CONVENTION

605519

AUSTRALIA

Patents Act

APPLICATION FOR A STANDARD PATENT

I/We SECTION 34(4)(a) DIRECTION SEE FOLIO 3

of NAME DIRECTED RCA LICENSING CORPORATION of TWO INDEPENDENCE WAY, PRINCETON, NEW JERSEY 08540, UNITED STATES of AMERICA.

~~UNITED STATES OF AMERICA.~~

hereby apply for the grant of a standard patent for an invention entitled:

A LEVEL SHIFTER FOR A POWER SUPPLY REGULATOR IN A TELEVISION APPARATUS

which is described in the accompanying complete specification.

Details of basic application

Number of basic application: 943,187

Convention country in which basic application was filed: UNITED STATES OF AMERICA

Date of basic application : 18 December 1986

Address for Service:

PHILLIPS ORMONDE & FITZPATRICK
Patent and Trade Mark Attorneys
367 Collins Street
Melbourne 3000 AUSTRALIA

LODGED AT SUB-OFFICE 20 NOV 1987 Melbourne

Dated: 18 November 1987

PHILLIPS ORMONDE & FITZPATRICK
Attorneys for:
RCA Corporation

By: David B Fitzpatrick

Our Ref : 75814
POF Code: 1447/1447

FEE STAMP TO VALUE OF $235 ATTACHED
MAIL OFFICER

PATENT OFFICE 100 ONE HUNDRED DOLLARS — PATENT OFFICE 100 ONE HUNDRED DOLLARS — PATENT OFFICE 20 TWENTY DOLLARS — PATENT OFFICE 10 TEN DOLLARS — PATENT OFFICE 5 FIVE DOLLARS

APPLICATION ACCEPTED AND AMENDMENTS ALLOWED 17-10-90

6012q/1

Form 8

Australia
RCA 83957
(Docket Number)

COMMONWEALTH OF AUSTRALIA
PATENTS ACT 1952-69

Regulation 12(2)

DECLARATION IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT

In support of a Convention Application made for a Patent for invention entitled:

A LEVEL SHIFTER FOR A POWER SUPPLY REGULATOR IN A TELEVISION APPARATUS
(Title of Invention)

I, Glenn H. Bruestle do solemnly and sincerely declare as follows: —

1. I am authorized by RCA CORPORATION of 201 Washington Road, Princeton, New Jersey 08540 United States of America, the applicant for the patent, to make this declaration on its behalf.

2. The basic application(~~s~~) as defined by section 141 of the Act was/~~were~~ made in The United States of America (Name of Priority Country) on December 18, 1986 (Date Filed)
by Jack Craft, Michael Louie Low and Bernard Joseph Yorkanis
(Full Name(s) of Inventor(s), or RCA CORPORATION if First Filed in Great Britain)

in ______ (Name of Second Priority Country) on ______ (Date Filed)
by ______
(Full Name(s) of Applicant(s) Inventor(s) or RCA CORPORATION)

3. (1) Jack Craft; 25 Ventura Drive, Bridgewater, New Jersey, United States of America
(Full Name and Address of First Inventor)

(2) Michael Louie Low, 86 Diamond Lane, Old Bridge, New Jersey, United States of America
(Full Name and Address of Second Inventor)

(3) Bernard Joseph Yorkanis, 217 Thomas Street, South Plainfield, New Jersey, United States of America
(Full Name and Address of Third Inventor)

(4) ______
(Full Name and Address of Fourth Inventor)

~~is~~/are the actual inventor(s) of the invention and the facts upon which RCA CORPORATION is entitled to make the application are as follows: The said RCA CORPORATION is the assignee of the said inventor(s) named in Paragraph 3 of this declaration in respect of said invention.

4. The basic Application(~~s~~) referred to in Paragraph 2 of this declaration was/~~were~~ the first application(~~s~~) made in a Convention country in respect of the invention the subject of the application.

Declared at Princeton, New Jersey, United States of America, this 10 (Date) day of Nov. (Month), 19 87 (Year).

[signature]

Glenn H. Bruestle, Director
Consumer Electronics
Patent Planning and Administration

To:
The Commissioner of Patents
Commonwealth of Australia

(No Attestation of any Kind Needed)

DES:df
Pat. 3363 2|87

RCA CORPORATION
Patent Operations
CN 5312
Princeton, New Jersey 08540-0028
U.S.A.

(12) **PATENT ABRIDGMENT** (11) Document No. **AU-B-81429/87**
(19) **AUSTRALIAN PATENT OFFICE** (10) Acceptance No. **605519**

(54) Title
A LEVEL SHIFTER FOR A POWER SUPPLY REGULATOR IN A TELEVISION APPARATUS

International Patent Classification(s)
(51)[4] **H04N 005/63**

(21) Application No. : **81429/87** (22) Application Date : **20.11.87**

(30) Priority Data

(31) Number **943187** (32) Date **18.12.86** (33) Country **US UNITED STATES OF AMERICA**

(43) Publication Date : **23.06.88**

(44) Publication Date of Accepted Application : **17.01.91**

(71) Applicant(s)
RCA LICENSING CORPORATION

(72) Inventor(s)
JACK CRAFT; MICHAEL LOUIE LOW; BERNARD JOSEPH YORKANIS

(74) Attorney or Agent
PHILLIPS ORMONDE & FITZPATRICK, 367 Collins Street, MELBOURNE VIC 3000

(56) Prior Art Documents
AU 533475 65363/80 H04N3/16, 3/18
AU 488188 83634/75 H03K 17/30, H04N 3/18
AU 466294 45481/72 H04N 3/18

(57) Claim

1. A power supply that includes a level shifter that controls an output voltage of said power supply, comprising:

a source of supply voltage;

a controllable conductive element coupled to said supply voltage for generating therefrom said output voltage;

means, including a comparator, coupled to said conductive element for varying, in accordance with an output signal of said comparator, the conduction of said conductive element to control said output voltage;

a current mirror arrangement including a first transistor and responsive to a current in a first circuit branch for generating a current in a first main current conducting electrode of said first transistor that is the current mirror of said current in said first circuit branch, said first main current conducting electrode being

.../2

coupled at a junction terminal to a second circuit branch for conducting at least a portion of a current in said second circuit branch;

a source of said input voltage coupled to said first transistor for varying said current in said first main current conducting electrode to produce a current that varies in accordance with said input voltage and that is related to a difference between said current in said first main current conducting electrode and said current in said second circuit branch;

a first resistance coupled to said junction terminal for conducting said difference related current to develop a voltage thereacross that varies in accordance with said input voltage; and

a source of temperature compensated first voltage coupled via said first resistance to said junction terminal such that said voltage across said resistance is combined with said first voltage for developing a temperature compensated second voltage at said junction terminal that varies in accordance with said input voltage and that is level shifted in accordance with said first voltage, said temperature compensated, level shifted, second voltage being coupled to an input of said comparator for varying said output signal of said comparator in accordance therewith to control said output voltage.

AUSTRALIA

Patents Act

605519

COMPLETE SPECIFICATION
(ORIGINAL)

	Class	Int. Class
Application Number:		
Lodged:		

Complete Specification Lodged:
Accepted:
Published:

This document contains the amendments made under Section 49 and is correct for printing

Priority

Related Art:

APPLICANT'S REFERENCE: 83957

Name(s) of Applicant(s):
RCA Licensing Corporation

Address(es) of Applicant(s):
Two Independence Way ~~201 Washington Road~~,
Princeton,
New Jersey,
UNITED STATES OF AMERICA.

Address for Service is:

PHILLIPS ORMONDE & FITZPATRICK
Patent and Trade Mark Attorneys
367 Collins Street
Melbourne 3000 AUSTRALIA

Complete Specification for the invention entitled:

A LEVEL SHIFTER FOR A POWER SUPPLY REGULATOR IN A TELEVISION APPARATUS

Our Ref : 75814
POF Code: 1447/1447

The following statement is a full description of this invention, including the best method of performing it known to applicant(s):

A LEVEL SHIFTER FOR A POWER SUPPLY REGULATOR IN A TELEVISION APPARATUS

The invention relates to an amplifier arrangement that combines an input signal with a reference signal to produce an output signal that is level shifted relative to that of the input signal. In particular, the invention relates to a level shifter used in an input stage of a power supply regulator of a television apparatus.

In a power supply arrangement of, for example, a television receiver, a voltage representative of a DC, regulated supply voltage B+ is coupled to, for example, an inverting input terminal of a B+ voltage regulator. A reference voltage is coupled to, for example, a noninverting input terminal of the regulator. The feed-back voltage that is representative, for example, of regulated supply voltage B+ is compared, in the input stage, with the reference voltage to generate an output voltage that is coupled to a controllable arrangement. The controllable arrangement regulates voltage B+ at a level that is determined by the reference voltage. Voltage B+ may be used, for example, to energize a deflection circuit output stage for a cathode ray tube (CRT).

In one prior art circuit, a voltage representative of, for example, a level of the beam current in the CRT is summed with the reference voltage, such that the sum of both, instead of the reference voltage alone, is applied to the noninverting input terminal of the input stage. A variation of the beam current representative voltage varies voltage B+ so as to maintain constant the raster width in the CRT when the beam current changes.

The summation of the constant reference voltage and the variable beam current representative voltage is done, in such prior art circuit, by coupling the beam current representative voltage via a zener diode to the noninverting input terminal. The zener diode develops between its anode and cathode electrodes the reference voltage. Thus, the reference voltage that level shifts the beam current representative voltage is series coupled with the beam current representative voltage.

A disadvantage of such zener diode level shifting is that a change in the zener voltage due to temperature, aging or an inherent noise in the zener diode, causes the level to change.

It may be desirable to sum the beam current representative voltage with a reference voltage to generate a sum voltage that is applied to the noninverting input terminal of the input stage without using such zener diode.

In an embodiment of the invention, the reference voltage preferably is produced by a voltage source of, for example, the well known bandgap type. The beam current representative voltage may be summed with, or level shifted by, the reference voltage that is produced by the bandgap type source. Advantageously, the bandgap type source is less susceptible than the zener diode to temperature changes, component aging or noise.

In a circuit embodying an aspect of the invention, an input signal, such as a beam current representative voltage, may be coupled in series with an emitter electrode of a first transistor that operates as a common base amplifier. A second transistor, operating as a current source, and having its collector coupled to the collector of the first transistor, may supply the collector current of the first transistor. A current mirror arrangement, that includes the first transistor, may cause the collector current in the first transistor to be equal to that supplied by the collector current of the second transistor, when the input signal is at a predetermined magnitude such as zero. A first voltage, such as produced by a bandgap type source, may be coupled via a resistor to a junction terminal between the collectors of the first and second transistors. The collector currents of the first and second transistors may produce a difference current that develops a voltage across the resistor that is summed with the first voltage to produce a second signal that is developed at the junction terminal. The second signal may be at a magnitude that is determined by the first voltage and not by the collector currents in any of the first and second transistors, when the magnitude of the input signal is predetermined such as zero. When the magnitude of the input signal is different from the predetermined magnitude, the second signal may be different from the first voltage by an amount that is proportional to the magnitude of the input signal.

According to one aspect of the present invention there is provided a power supply that includes a level shifter that controls an output voltage of said power supply, comprising:

a source of supply voltage;

a controllable conductive element coupled to said supply voltage for generating therefrom said output voltage;

means, including a comparator, coupled to said conductive element for varying, in accordance with an output signal of said comparator, the conduction of said conductive element to control said output voltage;

a current mirror arrangement including a first transistor and responsive to a current in a first circuit branch for generating a current in a first main current conducting electrode of said first transistor that is the current mirror of said current in said first circuit branch, said first main current conducting electrode being coupled at a junction terminal to a second circuit branch for conducting at least a portion of a current in said second circuit branch;

a source of said input voltage coupled to said first transistor for varying said current in said first main current conducting electrode to produce a current that varies in accordance with said input voltage and that is related to a difference between said current in said first main current conducting electrode and said current in said second circuit branch;

a first resistance coupled to said junction terminal for conducting said difference related current to develop a voltage thereacross that varies in accordance with said input voltage; and

a source of temperature compensated first voltage coupled via said first resistance to said junction terminal such that said voltage across said resistance is combined with said first voltage for developing a temperature compensated second voltage at said junction terminal that varies in accordance with said input voltage and that is level shifted in accordance with said first voltage, said temperature compensated, level shifted, second voltage being coupled to an input of said comparator for varying said output signal of said comparator in accordance therewith to control said output voltage.

According to a further aspect of the present invention there is provided a power supply that includes a level shifter that level shifts an input voltage that controls an output voltage of said power supply, comprising:

a source of supply voltage;

a controllable conductive element coupled to said supply voltage for generating therefrom said output voltage;

means, including a comparator, coupled to said conductive element for varying, in accordance with an output signal of said comparator, the conduction of said conductive element to control said output voltage;

a first circuit branch;

means coupled to said first circuit branch for controlling a current that flows therein;

a transistor for passing a current in a first main current conducting electrode of said transistor that is in accordance with said current in said first circuit branch, said first main current conducting electrode being coupled at a junction terminal to said first circuit branch for conducting at least a portion of said current in said first circuit branch such that a ratio between said current in said first main current conducting electrode and said current in said first circuit branch remains unchanged over a wide range of temperatures;

a source of said input voltage coupled in series with a second main current conducting electrode of said transistor for varying said current in said first main current conducting electrode to produce a current that varies in accordance with said input voltage and that is related to a difference between said current in said first main current conducting electrode and said current in said second circuit branch;

a first resistance coupled to said junction terminal for conducting said difference related current to develop a voltage thereacross that varies in accordance with said input voltage; and

a source of temperature compensated first voltage coupled via said first resistance to said junction terminal such that said voltage across said resistance is combined with said first voltage for developing a temperature compensated second voltage at said junction terminal that varies in accordance with said input voltage and that is level shifted in accordance with said first voltage, said temperature compensated, level shifted, second voltage being coupled to an input of said comparator for varying said output signal of said comparator in accordance therewith to control said output voltage.

~~According to a still further aspect of the present~~ invention there is provided an amplifier comprising:

first and second transistors that are coupled to form a differential amplifier;

an input stage coupled at a first junction terminal to a control electrode of said second transistor for establishing a voltage level at said control electrode of said second transistor in accordance with a voltage that is developed at an input terminal of said input stage such that an output current flowing in said input stage is coupled to said first junction terminal;

a source of a first current;

a third transistor having a current gain ~~characteristic that is representative of a current gain~~

characteristic of said second transistor; and

a current mirror arrangement coupled to said third transistor and responsive to said first current and to a control electrode current of said third transistor for generating at an output terminal of said current mirror arrangement a second current that is coupled to said first junction terminal, said second current having a first portion derived from said first current that generates said output current of said input stage and a second portion derived from said control electrode current of said third transistor that generates said control electrode current of said second transistor, wherein a deviation of said current gain characteristic of said second transistor from a nominal value thereof that produces a corresponding deviation in said control electrode current of said second transistor is compensated by said control electrode current of said third transistor so as to substantially prevent such current deviation from affecting said output current of said input stage.

A preferred embodiment of the present invention will now be described with reference to the accompanying drawings wherein:

~~resistance to the junction terminal such that the voltage~~ across the resistance is combined with the first voltage for developing a temperature compensated second voltage at the junction terminal. The second voltage varies in accordance with the input voltage. The second voltage is level shifted in accordance with the first voltage. The temperature compensated, level shifted, second voltage is coupled to an input of the comparator for varying the output signal of the comparator to control the output supply voltage.

~~In the Drawing:~~

FIGURE 1 illustrates a simplified schematic diagram of a power supply regulator circuit that includes a level shifter, embodying an aspect of the invention;

FIGURE 2 illustrates a detailed schematic diagram of the level shifter of FIGURE 1; and

FIGURES 3, 4, 5 and 6 illustrate level shifters embodying different aspects of the invention, respectively.

FIGURE 1 illustrates a simplified schematic diagram of a power supply of a television receiver, not shown in the FIGURES, that includes a regulator 100 that is an integrated circuit that regulates a supply voltage B+. Voltage B+ may be used, for example, to energize a horizontal deflection circuit or output stage 99 of the television receiver.

A voltage V+, representative of voltage B+, is obtained from output stage 99. Voltage V+ is coupled to a voltage divider 605 that includes series coupled resistors 601, 604 and 602. Resistor 604 includes a wiper k for developing at wiper k a voltage that is representative of, for example, voltage B+. The voltage at wiper k, that is adjustable by varying the position of wiper k, is coupled to an inverting input terminal 608 of an error amplifier 610 via a resistor 607.

A small voltage that is proportional to the beam current in the CRT of the receiver is coupled from a tertiary winding of transformer T to a terminal 611 to form a voltage V_{NINI} that is indicative of the beam current.

Voltage V_{NINI} that varies when a variation of the beam current occurs, is coupled via a level shifter 600, embodying an aspect of the invention, to a noninverting input terminal 609 of error amplifier 610 to produce an input voltage V_{NIN}. Level shifter 600 establishes a fixed offset voltage between terminals 611 and 609 that is determined by a voltage V_{BG}. Voltage V_{BG} is generated in a bandgap type voltage source 699. Bandgap type voltage source 699 advantageously maintains voltage V_{BG} constant such that voltage V_{BG} is affected significantly less by component aging or tolerance than would have occurred had a zener diode been used. As explained later on the feed back arrangement of regulator 100 causes voltage B+ to be such that voltage V_{IN} becomes equal to voltage V_{NIN}.

An integrating filter 612 is coupled between inverting input terminal 608 and an output terminal 618 of amplifier 610 to provide the loop filter of regulator 100. A filtered error voltage V_0, developed at terminal 618 is coupled to a first input terminal of an adder 613. A horizontal rate sawtooth generator 98 develops a horizontal rate signal, having an upramping portion, which is added to error voltage V_0 in adder 613. The sum signal that is also upramping, is applied to an inverting input terminal (614) of a comparator 615 functioning as a pulse width modulator.

When, during its upramping portion, the output of adder 613 becomes more positive than a constant DC voltage V_{REF}, that is coupled to a noninverting input terminal of comparator 615, a negative going transition at an output terminal 615a of comparator 615 is coupled via a buffer amplifier 616 to a control terminal 617a of a switch 617b of a switch mode power supply output stage 617 to turn on switch 617b of output stage 617.

An input terminal 617c of output stage 617 is coupled to unregulated voltage V_{UR}. Regulated voltage B+

is developed at an output terminal 617d of output stage 617.

The duration, during each horizontal period, H, in which switch 617b conducts is determined by the level of error voltage V_0 of error amplifier 610. Thus, regulated voltage B+ is determined by voltage V_{NIN}. As indicated before, voltage V_{NIN} is produced by level shifter 600, embodying an aspect of the invention, that is described now in detail.

FIGURE 2 illustrates a schematic diagram of level shifter 600 of FIGURE 1 and of error amplifier 610. Similar numbers in FIGURES 1 and 2 represent similar items or functions. Level shifter 600 of FIGURE 2 is temperature compensated over a wide range of ambient operating temperatures, such as between 0°C and 70°C, to produce voltage V_{NIN} that is substantially unaffected by a change in the temperature within such range.

A temperature compensated current control arrangement 650 generates a control voltage V_{BR} on a rail signal line 900. Rail signal line 900 is coupled to the base electrode of each of transistors Q142, Q725, Q727, Q736 and Q737. The emitter electrodes of the above-mentioned transistors are coupled through corresponding resistors to a fixed DC voltage V_{CC}. Current control arrangement 650 controls voltage V_{BR} in such a way that the collector current in each of the above-mentioned transistor stays substantially constant when the temperature changes. An example of an arrangement that is similar to current control arrangement 650 is described in detail in U.S. Patent No. 3,886,435, in the name of S. A. Steckler, entitled VBE VOLTAGE SOURCE TEMPERATURE COMPENSATION NETWORK.

Level shifter 600 includes transistors Q736 and Q737. The emitter currents in transistors Q736 and Q737 are controlled by resistors R728 and R69, respectively, having the same value, so as to cause the respective collector currents of transistors Q736 and Q737, that are temperature compensated, to be equal. The collector of transistor Q737 is coupled to a current mirror arrangement that includes transistors Q733, Q734 and Q735. The collector of transistor Q737 is coupled to the collector of transistor Q734. The emitter of transistor Q735 is coupled to each of the bases of transistors Q733 and Q734. Transistor Q735 provides the base current drive to each of transistors Q733 and Q734. The emitter of transistor Q734 is coupled to ground via a resistor R732. The P-N junction of transistor Q734 between the base and emitter electrodes of transistor Q734, provides temperature compensation that compensates for a temperature related variation of the base-emitter voltage of transistor Q733. The emitter of transistor Q733 is coupled through resistor R731 to terminal 611, where voltage V_{NINI} of FIGURE 1 is developed. The value of resistor R731 is equal to that of resistor R732. Voltage V_{NINI} is prevented from exceeding predetermined limits in either polarity by a diode network 675. The collector of transistor Q733 is coupled to the collector of transistor Q736 at a junction terminal 733A.

Assume that voltage V_{NINI} is zero. In this case, the current mirror arrangement of transistors Q733, Q734 and Q735, produces a collector current i_{Q733} in transistor Q733 that is equal to the collector current i_{Q734} in transistor Q734 because the base current of transistor Q735 is negligible. As explained before, when voltage V_{NINI} is zero, collector current i_{Q736} in transistor Q736 is equal to collector current i_{Q737} in transistor Q737 over a wide temperature range. Also, when voltage V_{NINI} is zero, each of collector current i_{Q733} that is the current mirror of current i_{Q734} is equal to current i_{Q737} over such wide temperature range. It follows that current i_{Q733} is also equal to current i_{Q736}.

Bandgap type voltage source 699 supplies temperature compensated reference voltage V_{BG} that is coupled via a resistor R729 to terminal 733A. Because, as described before, when voltage V_{NINI} is zero, current i_{Q733} is supplied entirely by current i_{Q736}, and because the impedance at terminal 733A, that is contributed by the collectors of transistors Q733 and Q736 is high, a current i_{R729} in resistor R729 is zero; therefore, voltage V_{NIN} at terminal 733A is equal to voltage v_{BG}. Thus, in accordance with an aspect of the invention, when voltage V_{NINI} is zero, voltage V_{NIN} is level shifted by an amount that is equal to voltage V_{BG}.

When voltage V_{NINI} at terminal 611 is different from zero, currents i_{Q736} and i_{Q737} will not be equal. The difference current between currents i_{Q733} and i_{Q736} will cause a voltage to develop across resistor R729 that, in turn, will cause a corresponding change in voltage V_{NIN} at terminal 733A. Because transistor Q733 is coupled, relative to voltage V_{NINI}, as a common base amplifier, and because resistors R731 and R729 are, illustratively, equal, the gain, or the ratio between voltage V_{NIN} and voltage V_{NINI}, is one, resulting in an amplifier having a unity gain.

In carrying out another aspect of the invention, voltage V_{NIN}, that is level shifted relative to voltage V_{NINI} by an amount that is equal to voltage V_{BG}, follows variations of voltage V_{NINI} that occur in a range between positive and negative values.

Voltage V_{BG} is temperature compensated and has a tolerance range that is narrow relative to, for example, a zener diode. Furthermore, component aging affects voltage V_{BG} substantially less than it affects, for example, the breakdown voltage of a zener diode. Moreover, the level shifting caused by level shifter 600 is, advantageously, less susceptible to temperature, aging and noise when compared with that produced by a corresponding level shifter in the prior art that utilizes a zener diode interposed between a beam current input terminal and a noninverting input terminal of a differential amplifier to perform such level shifting.

Should a temperature change cause a corresponding change in current i_{Q736}, for example, that, as indicated before, would be relatively small, transistors Q737, Q733, Q734 and Q735 will cause a proportional change in current

i_{Q733} to occur that will prevent even such small change in temperature from affecting the difference current between currents i_{Q736} and i_{Q733}. Therefore, when voltage V_{NINI} is zero, voltage V_{NIN} is, advantageously, not affected by collector currents i_{Q736} and i_{Q737}, but is entirely determined by voltage V_{BG} that is temperature compensated.

It should be understood that temperature compensation may be adequate even when voltage V_{NINI} is significantly different from zero. If temperature compensation, in this case, is inadequate, a further improvement in temperature compensation may be obtained by coupling the terminal of, for example, resistor R732, that, in FIGURE 2 is grounded, to a voltage that is different from zero and that is related to, for example, voltage V_{NINI}.

Advantageously, voltage V_{BG}, as explained before, is maintained at tight tolerances, is temperature compensated and is substantially unaffected by components aging. Therefore, advantageously, no factory temperature burn-in process is required prior to the installment of regulator 100 of FIGURE 1 in the television receiver. Furthermore, voltage divider 605 that includes resistors 601, 604 and 602 is required to compensate, advantageously, only for a narrower tolerance range than in prior art circuits in which a zener diode is used for performing the level shifting function of level shifter 600 of FIGURE 2.

Voltage V_{IN} is coupled to the base of a transistor Q721. The clamping operation of a pair of transistors Q145 and Q146 prevents voltage V_{IN} from being above voltage V_{BG} or from being below voltage V_{BG} by more than a predetermined magnitude. Voltage V_{IN} is coupled to inverting input terminal 608 and voltage V_{NIN} is coupled to noninverting input terminal 609 of error amplifier 610. Amplifier 610 includes a current source formed by a transistor Q142 that provides the combined emitter currents of a transistor Q148 and of a transistor Q149, coupled as a differential amplifier. The bases of transistors Q148 and Q149 are coupled to the emitters of transistors Q721 and

Q723 respectively. Transistors Q721 and Q723 operate as emitter followers to couple voltages V_{IN} and V_{NIN} to the bases of transistors Q148 and Q149, respectively.

A current mirror arrangement 610b that is coupled to the collectors of transistors Q148 and Q149 causes a current i_{610}, coupled to integrating filter 612 of FIGURE 1, to be equal to the difference between the collector currents in transistors Q148 and Q153. Consequently, current i_{610} that is coupled to filter 612 of FIGURE 1, is proportional to the difference between voltages V_{IN} and V_{NIN}. The proportionality factor is determined by the gain of error amplifier 610.

FIGURES 3, 4, 5 and 6 illustrate level shifters 600a, 600b, 600c and 600d, respectively, embodying other aspects of the invention, respectively. In FIGURES 2-6, numbers and symbols of similar items or functions are similar except that they include the letters a, b, c and d, in FIGURES 3, 4, 5 and 6, respectively.

In FIGURE 3, resistors R731 and R732, that are used in the circuit of FIGURE 2, were eliminated. Without resistors R731 and R732, the gain of amplifier 600a of FIGURE 3 is, advantageously, higher than unity.

In FIGURE 3, a diode D_{cma} and a temperature compensated current source I_{1a} cause the collector currents in transistors Q737a and Q736a to be, for example, equal. Similarly, transistor Q734a causes the collector current in transistor Q733a to be, for example, equal to that in each of transistors Q737a and Q736a when voltage V_{NINI} is zero.

In FIGURE 4, voltage V_{NINIb} is applied differentially between the emitters of transistors Q733b and Q734b. Such arrangement provides, advantageously, an improved common mode rejection.

In FIGURE 5 the type, N-P-N or P-N-P, of the corresponding transistors is opposite than that in FIGURE 2 so that voltage V_{NINIc} may, if desired, be referenced to voltage V_{CC}, instead of to ground.

In FIGURE 6, the input impedance to voltage V_{NINId} is, advantageously, higher than to voltage V_{NINI} of

FIGURE 2 because of the usage of a transistor Q750 that is coupled as an emitter follower.

The Claims defining the invention are as follows:

1. A power supply that includes a level shifter that controls an output voltage of said power supply, comprising:

a source of supply voltage;

a controllable conductive element coupled to said supply voltage for generating therefrom said output voltage;

means, including a comparator, coupled to said conductive element for varying, in accordance with an output signal of said comparator, the conduction of said conductive element to control said output voltage;

a current mirror arrangement including a first transistor and responsive to a current in a first circuit branch for generating a current in a first main current conducting electrode of said first transistor that is the current mirror of said current in said first circuit branch, said first main current conducting electrode being coupled at a junction terminal to a second circuit branch for conducting at least a portion of a current in said second circuit branch;

a source of said input voltage coupled to said first transistor for varying said current in said first main current conducting electrode to produce a current that varies in accordance with said input voltage and that is related to a difference between said current in said first main current conducting electrode and said current in said second circuit branch;

a first resistance coupled to said junction terminal for conducting said difference related current to develop a voltage thereacross that varies in accordance with said input voltage; and

a source of temperature compensated first voltage coupled via said first resistance to said junction terminal such that said voltage across said resistance is combined with said first voltage for developing a temperature compensated second voltage at said junction terminal that varies in accordance with said input voltage and that is

LS

level shifted in accordance with said first voltage, said temperature compensated, level shifted, second voltage being coupled to an input of said comparator for varying said output signal of said comparator in accordance therewith to control said output voltage.

2. ~~An~~ A power supply according to Claim 1 wherein said second circuit branch comprises a second transistor having a main current electrode that is coupled to said junction terminal and wherein said first circuit branch comprises a third transistor that generates, in a main current conducting electrode thereof, said current that is coupled to said current mirror arrangement such that said current mirror arrangement generates said current in said first main current conducting electrode of said first transistor at a level that is in accordance with said current in said third transistor.

3. ~~An~~ A power supply according to Claim 2 further comprising a temperature compensated means coupled to corresponding control electrodes of each of said second and third transistors for generating said corresponding currents in said first and second circuit branches that remain substantially unchanged over said wide range of temperatures.

4. ~~An~~ A power supply according to Claim 2 wherein said current mirror arrangement further includes a fourth transistor that is coupled to a control electrode of said first transistor and that is coupled in a path of said current in said third transistor to develop a voltage at said control electrode of said first transistor that causes said current in said first transistor to be the current mirror of said current in said fourth transistor.

5. ~~An~~ A power supply according to Claim 4 wherein said input voltage is coupled between corresponding main current conducting electrodes of each of said first and

fourth transistors for varying, in accordance with said input voltage, said currents in each of said first and fourth transistors.

6. ~~An~~ A power supply according to Claim 2 further comprising a second resistance, wherein said input voltage is coupled to an emitter electrode of said first transistor via said second resistance.

7. ~~An~~ A power supply according to Claim 6 wherein said first transistor forms an amplifier having a gain that is determined by a ratio between said second and first resistances.

8. ~~An~~ A power supply according to Claim 6 wherein said second resistance has a value substantially less than said first resistance such that said gain is higher than unity.

9. ~~An~~ A power supply according to Claim 6 further comprising a fourth transistor responsive to said input voltage and coupled as an emitter follower such that an emitter electrode of said fourth transistor is coupled to said emitter electrode of said first transistor.

10. ~~An~~ A power supply according to Claim 2 wherein an impedance that is formed at said junction terminal by said first and second transistors is substantially higher than said first resistance.

11. ~~An~~ A power supply according to Claim 1 wherein said source of said first voltage comprises a bandgap type voltage source.

12. ~~An~~ A power supply according to Claim 1 wherein said current mirror arrangement maintains a ratio between said current in said first main current conducting

electrode and said current in said second circuit branch unchanged over a wide range of temperatures.

13. A power supply according to Claim 1 wherein said first voltage is developed at a first terminal of said first resistance and said second voltage is developed at a second terminal of said first resistance remote from said first terminal and wherein said second voltage comprises an algebraic sum of said first voltage and said voltage across said first resistance.

14. A power supply according to Claim 1 wherein a feedback voltage representative of said output voltage is coupled in a negative feedback manner to an input said comparator for regulating said output voltage.

15. A power supply according to Claim 14 further comprising a deflection circuit coupled to said output voltage for energization thereof, wherein said feedback voltage is representative of said B+ energizing voltage.

16. A power supply according to Claim 15 wherein said temperature compensated, level shifted, second voltage is coupled to a noninverting input terminal of said comparator and said feedback voltage that is representative of said B+ energizing voltage is coupled to an inverting input terminal thereof.

17. A power supply according to Claim 15 or 16 wherein said input voltage is representative of cathode ray tube beam current loading.

18. A power supply that includes a level shifter that level shifts an input voltage that controls an output voltage of said power supply, comprising:

a source of supply voltage;

a controllable conductive element coupled to said supply voltage for generating therefrom said output voltage;

means, including a comparator, coupled to said conductive element for varying, in accordance with an output signal of said comparator, the conduction of said conductive element to control said output voltage;

a first circuit branch;

means coupled to said first circuit branch for controlling a current that flows therein;

a transistor for passing a current in a first main current conducting electrode of said transistor that is in accordance with said current in said first circuit branch, said first main current conducting electrode being coupled at a junction terminal to said first circuit branch for conducting at least a portion of said current in said first circuit branch such that a ratio between said current in said first main current conducting electrode and said current in said first circuit branch remains unchanged over a wide range of temperatures;

a source of said input voltage coupled in series with a second main current conducting electrode of said transistor for varying said current in said first main current conducting electrode to produce a current that varies in accordance with said input voltage and that is related to a difference between said current in said first main current conducting electrode and said current in said second circuit branch;

a first resistance coupled to said junction terminal for conducting said difference related current to develop a voltage thereacross that varies in accordance with said input voltage; and

a source of temperature compensated first voltage coupled via said first resistance to said junction terminal such that said voltage across said resistance is combined with said first voltage for developing a temperature compensated second voltage at said junction terminal that varies in accordance with said input voltage and that is level shited in accordance with said first voltage, said temperature compensated, level shifted, second voltage being coupled to an input of said comparator for varying said output signal of said comparator in accordance therewith to control said output voltage.

LS

19. A power supply that includes a level shifter that controls an output voltage of said power supply substantially as herein described with reference to the accompanying drawings.

DATED: 10 October 1990

PHILLIPS ORMONDE & FITZPATRICK
Attorneys for:
RCA LICENSING CORPORATION

David B Fitzpatrick

PATENT OFFICE

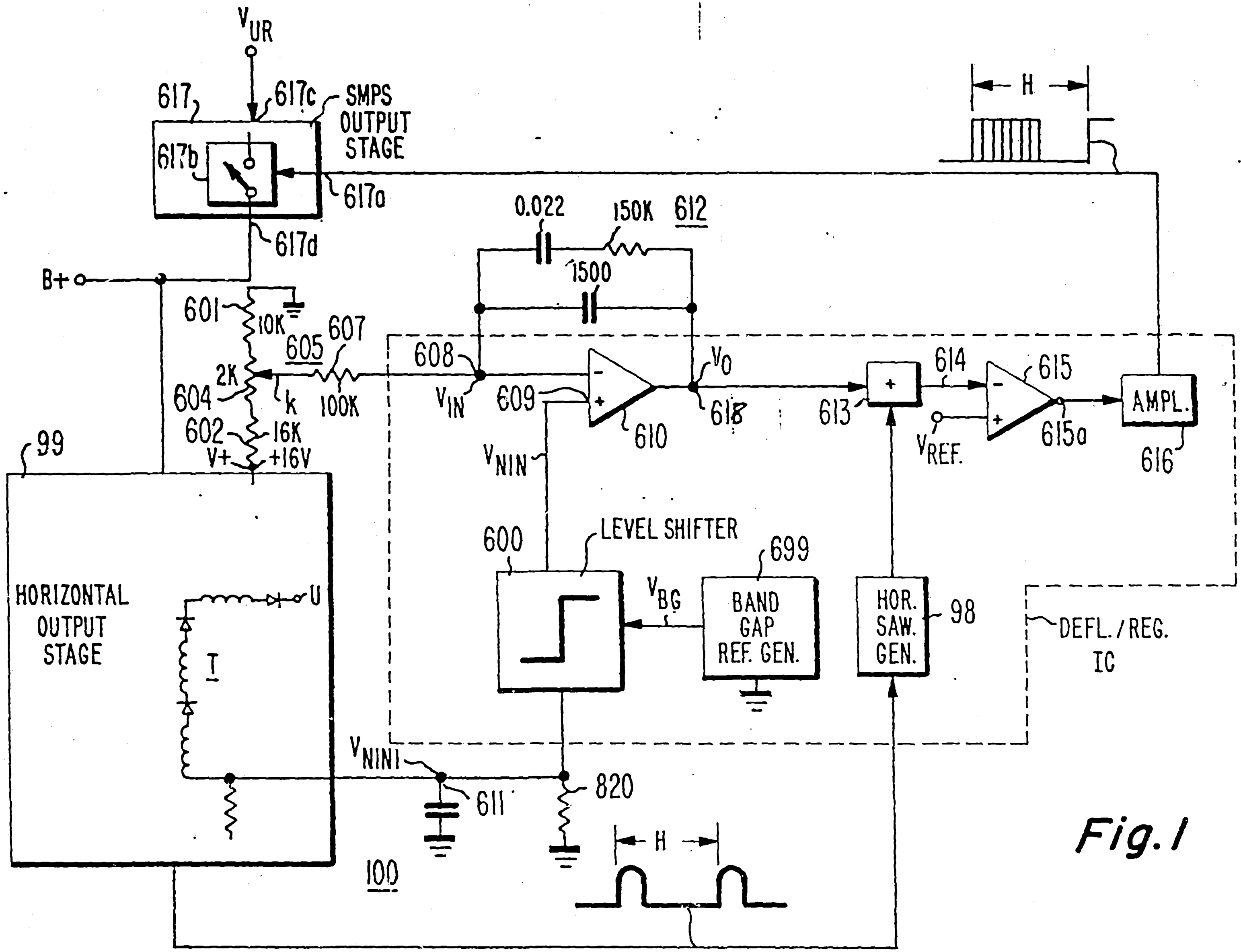
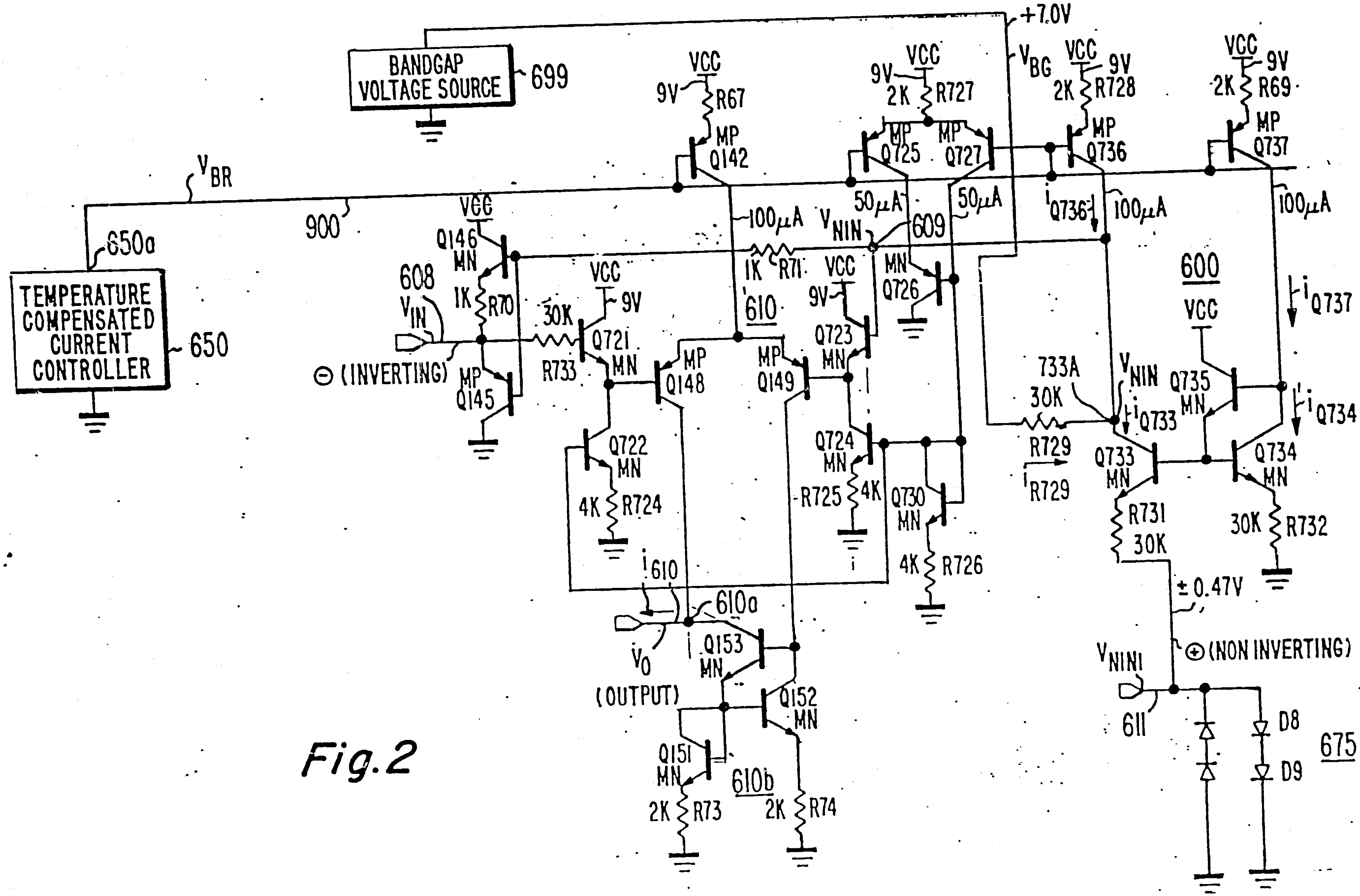


Fig. 1

J. CRAFT ET AL.
1 OF 4

81 429/87


BANDGAP VOLTAGE SOURCE
699
+7.0V
V_{BG}
V_{BR}
900
TEMPERATURE COMPENSATED CURRENT CONTROLLER
650
650a
VCC
9V
R67
MP
Q142
R727
2K
Q725
Q727
R728
Q736
R69
Q737
Q146
MN
608
V_{IN}
1K
R70
⊖ (INVERTING)
Q145
30K
R733
Q721
100μA
1K
R71
V_{NIN}
609
50μA
Q726
610
Q723
Q148
Q149
Q722
4K
R724
Q724
R725
Q730
R726
i_{Q736}
i_{Q737}
600
733A
Q735
R729
i_{R729}
i_{Q733}
i_{Q734}
Q733
Q734
R731
R732
±0.47V
⊕ (NON INVERTING)
V_{NIN1}
611
D8
D9
675
i_{610}
610a
V_0
(OUTPUT)
Q153
Q152
Q151
610b
2K
R73
R74
Fig.2

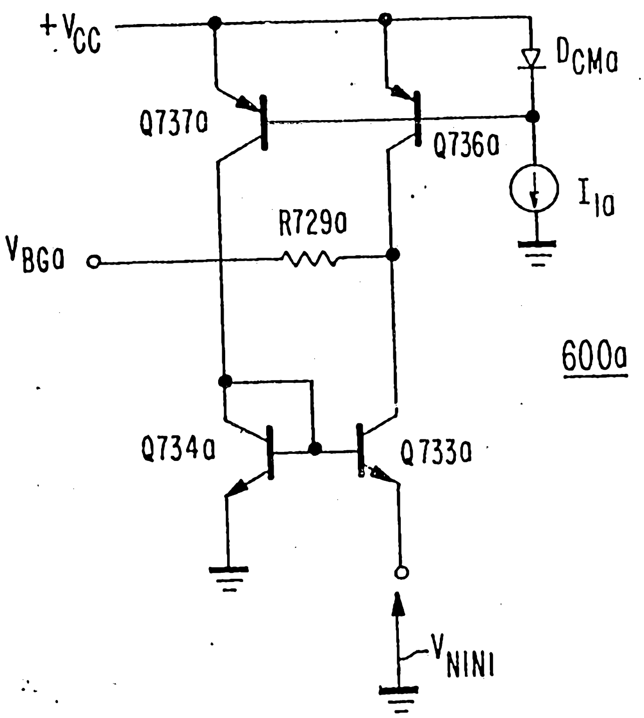

+VCC
DCMa
Q737a
Q736a
I1a
R729a
VBGa
600a
Q734a
Q733a
VNIN1

Fig.3

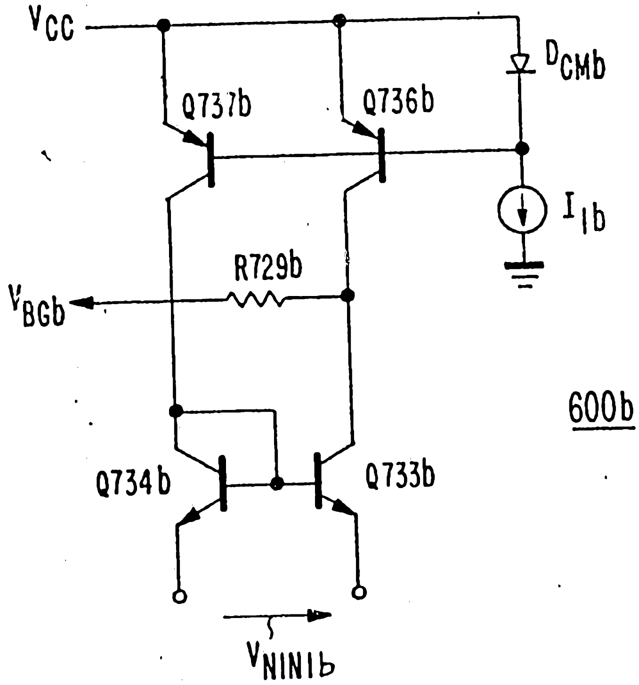

VCC
DCMb
Q737b
Q736b
I1b
R729b
VBGb
600b
Q734b
Q733b
VNIN1b

Fig.4

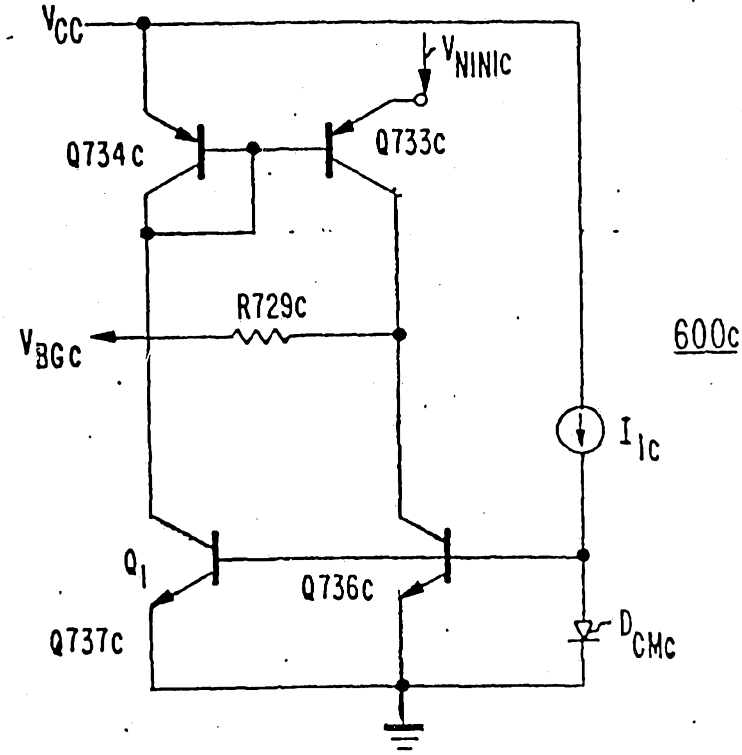

VCC
VNINIC
Q734c
Q733c
R729c
VBGc
600c
I1c
Q1
Q736c
Q737c
DCMc

Fig. 5

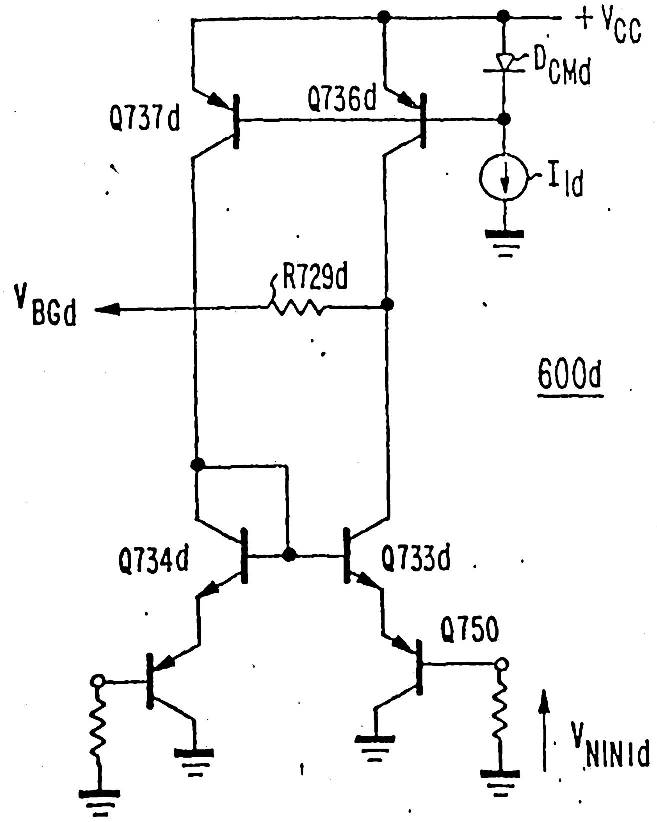

+VCC
DCMd
Q737d
Q736d
I1d
R729d
VBGd
600d
Q734d
Q733d
Q750
VNINId

Fig. 6