hammer are all subjected initially to a very high acceleration, which despite the subsequent decrease in energization of the winding 22 increases with closure of the air gap between the armature and poles of the electro-magnet due to the progressive reduction in the reluctance of the magnetic path which includes the armature and electro-magnet core.

Since the energy supplied by the winding 22 is provided by the charged capacitor 27, this energy is inherently limited by the magnitude of the charge stored in the capacitor. Thus by controlling the voltage appearing across the capacitor during the charging period, so that the stored charge is limited at a desired value, the energy subsequently imparted to the printing hammer mechanism is also limited to a predetermined value. It will be appreciated that this value is determined on the one hand by the setting of the reference potentiometer tapping 41 which provides independent and individual control of the impression made by the individual hammer, and on the other hand by the value of the stabilized voltage produced by the source 44 which provides simultaneous and proportional control of the impressions made by all of the printing hammers. Thus when setting up the printing apparatus for operation, the individual impressions made by the several hammers of the apparatus are initially made similar with one another by adjustment of the respective potentiometer tappings 41, and after so adjusting the apparatus simultaneous adjustment of the impressions of all of the hammers is obtained by varying the potential of the stabilized source 44.

The trigger impulses for the primary winding 46 of the

trigger transformer 45 are produced by a change in the conductive state of the trigger transistor 48 each time a negative-going input pulse is received at the input terminal 53. The trigger transistor is normally held in a non-conductive state by a negative bias potential developed across the resistor 50, whilst the input terminal is normally held at +6.5 volts potential.

When a negative-going input pulse is received at the input terminal no immediate change occurs in the state of the trigger transistor since the front negative-going edge of the input pulse only carries the base of the trigger transistor in the negative direction to increase the existing reverse bias. During the period when the input potential is at zero value the capacitor 54 becomes discharged, so that when the input pulse ceases the positive-going trailing edge of the pulse raises the potential of the base to a value positive with respect to the emitter of the trigger transistor, and current then flows in the emitter-collector path of that transistor. This current flows in the primary winding of the trigger transformer to provide the trigger impulse for rendering the silicon-controlled rectifier conductive. As the capacitor 54 recharges, the potential of the base of the trigger electrode falls exponentially to its normal negative value, so that eventually when the base potential falls below a cut-off value current ceases to flow in the emitter-collector path of the trigger transistor.

The generation of high back E.M.F. by the primary winding of the trigger transformer 45 when the trigger transistor ceases to conduct is prevented by the provision of the diode 49.

Since the input terminal 53 is normally held at +6.5 volts, any positive noise signal applied at the input terminal is absorbed by the 6.5 volt source 47 through the diode 56. Negative noise signals, on the other hand, merely increase temporarily the reverse bias of the trigger transistor base. Thus the trigger transistor is inherently insensitive to noise signals.

In order to render the trigger transistor conducting, it is first necessary to discharge the capacitor 54 to an extent sufficient to enable a positive-going signal of desired high value to momentarily carry the grid of the trigger transistor a predetermined amount in a positive sense. This action is achieved by each input signal, since the reduction of the input terminal to earth potential maintained during the pulse completely discharges the capacitor 54, so that at the end of the pulse the positive-going trailing edge is able to raise the base of the trigger transistor to the conduction value.

The flow of the capacitor discharge current through the primary winding 28 of the sensing transformer 29 gives rise to the production of feedback or checking signals in the several secondary windings. These checking signals are supplied to checking apparatus not shown which inter alia compares one such feedback signal with a checking signal developed by the apparatus providing the input signals to the input terminal 52.

In order to prevent the generation of spurious feedback signals in the various feedback secondary windings such as 57 on the transformer 29 due to the capacitance effects of the electro-magnet winding 22 on rendering the silicon-controlled rectifier 24 conductive, a capacitor 58 of substantially the same capacitance as that of the winding 22 may be connected in parallel with the winding 22 through a further primary winding 59 of the transformer 29. This primary winding 59 should be arranged to produce a magnetic flux which is opposite in sense to that produced by the primary winding 28, so that when the silicon-controlled rectifier is rendered conductive the flow of capacitive currents in the two primary windings 28 and 59 produces two M.M.F.'s which more or less balance one another. Hence no appreciable feedback signal is produced in the secondary windings such as 57 until, after the initial transient, a conductive current builds up in the electro-magnet winding 22. This modified circuit arrangement also enables the detection of an open-

circuit in the connections supplying the electro-magnet winding 22, in that the capacitive current flowing in the primary winding 59 on rendering the silicon-controlled rectifier conductive is unbalanced by a corresponding current in the primary winding 28. This latter effect can be substantially enhanced by increasing the size of the capacitor 58.

It may also be necessary in practice to connect a resistor such as 60 in parallel with the electro-magnet winding in order to provide a sufficiently rapid growth of current in the silicon-controlled rectifier on being triggered such as will maintain conduction after the trigger pulse has passed.

The resistor 39 controlling the base potential of the control transistor 36 is made of high ohmic value so as to prevent the current drawn through it and the silicon-controlled rectifier 24 when the capacitor is being discharged preventing the return of the silicon-controlled rectifier to the non-conductive state at the end of the discharge period.

The provision of the capacitor 27 from which to supply the energy to the printing hammer mechanism is highly advantageous in that should all of the hammers be required to print simultaneously, no severe transient load is demanded from the electric supply source. This is particularly important in that well over a hundred hammer mechanisms may be required to function simultaneously.

By adjustment of the duration of the input pulses, the positioning of the character impressions on the paper may be adjusted. Thus by lengthening the input pulse duration the printing of the character impressions may be delayed, and in the limiting case the bottom part only of each character would be printed. By shortening the input pulse duration, the opposite effect is produced, so that in the opposite limiting case the top part only of each character would be printed.

What I claim as my invention and desire to secure by Letters Patent is:

1. Operating means for a data printing hammer including an electro-magnet for applying a printing impulse to the hammer on energization of an electrical winding thereof whereby to make a data character impression on a data record carrier, an electric storage capacitor, a charging transistor for controlling the flow of charge into the capacitor, the capacitor being connected between a first supply terminal and the emitter of the transistor, a first collector load resistor connected between a second supply terminal and the collector of the charging transistor, a charge control transistor, a second collector load resistor connected between the collector of the charge control transistor and the second supply terminal, an emitter load resistor connected at one end to the emitter of the charge control transistor and circuit means connecting the electro-magnet winding between the other end of the emitter load resistor and the first supply terminal, circuit means connecting the emitter of the charge control transistor with the base of the charging transistor, a controllable switching means connected between the emitter of the charging transistor and the junction of the electro-magnet winding with the said emitter load resistor, trigger means connected with the controllable switching means for supplying thereto in response to input signals supplied to the trigger means trigger signals for rendering the controllable switching means temporarily conductive, a reference potential divider for connection across a constant potential supply source and for supplying at an adjustable tapping thereof a reference potential, and means for applying the reference potential to the base of the charge control transistor.

2. Operating means according to claim 1, including between the controllable switching means and the emitter of the charging transistor two series-connected diodes for conducting current towards the emitter of the charging transistor, and circuit means connecting the junction of

the controllable switching means with the first diode to the base of the charge control transistor, and other circuit means connecting the junction of the two diodes with the base of the charging transistor.

3. Operating means according to claim 2, wherein the trigger means includes a trigger transistor, means for connecting the emitter of the trigger transistor to a supply terminal, an output pulse transformer having a primary winding connecting the collector of the trigger transistor to a further supply terminal, a potential divider connected between the emitter of the trigger transistor and a first bias supply terminal and having a tapping connected on the one hand to the base of the trigger transistor, and on the other hand to one side of a buffer capacitor, the other side of the buffer capacitor being connected to a source of opposite bias potential through a diode arranged to allow current to flow towards the last-mentioned source of bias potential, and an input circuit connected to the junction of the buffer capacitor and the associated diode and including a current limiting resistor, the output pulse transformer having a secondary winding for supplying the said trigger pulses.

4. Operating means according to claim 3, including a sensing transformer having a first primary winding connected between the electro-magnet winding and the said first supply terminal, a second primary winding and an output winding, means for connecting the second primary winding in series with a matching capacitor across the series-connected electro-magnet winding and the first primary winding of the sensing transformer, the matching capacitor having a capacitive value matched to that of the first primary winding, and the two primary windings being arranged to produce equal and opposite magnetic fields due to the flow of capacitive currents on first rendering the controllable switching means conductive.

5. A solenoid firing circuit comprising:

- a capacitor;
- a charging transistor having emitter, base and collector electrodes and an emitter-collector path extending between emitter and collector electrodes;
- a first series circuit connected across the capacitor and comprising the solenoid and an electronic switch;
- a second series circuit connected across the capacitor and comprising a power supply and the emitter-collector path of the charging transistor; and
- means for defining a reference voltage, and capacitor voltage control means for turning said charging transistor off when the voltage on the capacitor equals the reference voltage of said reference means.

6. A circuit according to claim 5, wherein the emitter-electrode of the charging transistor is connected adjacent to the capacitor and the capacitor voltage control means comprises a bias voltage supply coupled to the base electrode of the charging transistor.

7. A circuit according to claim 6 wherein the bias voltage is adjustable.

8. A circuit according to claim 6 wherein a charge control transistor arranged as an emitter follower is connected between the charging transistor and the bias voltage supply.

9. A solenoid firing circuit comprising:

- a capacitor;
- a charging transistor having emitter, base and collector electrodes and an emitter-collector path extending between emitter and collector electrodes;
- a first series circuit connected across the capacitor and comprising the solenoid and an electronic switch;
- a second series circuit connected across the capacitor and comprising a power supply and the emitter-collector path of the charging transistor; and
- current sensing means connected in the first series circuit and coupled to the charging transistor so as to maintain it off when current flows in the first series circuit.

10. A circuit according to claim 9 wherein the electronic switch is a thyristor.

11. A multi-load single power source arrangement in which each load is to be energized independently and with minimum interference from the others, said arrangement comprising:

- a relatively low quality power source;
- a bias voltage source; and
- a plurality of load circuits each of which comprises:

- a solenoid;
- a capacitor;
- a charging transistor having emitter, base and collector electrodes and an emitter-collector path extending between the emitter and collector electrodes;
- a first series circuit connected across the capacitor and comprising the solenoid and an electronic switch;
- a second series circuit connected across the capacitor and comprising the power supply and the emitter-collector path of the charging transistor, the emitter electrode of the charging transistor being connected adjacent to the capacitor; and

transistor control means for turning the charging transistor off when the voltage on the capacitor reaches a predetermined value comprising connection means connecting the base electrode of the charging transistor to the bias voltage source.

12. An arrangement according to claim 11 wherein the bias voltage source is adjustable.

13. An arrangement according to claim 11, wherein each connection means includes a respective charge control transistor arranged as an emitter follower.

14. An arrangement according to claim 11, wherein each connection means includes respective voltage adjusting means for adjusting said predetermined value of the voltage on the capacitor independently of the predetermined value of the voltage on the capacitor of any other load circuit.

15. A circuit according to claim 5, including voltage adjusting means for adjusting to a desired value the value of the capacitor voltage at which the charging transistor turns off.

16. A circuit according to claim 9, wherein the emitter electrode of the charging transistor is connected adjacent to the capacitor, a diode is connected in the first series circuit adjacent to the emitter of the charging transistor, and the base of the charging transistor is connected to the first series circuit at a point separated from the capacitor by the diode.

17. A circuit according to claim 9, wherein the emitter electrode of the charging transistor is connected adjacent to the capacitor, and including: a charge control transistor having emitter, base and collector electrodes and arranged as an emitter follower and having its emitter connected to the base of the charging transistor; a first diode connected in the first series circuit adjacent to the emitter of the charging transistor, the base of the charging transistor being connected to the first series circuit at a point separated from the capacitor by the first diode; and a second diode connected in the first series circuit adjacent to the first diode, the base of the charge control transistor being connected to the first series circuit at a point separated from the first diode by the second diode.

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