Aug. 16, 1966 A. I. DRANETZ 3,267,355

MULTI-RANGE CONSTANT CURRENT SOURCE

Filed Dec. 10, 1963 2 Sheets-Sheet 1

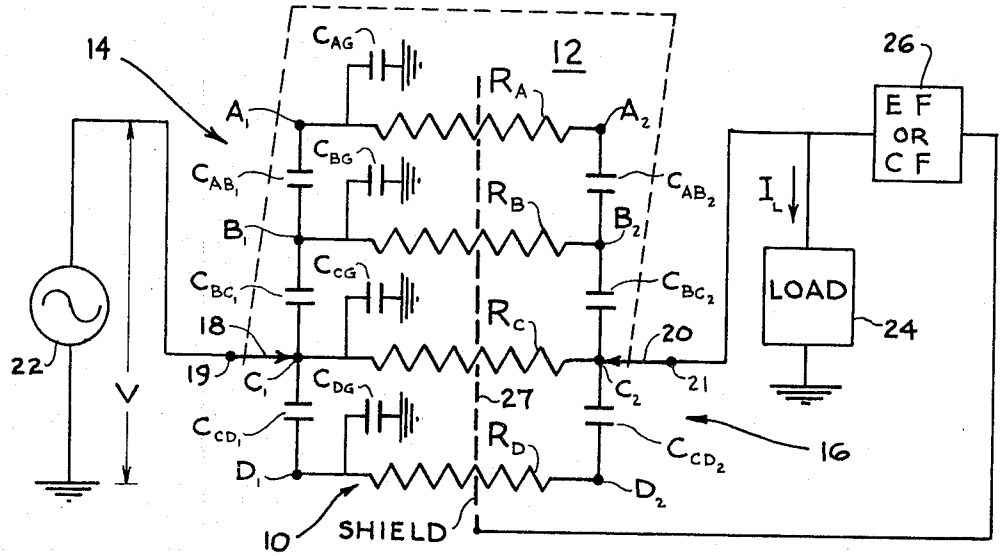


Fig. 2

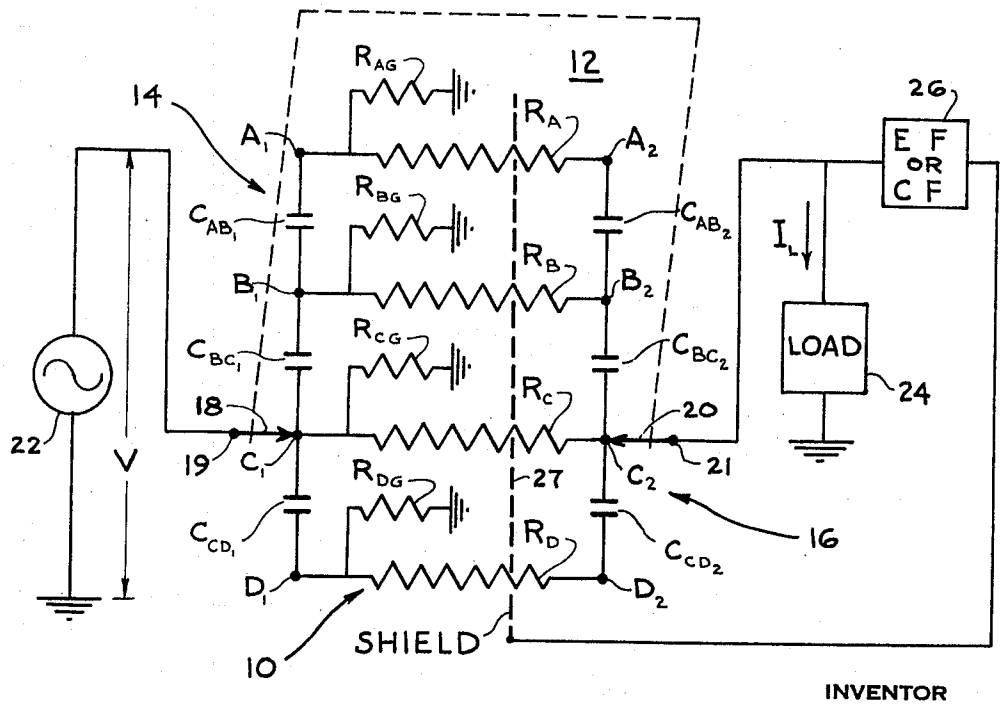


Fig. 1

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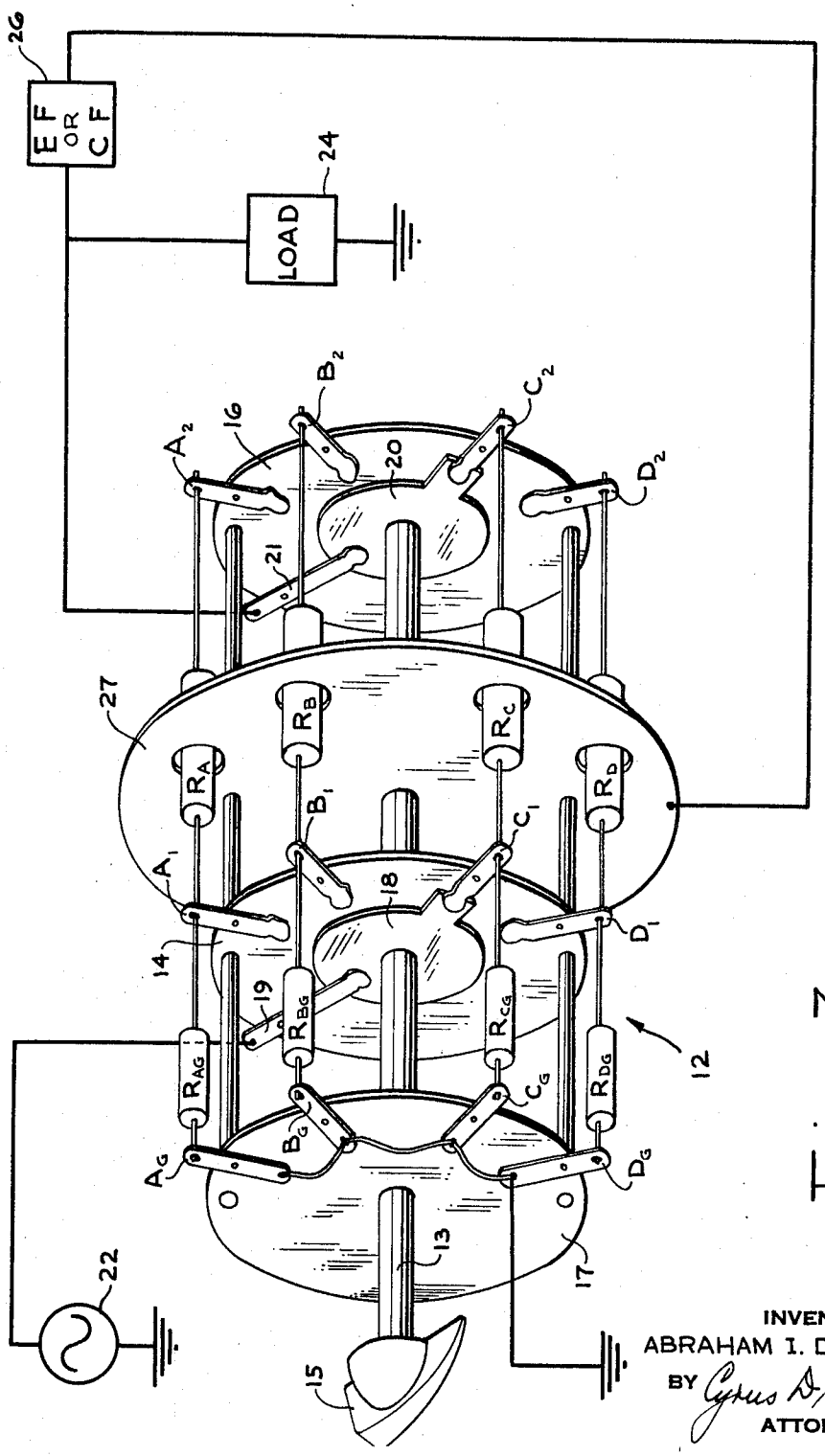


Fig. 3

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3,267,355

MULTI-RANGE CONSTANT CURRENT SOURCE

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The invention relates to multi-range constant current sources and in particular to those multi-range constant current sources wherein the effects due to interterminal and other stray capacities of the switching system are minimized.

Multi-range constant current sources are employed to deliver a substantially constant current through a load impedance for a given fixed input voltage. This current is substantially independent of the frequency of the input signal and is dependent only on the value of resistance of the constant current resistors. It is also desirable that the current through the load be in phase with the voltage at the source of the input signal. The current through the load remains substantially constant and in phase with the voltage at the source if the constant current resistor has a value at least ten times the impedance of the load regardless of the voltage fed from the source or of changes in the impedance of the load.

At low frequencies these multi-range constant current devices will operate quite satisfactorily but at higher frequencies the interterminal and other stray capacities introduce a quadrature components of current which affects the total amplitude and phase of the current through the load impedance.

It is an important object of the invention to provide a multi-range constant current source wherein the effects due to interterminal and other stray capacities of the switching system are minimized by connecting an impedance between each of one set of terminals and ground such that the unselected switch terminals are brought to substantially ground potential.

It is a further object of the invention to provide such a device wherein the grounding impedances are substantially resistive.

It is a still further object of the invention to provide such a device wherein the grounding impedances are substantially capacitive.

It is a still further object of the invention to provide such a device wherein a shield is located between the input and output decks of the switch, the input of a low output impedance device having a gain of substantially one is connected to the output deck and the shield is connected to the output of the low output impedance device.

It is a still further object of the invention to provide such a multi-range constant current device wherein a shield is located between the input and output decks of the switch and is connected to ground.

These and other objects, features, uses and advantages will be apparent during the course of the following discussion when taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a schematic diagram of a multi-range constant current source in which the grounding impedances are substantially resistive;

FIGURE 2 is a schematic diagram of a multi-range constant current source in which the grounding impedances are substantially capacitive; and

FIGURE 3 is a view, partially in perspective and partially schematic, of a typical switching system for use with the circuits of either FIGURE 1 or FIGURE 2.

In the drawings, wherein, for the purpose of illustration, are shown embodiments of the invention and wherein like numerals are employed to designate like parts throughout the same, the numeral **10** designates the multi-range constant current source generally. The reference to ground throughout this application is to one side of the signal source and does not necessarily refer to earth ground.

Multi-range constant current source **10** is utilized to produce a constant current in load impedance **24** and is seen to comprise (FIGURE 1) two deck ganged switch **12**, having decks **14** and **16** and ganged movable wiper arms **18** and **20**, constant current resistors R_A, R_B, R_C, and R_D and source of alternating voltage **22**. Shield **27** is employed to eliminate electrostatic coupling across the constant current resistors and is located between the switch decks **14** and **16**. Shield **27** is connected either to the output of low output impedance means **26** or to ground. Low output impedance means **26** may be either a cathode follower or an emitter follower having substantially unity gain (say .99) and whose circuits are well-known in the art.

If desired, more than the four switch positions illustrated in the figures may be used in multi-range constant current sources of the invention. The terminals on the first or input switch deck **14** have been designated A_1, B_1, C_1, and D_1 and the terminals on the second or output switch deck **16** have been designated A_2, B_2, C_2 and D_2. The effect of the interterminal and other stray capacities on deck **14** are represented as C_{AB_1}, C_{BC_1} and C_{CD_1} and the effect of the interterminal and other stray capacities on deck **16** are represented as C_{AB_2}, C_{BC_2} and C_{CD_2}.

At high frequencies, a significant current flows through capacitances C_{AB_1} etc. and C_{AB_2} etc. and a phase shift and amplitude error are introduced in the load current I_L. To reduce the effect of these interterminal and stray capacities, resistors R_{AG}, R_{BG}, R_{CG} and R_{DG} are respectively connected between the terminals A_1, B_1, C_1, D_1 and ground. These resistors are of low enough resistance so that each of the terminals A_1 etc. is brought to substantially ground potential when the input voltage is not connected to that particular terminal. These resistors must be of sufficiently high value so that the source **22** is not overloaded.

During operation, at a particular frequency, the switch is rotated so as to select a constant current resistor whose impedance is much greater than the impedance of the load **24** and the output voltage of the source of alternating voltage **22** is adjusted to obtain the desired constant load current I_L.

When the value of the constant current resistor is at least ten times the impedance of the load, the current is constant within 10% of the selected value regardless of variations in load impedance; when the resistor is at least 50 times the impedance of the load, the current is constant within 2% of the selected value; when the resistor is at least 100 times the impedance of the load, the current is constant within 1% of the selected value; and so on.

By way of example but without limitation of the scope of the invention, following are illustrations of typical values of parameters for carrying out the teachings of the invention:

Maximum Load Impedance, ohms	Constant Current Resistor, ohms	Grounding Resistor, ohms
10	1,000	8,200
25	2,500	8,200
50	5,000	8,200
100	10,000	8,200
500	50,000	8,200
1,000	100,000	8,200
5,000	500,000	8,200
10,000	1,000,000	8,200
50,000	5,000,000	8,200

At 150 kc. using a 1,000,000 ohm constant current resistor and an 8,200 ohm grounding resistor, the phase shift error is maintained at less than 2° and the amplitude error is less than ½%.

In FIGURE 3 there is illustrated an embodiment of a multi-terminal two deck switch for carrying out the invention of FIGURE 1. Shaft **13** is rotated by means of knob **15** and is used to gang the rotation of movable wiper arms **18** and **20** so each wiper arm selectively contacts a terminal on the switch deck associated with the wiper arm. Terminals A_G, B_G, C_G and D_G on deck **17** are tied together and grounded as shown in the figure. The ground sides of resistors R_{AG}, R_{BG}, R_{CG} and R_{DG} are respectively connected to terminals A_G, B_G, C_G and D_G. Connection is made to the output of alternating voltage source **22** by means of terminal **19** which is mounted on deck **14** and always makes contact with movable wiper arm **18**. Similarly, connection is made from the individual constant current resistor to load impedance **24** and the input of cathode follower or emitter follower **26** by means of terminal **21** which is mounted on deck **16** and always makes contact with movable wiper arm **20**. As shown in the figure, shield **27** is connected to the output of low output impedance means **26**. If desired, low output impedance means **26** may be dispensed with and shield **27** may be grounded.

In FIGURE 2 there is illustrated a modification of the invention wherein grounding capacitors C_{AG}, C_{BG}, C_{CG} and C_{DG} are used to replace the grounding resistors R_{AG}, R_{BG}, R_{CG} and R_{DG} of FIGURE 1. In order to utilize these grounding capacitors effectively each must have a value of capacitance at least 10 times that of the individual interterminal and stray capacitances so that the grounding impedance is much less than the impedance due to the interterminal and stray capacitances. This brings the unselected terminals on deck 14 to substantially ground potential.

The operation of the embodiment of FIGURE 2 and the improvements obtained therefrom are substantially the same as those of FIGURE 1. The embodiment of FIGURE 3 may be used to carry out the teachings of the embodiment of FIGURE 2 by substituting the grounding capacitors of FIGURE 2 for the grounding resistors of FIGURE 1.

It is also within the contemplation of the invention to use both grounding resistors and grounding capacitors in a single multi-range constant current source of the invention.

While particular embodiments of the invention have been shown and described, it is apparent to those skilled in the art that modifications are possible without departing from the spirit of the invention or the scope of the subjoined claims.

What is claimed is:

1. A multi-range constant current source comprising:

(A) a source of alternating voltage;

(B) a load impedance;

(C) a plurality of constant current resistors of such value that at least one of them has a value at least ten times that of the load impedance;

(D) a first switch deck having a plurality of terminals and a movable wiper arm for selectively making connection to each of said plurality of terminals;

(E) a second switch deck having a plurality of terminals and a movable wiper arm for selectively making connection to each of said plurality of terminals;

(F) each of said plurality of constant current resistors being connected between a terminal on the first switch deck and a terminal on the second switch deck;

(G) a plurality of impedances;

(H) each of said plurality of impedances being connected between one of the terminals of the first switch deck and ground;

(I) the load impedance being connected between the movable wiper arm of the second switch deck and ground;

(J) the source of alternating voltage being connected to the movable wiper arm of the first switch deck;

(K) means for selectively moving the movable wiper arm of the first switch deck such that one of the plurality of constant current resistors is connected to the source of alternating voltage;

(L) means for selectively moving the movable wiper arm of the second switch deck such that the constant current resistor selected by the movable wiper arm of the first switch deck is connected to the load impedance;

(M) the values of the plurality of impedances being such that the unselected terminals to which they are connected are at substantially ground potential.

2. A multi-range constant current source as described in claim **1** and including a shield placed between the first switch deck and the second switch deck, the shield being connected to ground.

3. A multi-range constant current source as described in claim **1** and including:

(A) a shield placed between the first switch deck and the second switch deck;

(B) low output impedance means having a gain of the order of one whose input is connected to the movable wiper arm of the second switch deck;

(C) the shield being connected to the output of the low output impedance means.

4. A multi-range constant current source as described in claim **1** wherein the means for selectively moving the movable wiper arm of the first switch deck and the means for selectively moving the movable wiper arm of the second switch deck are ganged.

5. A multi-range constant current source as described in claim **2** wherein the means for selectively moving the movable wiper arm of the first switch deck and the means for selectively moving the movable wiper arm of the second switch deck are ganged.

6. A multi-range constant current source as described in claim **3** wherein the means for selectively moving the movable wiper arm of the first switch deck and the means for selectively moving the movable wiper arm of the second switch deck are ganged.

7. A multi-range constant current source as described in claim **1** wherein the plurality of impedances are resistors.

8. A multi-range constant current source as described in claim **2** wherein the plurality of impedances are resistors.

9. A multi-range constant current source as described in claim **3** wherein the plurality of impedances are resistors.

10. A multi-range constant current source as described in claim **4** wherein the plurality of impedances are resistors.

11. A multi-range constant current source as described in claim **5** wherein the plurality of impedances are resistors.

12. A multi-range constant current source as described in claim **6** wherein the plurality of impedances are resistors.

13. A multi-range constant current source as described in claim **1** wherein the plurality of impedances are capacitors.

14. A multi-range constant current source as described in claim **2** wherein the plurality of impedances are capacitors.

15. A multi-range constant current source as described in claim **3** wherein the plurality of impedances are capacitors.

16. A multi-range constant current source as described in claim 4 wherein the plurality of impedances are capacitors.

17. A multi-range constant current source as described in claim 5 wherein the plurality of impedances are capacitors.

18. A multi-range constant current source as described in claim 6 wherein the plurality of impedances are capacitors.

No references cited.

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