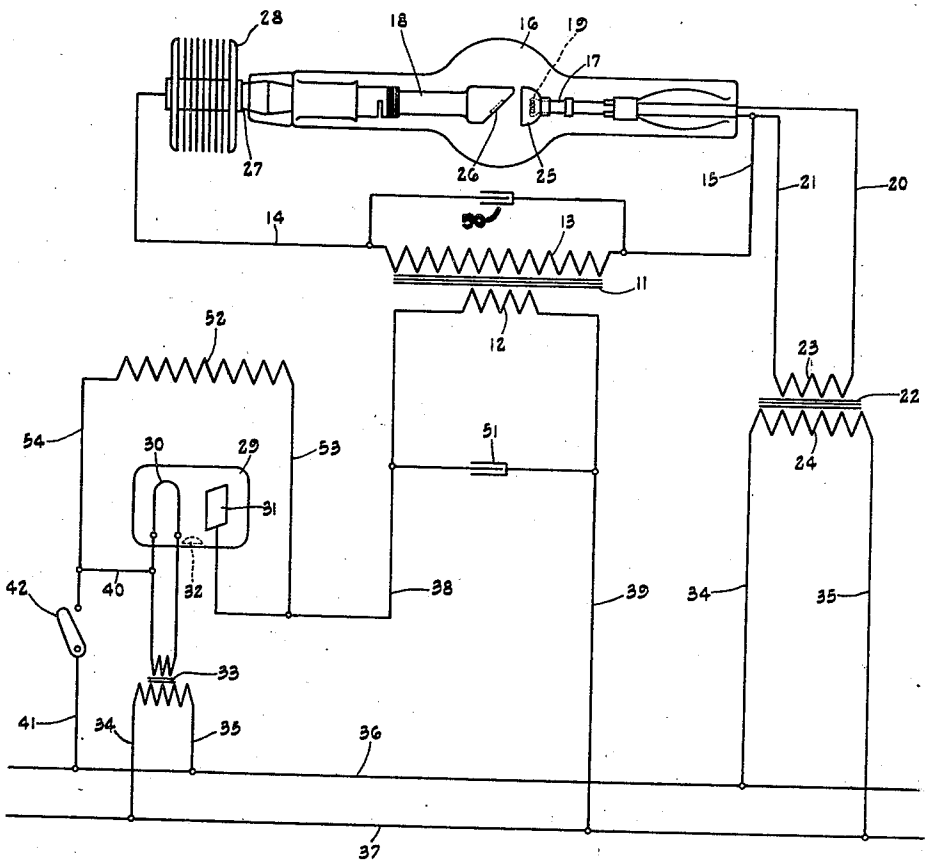
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INVERSE REDUCER CIRCUIT

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INVERSE REDUCER CIRCUIT

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The present invention relates to a circuit for use with a unilaterally conductive device. The circuit illustrating the invention includes an X-ray tube as a load.

Separate rectification of alternating current has been generally abandoned for low energy X-ray tubes. Self rectifying tubes requiring low energy and without separate rectification have been satisfactory to a fair degree. Circuits without separate rectification develop an inverse voltage larger than the useful voltage. This has made it necessary to design such X-ray and other apparatus for voltages in excess of those actually employed. This has limited the expansion of self rectifying devices to larger voltages. It has been usual to make apparatus employing self rectifying X-ray tubes with a margin of safety in insulation and otherwise approximating twenty-five per cent of the normal operating voltage. An X-ray apparatus designed to use sixty kilovolts and of conventional design usually is built to handle with safety at least eighty kilovolts because of the presence of inverse energy. Various devices and circuits have been proposed for overcoming the difficulties incident to the development of such inverse energy. These devices and circuits may be designated as inverse suppressors.

One of the circuits for suppressing inverse is illustrated and described in the patent to William K. Kearsley, Number 1,890,330, issued December 6, 1932, and entitled "Apparatus for and method of operating rectifying load devices." Such Kearsley inverse suppressor operates with all types of transformers. Transformers of given characteristics, however, appear to possess better inverse suppressing capabilities than other transformers when used with the Kearsley circuit. It has been demonstrated by experiment in respect to certain transformers that if a limited proportion of exciting current is supplied to the primary of the transformer during the inverse half-wave, the inverse suppressing characteristics of the circuit are improved. The exciting current supplied during the inverse half-wave may be supplied in a number of different ways.

It may be supplied among others by the introduction of a leakage resistance across the rectifier in series with the primary of the high tension transformer; by a condenser placed in parallel with either the primary or the secondary of the high tension transformer or both, or by such condensers in conjunction with a leakage resistance across the rectifier in series with the primary of the high tension transformer.

The primary object of the present invention, therefore, is to increase the inverse suppressing capacity of a circuit like that shown in the Kearsley patent. Other objects of the invention include a new circuit or circuits having enlarged inverse suppressing values.

These objects, and such other objects as may hereinafter appear, are obtained by the novel arrangement, unique combination, and improved construction of the several elements constituting the circuit illustrated in the accompanying single sheet of drawing in which the figure is a diagrammatic representation of an improved circuit forming the subject matter of the present invention. An X-ray tube is shown in said circuit as a unilaterally conductive load.

Like reference characters are used to designate similar parts in the drawing and in the following description of the new and improved circuit.

The circuit includes a high tension transformer having a magnetic core 11, a primary 12, and a secondary 13. Electrical energy is conducted by conduit 14 from one terminal of the secondary 13 to the anode 18 of an X-ray tube 16. The anode 18 comprises a head having therein a refractory metal target 26 and a stem 27 within the tube 16 for supporting said head. Stem 27 at its external end is surrounded by fins 28 designated generally in the art as a "radiator".

The other terminal of the secondary 13 is electrically connected by conduit 15 to a cathode structure 17. The cathode structure 17 includes a focusing cup 25 and a filament 19 within the focusing cup. The filament 19 is energized by alternating current potential supplied by conduits 21 and 20 connected to opposite ends of a secondary 23 of a step-down transformer having a magnetic core 22. The primary of the step-down transformer is designated 24.

Condenser 50 is connected across the terminals of the secondary 13.

Primary 12 and primary 24 of the high tension transformer and of the filament current transformer, respectively, are energized by current flowing from conduits or lines 36 and 37 in electrical connection with a source of alternating current potential (not shown). Conduits 34 and 35 are electrically connected to the lines 36 and 37 and the latter are connected to opposite terminals of the primary 24 of the step-down transformer.

A conduit 39 extends from the line 37 to one terminal of the primary 12. A conduit 38 extends from the other terminal of said primary 12 to a plate 31 in a valve 29. The valve is of a vacuum type and has a filament 30 within the glass envelope thereof. A predetermined quantity of mercury 32 is sealed within such envelope.

The filament 30 in the valve 29 is energized by current flowing from the secondary of a step-down transformer 33. The primary of the step-down transformer 33 is electrically connected at its opposite terminals through conduits 34 and 35 to the lines 37 and 36, respectively. One of

the legs of the circuit between the secondary of said transformer 33 and the filament 30 has connected thereto a conduit 40 which is in electrical connection with a conduit 41 having therein a manually controlled switch 42. The conduit 41 is in electrical connection with line 36.

A condenser 51 is connected across the conduits 38 and 39. A leakage resistance across the valve 29 in series with the primary 12 of the high tension transformer comprises conduits 53 and 54 having resistance 52 therein.

Alternating current potential is supplied by the lines 35 and 37. Such potential energizes the primary of the filament current transformer to provide filament current in the valve 29 through the step-down transformer 33. The current flowing in lines 36 and 37 also energizes the primary 12 of the high tension transformer. The energization of the primary of said high tension transformer is acquired from alternate half cycles of low tension current because of the valve 29 in circuit therewith.

Other devices may be substituted for those shown. One condenser may be employed, or two, or the resistance leakage employed without or with one or both of the condensers. The circuit may be modified to meet special requirements. Any of such devices or any combination thereof permits of the flow of magnetizing current of predetermined value in the high tension transformer during the inverse half wave.

The following tabulation was made as a result of experiments with an X-ray tube excited by a sixty milliampere current and having a constant inverse voltage of eighty-five kilovolts peak.

Tabulation

Current characteristics	Milli-ampere	Inverse voltage	Useful kilo-volts	Differ-ence
With no inverse suppressor	60	85	60	25
With Kearsley inverse suppressor	60	85	72	13
With Kearsley inverse suppressor and 25 microfarads across primary	60	85	80	5
With Kearsley inverse suppressor and 80 microfarads across primary	60	85	83	2
With Kearsley inverse suppressor and 300 microfarads across primary	60	85	83	2
With Kearsley inverse suppressor and .002 microfarad across secondary	60	85	80	5
With Kearsley inverse suppressor and .004 microfarad across secondary	60	85	83	2
With Kearsley inverse suppressor and 25 ohms resistance across valve	60	85	78	7
With Kearsley inverse suppressor and 50 ohms resistance across valve	60	85	81	4
With Kearsley inverse suppressor and 125 ohms resistance across valve	60	85	83	2
With Kearsley inverse suppressor and 200 ohms resistance across valve	60	85	75	10

The Kearsley circuit, as shown by such experiments, has a definite inverse suppressing quality. This quality is enhanced by the modifications hereinabove described. It is established by the experiments which have been conducted that a certain minimum value of capacity across the primary and another certain minimum value of capacity across the secondary are necessary to attain maximum inverse suppression. Resistance in parallel with the valve is critical in that a certain minimum value is necessary. Any large increase over such minimum value adversely affects the inverse suppressing qualities of such resistance.

What is claimed as new and is desired to be secured by Letters Patent of the United States is:

1. An X-ray system comprising a transformer having a primary winding and a secondary winding, an X-ray tube, a high tension circuit including the secondary winding of said transformer, a source of alternating current potential, a low tension circuit including said source of potential and the primary winding of said transformer, a valve rectifier in said low tension circuit and in series with said primary winding, and a condenser in one of said circuits in parallel with one of the windings of said transformer for delivering an exciting current of predetermined value in said transformer during the inverse half wave.

2. An X-ray system comprising a transformer having a primary and a secondary, an X-ray tube, a high tension circuit including the secondary of said transformer and said tube, a source of alternating current potential, a low tension circuit including said source of potential and the primary of said transformer, a valve rectifier in said low tension circuit, and resistance means in parallel with said valve rectifier for delivering an exciting current of predetermined value in said transformer during the inverse half wave.

3. An X-ray system comprising a transformer having a primary and a secondary, an X-ray tube, a high tension circuit including the secondary of said transformer and said tube, a source of alternating current potential, a low tension circuit including said source of potential and the primary of said transformer, a valve rectifier in said primary circuit, and a condenser in one of said circuits and a resistance in parallel with said valve rectifier for delivering an exciting current of predetermined value in said transformer during the inverse half wave.

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