

PATENT SPECIFICATION

DRAWINGS ATTACHED

L100.728

L100.728



Date of Application and filing Complete Specification: Feb. 15, 1965.

No. 6473/65.

Application made in United States of America (No. 346321) on Feb. 20, 1964.

Complete Specification Published: Jan. 24, 1968.

© Crown Copyright 1968.

Index at acceptance: —H3 P(1A1, 1M4, 1M5A1, 1S, 2T, 3B1A, 3B2A, 3B2B, 3E, 3M, 4T2)

Int. Cl.: —H 03 k 3/62

COMPLETE SPECIFICATION

Deflection Circuit Arrangement for a Television Receiver

We, RADIO CORPORATION OF AMERICA, a corporation organized under the laws of the state of Delaware, United States of America, of 30 Rockefeller Plaza, City and State of New York, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to a circuit arrangement having an electron discharge device for providing deflection of an electron beam in the cathode ray tube of a television receiver, and the invention seeks to improve circuit arrangements of this type.

A form of deflection circuit arrangement for use in a vertical deflection stage of a television receiver employs a single, multi-electrode, electron discharge amplifying device which functions both as a waveform generator and as an output amplifier. A deflection winding is transformer coupled to the device and the circuit is adapted to oscillate and generate a current of sawtooth waveform in the winding. Circuit means are coupled to electrodes of the device for causing the circuit to oscillate at a desired frequency. The circuit means include means for generating a voltage in accordance with a current (i_1) flowing to a first electrode which is spaced intermediate the anode and cathode electrodes of the device, and for applying this voltage to a second intermediate electrode. For example, in a form of this circuit arrangement utilizing a pentode, a negative-going voltage is generated at the screen electrode during a trace interval of a deflection cycle and is coupled to a suppressor electrode. A decreasing voltage at the suppressor reduces anode current and initiates the generation of a retrace segment of the sawtooth current waveform.

The current (i_1) flowing to the first intermediate electrode has a generally sawtooth waveform which includes trace and retrace segments. The voltage at the second intermediate electrode varies continuously during the trace interval in accordance with the trace segment of the current (i_1). In some electron discharge devices, as for example the pentode, greater power output and a corresponding greater deflection capability is realized when the second intermediate electrode is maintained at an established direct current potential. Although the voltage at the second intermediate electrode of the single tube deflection circuit varies during the retrace interval, it is advantageous, for purposes of circuit efficiency as indicated, to maintain the voltage at this electrode at a relatively more uniform and more positive value during the trace interval than has heretofore been provided.

Television receivers generally include adjustable circuit means in the vertical deflection stage for varying the rate of vertical deflection. For viewer convenience and in order to avoid multiple adjustments to the raster, it is desirable to vary the frequency of deflection without substantially interfering with other characteristics of the raster such as height and vertical linearity. In a deflection circuit having a single electron discharge device, it is relatively difficult to attain this result in view of the small degree of isolation which can be provided between elements in this circuit arrangement.

Operation of a single tube deflection circuit is improved when the voltage which is coupled to the second intermediate electrode is of relatively large amplitude. During the retrace interval, anode current is caused to decrease sharply and the inductance in the anode circuit causes anode voltage to increase rapidly to a relatively large value.

[Price 4s. 6d.]

SPECIFICATION AMENDED - SEE ATTACHED SLIP



5 The large voltage amplitude at the second intermediate electrode is desirable for turning off the anode current during the retrace interval. Concurrent circuit operating requirements often restrict the voltage amplitude variation which can be provided at the first intermediate electrode and in some instances this amplitude is insufficient for providing desired control of the anode current under the influence of the increased anode voltage.

10 An alternative known circuit arrangement utilizes an electron discharge device having a second intermediate electrode with a relatively high transconductance. The increased transconductance avoids the need for providing a voltage of a relatively large amplitude at the second intermediate electrode. In providing the increased transconductance, however, the number of turns in the actual physical spiral grid structure of the second electrode is increased and the power handling capability of the device is disadvantageously reduced.

25 This invention accordingly seeks to provide an improved circuit arrangement.

30 In accordance with the present invention, there is provided, in a television receiver, a deflection circuit arrangement comprising: an electron beam deflection winding; an electron discharge device having anode and cathode electrodes, a control grid and first and second electrodes spaced intermediate said anode and cathode; a transformer having a first winding for coupling deflection windings to said anode and cathode electrodes; and a control circuit coupled to electrodes of said device for causing the deflection circuit to oscillate and to generate a current of periodically recurring sawtooth waveform in said deflection winding; said control circuit including means for generating a first voltage having a waveform including a trace segment which varies in accordance with the flow of current to said first intermediate electrode, means including a second winding of said transformer for generating a second varying voltage having a waveform which includes a trace segment of opposite polarity to the trace segment of the first voltage; said second transformer winding being arranged for additively combining and applying said first and second voltages to said second intermediate electrode, there being an adjustable impedance means coupled between said first and second intermediate electrodes for varying the relative amplitudes of the first and second voltages; a feedback circuit via a capacitor being connected between anode and control grid, said control grid being connected via a resistance to a source of direct current operating potential.

65 The circuit may be arranged for providing that the waveform of the second voltage includes a pulse segment occurring during

a retrace interval of the waveform. This segment conveniently has an amplitude and a polarity adapted to control anode current during occurrence of increased anode voltage. Thus, by this circuit arrangement the deflection capability of the circuit may be improved, anode current turn-off enhanced, and a frequency control which can be varied without substantially interfering with raster linearity or height provided.

The invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a diagram, partly in block form, of a one-tube vertical deflection circuit of a television receiver illustrating an embodiment of the present invention; and

Figure 2 is a diagram illustrating various voltage and current waveforms existing at different points in the diagram of Figure 1.

For an explanation of the operation of the vertical deflection circuit arrangement and its use in a television receiver, reference is now made to Figure 1. In simplifying the description, only those stages of a television receiver are illustrated in Figure 1 as are believed necessary for a complete understanding of the invention. A signal voltage having a composite video modulation component is induced in an antenna 10, converted to an intermediate frequency, and amplified. The video modulation component is then detected and amplified. Stages for performing these operations are conventional and are represented by the block 12. The amplified video signal is coupled to a beam-controlling electrode 13, of a picture tube 14 of the television receiver for intensity modulating an electron beam. The composite video signal, which includes synchronizing components, is also coupled to a conventional synchronizing signal separator stage 16. Horizontal and vertical synchronizing voltages are derived from the synchronizing components in this stage and are coupled to a horizontal deflection stage 18 and a vertical deflection stage, indicated generally as 19. The horizontal deflection stage 18 generates a sawtooth current in horizontal deflection coils 20 and 22 causing the electron beam of the picture tube 14 to be electromagnetically deflected.

The vertical deflection stage 19, is of the type employing a single, multi-electrode, electron discharge amplifying device which functions both as a waveform generator and as an output amplifier. While other suitable multi-electrode devices may be utilized, the device 28 of Figure 1 is shown to be a pentode. The device 28 includes anode and cathode electrodes 29 and 30 respectively and first and second electrodes, 31 and 32 respectively which are spaced intermediate the anode and cathode electrodes in the device. The first and second intermediate

illustrating



electrodes 31 and 32 are respectively the screen and suppressor electrodes in the pentode shown. An output transformer 33 is provided for coupling vertical electron beam deflection windings 34 and 35 to the anode electrode 29 and to the cathode electrode 30. The circuit arrangement is adapted to be oscillatory and for causing oscillations, a circuit means comprising an RC discharge circuit including a capacitor 40 and resistors 42 and 44 is provided as well as circuit means coupled between electrodes 31 and 32. These latter circuit means are described more fully hereinafter. The resistors 42 and 44 are adjustable and provide respectively for adjustment of vertical linearity and height of a raster being produced. A resistor 51 serves to limit the amplitude of current flow in a control electrode 52. For improving linearity, the resistor 44 is returned to a boost voltage B++ which is represented by a source 53. Direct current B+ operating potential is provided for the device by a source 54 and is applied to the anode electrode 29 via a winding 56 of the transformer 33 and to the screen electrode 31 by a resistor 58. The suppressor electrode 32 is coupled to ground potential by a resistor 64, a winding 62 of the transformer 33 and a resistor 60. A capacitor 66 is provided for coupling voltage alternations at the screen 31 to the suppressor electrode 32.

Referring now to Figures 1 and 2, the general operation of the vertical deflection circuit arrangement may be explained as follows: during a trace interval, (T_t) of a vertical deflection cycle having a period (T_v), the capacitor 40 which was discharged during a prior retrace interval (T_r) charges through resistors 42 and 44 toward the B-boost voltage. A charging voltage waveform existing at the junction of resistors 42 and 44 is coupled to the control electrode 52 by the resistor 51. This voltage causes anode electrode current (i_a), which flows in the transformer winding 56, to increase parabolically, as illustrated in Figure 2A. As a result, a trace segment 69 of a sawtooth deflection waveform 70, illustrated in Figure 2B, flows in the deflection windings 34 and 35. An electromagnetic field is therefore generated for deflecting the electron beam in a vertical direction across a viewing face of the picture tube 14. The duration of the trace interval is primarily determined by the time constant of the R-C charge circuit. A current (i_s) in the screen electrode varies in a manner similar to the anode current (i_a) and a voltage (e_s) at the screen electrode 31 decreases with a generally parabolic waveform, as indicated in Figure 2C due to the $i_s r$ drop in the screen electrode circuit. As described in more detail hereinafter, circuit means combine the decreasing screen voltage with a second voltage (e_2)

(Figure 2E) and apply a resultant voltage to the suppressor electrode 32. When the voltage at the suppressor electrode becomes negative with respect to the cathode electrode, then electrons are returned to the screen electrode 31. These electrons increase the current (i_s) and cause the voltage (e_s) to become more negative. A regenerative action is initiated whereby the suppressor electrode voltage is rapidly driven further negative and current to the anode 29 is reduced to cutoff.

Because of the inductance including the winding 56 of the transformer 33 and the deflection windings 34 and 35 which are coupled to the anode 29, a large positive voltage pulse 74, illustrated in Figure 2D, is generated at the anode electrode when the anode current is rapidly cut off. The amplitude of the various voltages and currents of Figure 2 are not to scale and Figure 2 illustrates the waveforms and relative timing of the voltages and currents occurring in the circuit. The duration of the pulse 74 is primarily determined by the characteristics of the transformer 33. This pulse causes the control electrode 52 to become positive with respect to the cathode 30 and the capacitor 40 discharges through the resistor 42, the resistor 51, and the control electrode-to-cathode circuit of the device 28. During the discharge period, a negative voltage is developed at the control electrode 52. At the termination of the retrace interval, the capacitor 40 charges through the resistors 42 and 44 and the trace proceeds once again. The vertical deflection cycle then repeats and oscillations are maintained. A vertical synchronizing voltage 75, illustrated in Figure 1, is provided at the output of synchronizing separator stage 16 and is coupled by a capacitor 76 to the suppressor electrode 32. The voltage 75 provides for synchronization of the oscillations in the circuit 19 with other stages of the receiver by causing the suppressor electrode to be driven negative and to initiate retrace.

Circuit means are provided for generating a voltage (e_1) (Figure 2C) which varies in accordance with the current (i_s); for generating a second voltage (e_2) (Figure 2E) having a waveform including a trace segment of somewhat similar configuration but opposite polarity to a trace segment of the voltage (e_1); and for combining and applying these voltages to the suppressor electrode. The waveform of the trace segment of (e_1) and (e_2) are of similar configuration when the amplitude of each segment progresses in a substantially continuous manner from a first value at the beginning of trace to a second differing value at the termination of trace. The waveform of the trace segment of (e_1) and (e_2) need not have the same appearance to be of similar configuration. This is illustrated by the parabolic trace segment 83 of

ital



ital
 5 (e₁), Figure 2C and the linear trace segment 84 of (e₂), Figure 2E. In Figure 1, the transformer 33 is shown to include a winding 62. This winding is positioned in the field of the transformer and a voltage (e₂) Figure 2E having a similar waveform as that of the anode voltage (e_p) is generated across the winding. However, the winding is polarized for generating the voltage (e₂) as shown in Figure 2E which is inverted with respect to the anode voltage (e_p).

10 A conventional by-pass capacitor is eliminated at the screen electrode 31. Thus, the voltage (e₁) at the screen electrode, which is described above, varies in accordance with the screen current (i₁). This voltage (e₁) is applied to the suppressor electrode through the winding 62. Since the voltages (e₁) and (e₂) are applied in series to the suppressor electrode, the voltages add and a composite voltage (e₃) exists at the junction of the resistor 64 and the winding 62. The waveform of the voltage (e₃) and its variation about the cathode voltage E_k is illustrated at Figure 2F. A resultant voltage (e₄) illustrated at Figure 2G is developed at the suppressor electrode.

15 The circuit is adapted for providing that the amplitudes of the trace segments 83 and 84 of the voltages (e₁) and (e₂) do not differ greatly. The resistor 58 and winding 62 are arranged to provide this desired relation. Because the trace segments 83 and 84 are of somewhat similar waveform and of opposite polarity, and their amplitudes do not differ greatly, the sum of the voltages is the voltage (e₃) having a relatively smaller amplitude variation during the trace interval than (e₁) or (e₂). Thus, the voltage at the suppressor electrode is maintained relatively more uniform during the trace interval and more positive near to the end of this interval and the power efficiency of the device and deflection capability of the circuit is improved over prior arrangements.

20 Vertical retrace is initiated when the voltage at the suppressor electrode becomes negative with respect to the cathode electrode. Since the voltages (e₁) and (e₂) are combined and applied to the suppressor electrode, the time during the cycle at which retrace is initiated is a function of the relative amplitudes of the voltages (e₁) and (e₂). By controlling the relative amplitudes of these voltages, the initiation of retrace and thus the frequency of oscillation can be regulated. In Figure 1, an adjustable impedance comprising the adjustable resistor 60 is provided for controlling the frequency of oscillation. The resistor 60 is a component of a voltage divider formed with D.C. blocking capacitor 66. By varying the resistance of the resistor 60, the amplitude of the voltage (e₁) is regulated and consequently the fre-

quency of oscillation is controlled. Since this circuit arrangement for controlling frequency is coupled between the first and second intermediate electrodes, substantial isolation exists between the frequency control and the linearity and height controls. The frequency of vertical oscillation can therefore be varied without substantially affecting the linearity and height of the raster.

25 In addition to attenuating the voltage (e₁), the voltage divider comprising resistor 60 and capacitor 66 functions as a differentiating circuit to remove the parabolic component in the trace segment of the voltage (e₁). The differentiated waveform which exists across the resistor 60 is illustrated in Figure 2H. The voltage (e₁) includes a relatively low frequency component represented by the parabolic segment 83 and a relatively high frequency component represented by the relatively steep positive-going step segment occurring during the retrace interval. The time constant of resistor 60 and capacitance 66 is adapted for differentiating the trace segment of the waveform of (e₁) and causing the low frequency component to be altered while the high frequency component remains substantially unaffected. It is advantageous to differentiate the trace segment while leaving the high frequency component substantially unaffected since variations in the later component can affect the pulse component 74 of the voltage (e_p) (Figure 2D) at the anode and hence the linearity of deflection.

30 During the retrace interval, a pulse 77 of relatively large negative amplitude is generated across the winding 62 and forms a segment of the waveform of the voltage (e₂) (Figure 2E). This pulse, which occurs coincidentally in time with the pulse 74 of the voltage (e_p) (Figure 2D) at the anode electrode, is applied to the suppressor electrode 32. The pulse 77 therefore provides for maintaining the anode current cutoff when the device 28 is under the influence of an increased anode voltage due to the pulse 74.

35 Figure 2G illustrates the resultant waveform which exists at the suppressor electrode 32. During the retrace interval (T_r), a negative pulse component 78, occurs, as indicated hereinbefore for maintaining anode current cutoff. During an early portion of the trace interval (T_t), the circuit is recovering from this pulse 78 while the voltages (e₁) and (e₂) are combined and a resultant ramp segment 79 occurs at the suppressor. After the circuit recovers, the voltages (e₁) and (e₂) determine the voltage applied to the suppressor. When the sum of these voltages, i.e., (e₃) exceeds the cathode voltage (E_k), the suppressor is clamped at the cathode voltage. At a time when (e₃) becomes negative with respect to the cathode,

regeneration is initiated and the retrace interval is repeated.

Thus, an improved one tube deflection circuit arrangement has been described for increasing circuit efficiency and deflection capability; for providing a frequency control which can be varied substantially, independently of raster linearity and height; and which maintains a decreasing anode current under the influence of increased anode voltage during retrace.

While it will be understood that the value of circuit components of the one-tube generator may vary in order to fit individual requirements, the following circuit parameters have been found to provide satisfactory operation and are included herein only by way of example, as follows:

Electron discharge device 28—Type RCA—17JQ6

Transformer 33—Type $\frac{1}{2}$ " stack vertical output; autotransformer winding; winding 56 having approximately 2,600 turns; winding 62 having approximately 1,300 turns

Vertical deflection windings 34 and 35: Toroidal winding, resistance approximately 27 ohm.

Resistors—42—100 K ohm adjustable
44—5 meg. ohm adjustable
51—27 K ohm
58—3.3 K ohm
60—1 meg. ohm adjustable
64—47 K ohm

Capacitors—40—0.0047 μ f
66—0.01 μ f

B+ voltage 54—270 volts D.C.

B—boost voltage 53—600 volts D.C.

Frequency of operation—60 cps.

WHAT WE CLAIM IS:—

1. In a television receiver, a deflection circuit arrangement comprising: an electron beam deflection winding; an electron discharge device having anode and cathode electrodes, a control grid and first and second electrodes spaced intermediate said anode and cathode; a transformer having a first winding for coupling said deflection windings to said anode and cathode electrodes; and a control circuit coupled to electrodes of said device for causing the deflection circuit to oscillate and to generate a current of periodically recurring sawtooth waveform in said deflection winding, said control circuit including means for generating a first voltage having a waveform including a trace segment which varies in accordance with the flow of current to said first intermediate electrode, means including a second winding of said transformer for generating a second varying voltage having a waveform which includes a trace segment of opposite polarity to the trace segment of the first voltage; said second transformer winding being arranged for addi-

tively combining and applying said first and second voltages to said second intermediate electrode, there being an adjustable impedance means coupled between said first and second intermediate electrodes for varying the relative amplitudes of the first and second voltages; a feedback circuit via a capacitor being connected between anode and control grid, said control grid being connected via a resistance to a source of direct current operating potential.

2. A deflection circuit arrangement according to Claim 1, wherein said control circuit includes a resistive impedance connected between a source of direct current operating potential and said first intermediate electrode, said second transformer winding being polarized with respect to said first transformer winding so that the second voltage generated thereby is inverted relative to the anode voltage, there being means coupling said second transformer winding between said resistive impedance and said second intermediate electrode.

3. A deflection circuit arrangement according to Claim 2, wherein said electron discharge device is an evacuated pentode tube, said second transformer winding has first and second terminals, a connection couples said first terminal of said second transformer winding to said second intermediate electrode, means couple said second terminal of said second transformer winding to said resistive impedance, and said first and second intermediate electrodes respectively comprise the screen and suppressor electrodes of said pentode tube.

4. A deflection circuit arrangement according to Claim 2, wherein said electron discharge device is an evacuated pentode tube, said second transformer winding has first and second terminals, means couple said first terminal of said second transformer winding to said second intermediate electrode, and means couple said second terminal of said second transformer winding to said resistive impedance, said adjustable impedance means being adapted for differentiating a voltage generated between said first intermediate electrode and cathode.

5. A deflection circuit arrangement according to Claim 3 or Claim 4, wherein said last-mentioned means includes an adjustable impedance adapted for varying the frequency of oscillation.

6. A deflection circuit arrangement according to Claim 2, wherein said deflection winding is a vertical deflection winding adjacent to a cathode ray device of the receiver and is adapted to deflect an electron beam in said device when a sawtooth current flows in said winding; said discharge device is a pentode electron discharge device having anode, cathode, control, screen and suppressor electrodes; said screen and suppressor elec-



regeneration is initiated and the retrace interval is repeated.

Thus, an improved one tube deflection circuit arrangement has been described for increasing circuit efficiency and deflection capability; for providing a frequency control which can be varied substantially, independently of raster linearity and height; and which maintains a decreasing anode current under the influence of increased anode voltage during retrace.

While it will be understood that the value of circuit components of the one-tube generator may vary in order to fit individual requirements, the following circuit parameters have been found to provide satisfactory operation and are included herein only by way of example, as follows:

Electron discharge device 28—Type RCA—17JQ6

Transformer 33—Type $\frac{1}{4}$ " stack vertical output; autotransformer winding; winding 56 having approximately 2,600 turns; winding 62 having approximately 1,300 turns

Vertical deflection windings 34 and 35: Toroidal winding, resistance approximately 27 ohm.

Resistors—42—100 K ohm adjustable
44—5 meg. ohm adjustable
51—27 K ohm
58—3.3 K ohm
60—1 meg. ohm adjustable
64—47 K ohm

Capacitors—40—0.0047 μ f
66—0.01 μ f

B+ voltage 54—270 volts D.C.

B—boost voltage 53—600 volts D.C.

Frequency of operation—60 cps.

WHAT WE CLAIM IS:—

1. In a television receiver, a deflection circuit arrangement comprising: an electron beam deflection winding; an electron discharge device having anode and cathode electrodes, a control grid and first and second electrodes spaced intermediate said anode and cathode; a transformer having a first winding for coupling said deflection windings to said anode and cathode electrodes; and a control circuit coupled to electrodes of said device for causing the deflection circuit to oscillate and to generate a current of periodically recurring sawtooth waveform in said deflection winding, said control circuit including means for generating a first voltage having a waveform including a trace segment which varies in accordance with the flow of current to said first intermediate electrode, means including a second winding of said transformer for generating a second varying voltage having a waveform which includes a trace segment of opposite polarity to the trace segment of the first voltage; said second transformer winding being arranged for addi-

tively combining and applying said first and second voltages to said second intermediate electrode, there being an adjustable impedance means coupled between said first and second intermediate electrodes for varying the relative amplitudes of the first and second voltages; a feedback circuit via a capacitor being connected between anode and control grid, said control grid being connected via a resistance to a source of direct current operating potential.

2. A deflection circuit arrangement according to Claim 1, wherein said control circuit includes a resistive impedance connected between a source of direct current operating potential and said first intermediate electrode, said second transformer winding being polarized with respect to said first transformer winding so that the second voltage generated thereby is inverted relative to the anode voltage, there being means coupling said second transformer winding between said resistive impedance and said second intermediate electrode.

3. A deflection circuit arrangement according to Claim 2, wherein said electron discharge device is an evacuated pentode tube, said second transformer winding has first and second terminals, a connection couples said first terminal of said second transformer winding to said second intermediate electrode, means couple said second terminal of said second transformer winding to said resistive impedance, and said first and second intermediate electrodes respectively comprise the screen and suppressor electrodes of said pentode tube.

4. A deflection circuit arrangement according to Claim 2, wherein said electron discharge device is an evacuated pentode tube, said second transformer winding has first and second terminals, means couple said first terminal of said second transformer winding to said second intermediate electrode, and means couple said second terminal of said second transformer winding to said resistive impedance, said adjustable impedance means being adapted for differentiating a voltage generated between said first intermediate electrode and cathode.

5. A deflection circuit arrangement according to Claim 3 or Claim 4, wherein said last-mentioned means includes an adjustable impedance adapted for varying the frequency of oscillation.

6. A deflection circuit arrangement according to Claim 2, wherein said deflection winding is a vertical deflection winding adjacent to a cathode ray device of the receiver and is adapted to deflect an electron beam in said device when a sawtooth current flows in said winding; said discharge device is a pentode electron discharge device having anode, cathode, control, screen and suppressor electrodes; said screen and suppressor elec-

- trodes respectively being the first and second intermediate electrodes, a source of direct current operating potential is provided for said device; said control circuit includes a
- 5 discharge circuit coupled between the anode and the control electrode of said device and adapted to establish a period of a trace interval of said sawtooth waveform; a first
- 10 resistive impedance is connected between said source of operating potential and said screen electrode; said second transformer winding has first and second output terminals and being polarized with respect to said
- 15 first winding so that the second voltage generated thereby is inverted relative to the anode voltage; means direct couple a first terminal of said second winding current to said suppressor electrode; an adjustable resistive impedance is connected between said
- 20 source of operating potential and said second terminal of said second transformer winding; and a capacitor is coupled between said first resistive impedance and said adjustable resistive impedance.
- 25 7. In a television receiver, a deflection circuit arrangement constructed and adapted to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

A. M. & WM. CLARK,
Chartered Patent Agents,
5, Stone Buildings,
Lincoln's Inn,
London, W.C.2.

NR

Leamington Spa: Printed for Her Majesty's Stationery Office by the Courier Press.—1968.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.



* C L M S *