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A. KÜNTKE
CIRCUIT ARRANGEMENT FOR A GENERATOR
OF THE HIGH-VOLTAGE REQUIRED FOR
X-RAY APPARATUS OR THE LIKE

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2 Sheets-Sheet 1

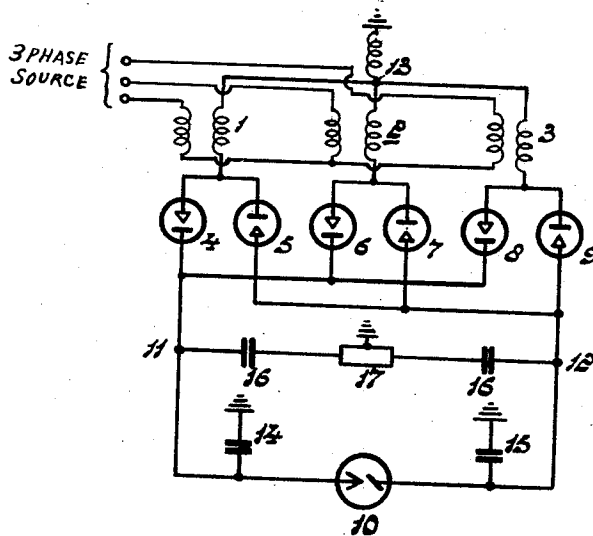


Fig. 1

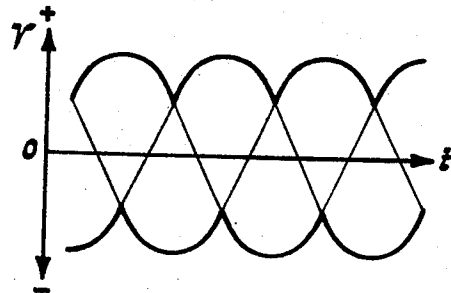


Fig. 2.

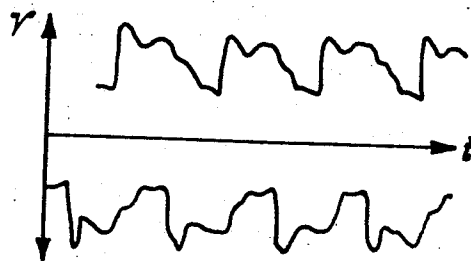


Fig. 3.

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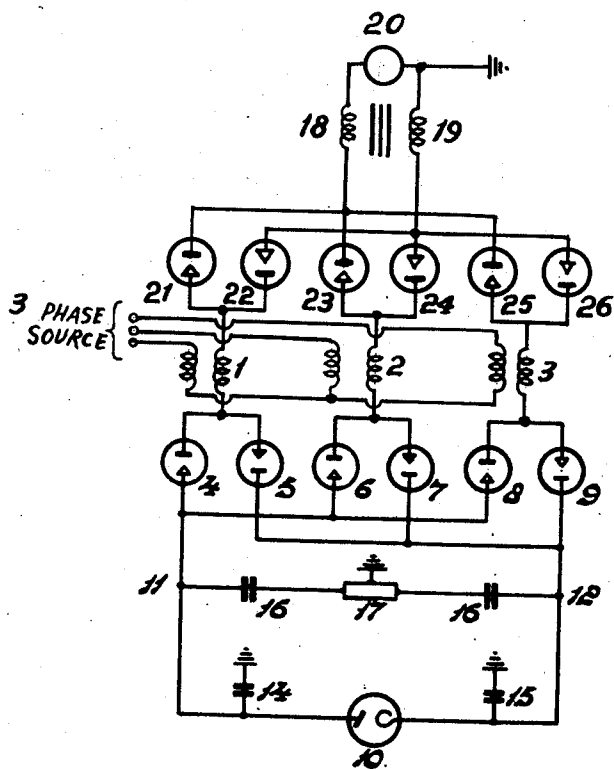
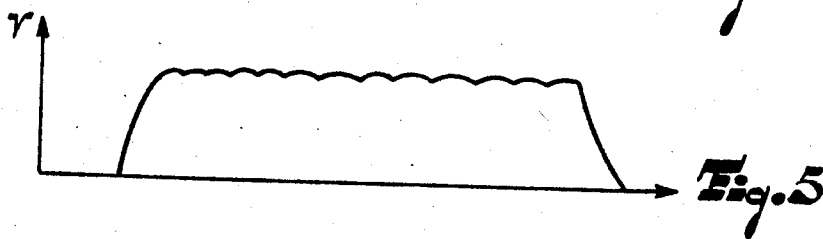
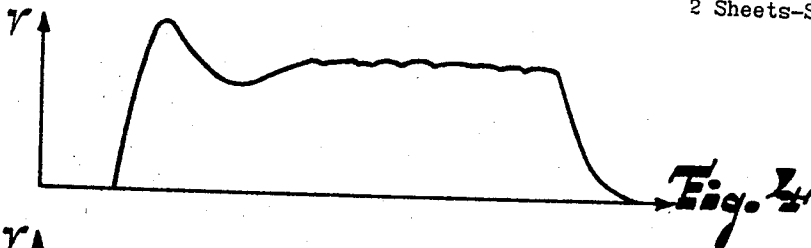


Fig. 6

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CIRCUIT ARRANGEMENT FOR A GENERATOR OF THE HIGH VOLTAGE REQUIRED FOR X-RAY APPARATUS OR THE LIKE

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3 Claims. (Cl. 321-16)

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This invention relates to a high-voltage device for supplying X-ray apparatus or similar apparatus operating with high direct voltage.

The standard practice is to produce the direct voltage by transforming alternating voltage with the use of rectifiers. With devices required to supply high load currents, the high direct voltage is obtained by full wave rectification of the alternating voltage supplied from a star-connected three-phase transformer, each phase being connected via a rectifier to each of the two high-voltage terminals. The current load is connected across these high-voltage terminals.

The star-point of the transformer is generally connected to earth potential and in this case the voltage at each supply terminal varies between $E_{\max}$ and $0.5 E_{\max}$ in relation to earth, if $E_{\max}$ indicates the highest value of the voltage which is supplied from each of the transformer windings. The direct voltage produced has a maximum value equal to $\sqrt{3} E_{\max}$ and a minimum value $1.5 E_{\max}$ so that a low voltage variation occurs. This voltage variation, which per se is not inconvenient, is found in practice to be considerably higher due to the fact that distortions of the voltage characteristic curve result from abstraction of current. Instead of the minimum relationship

$$\frac{\text{minimum value}}{\text{maximum value}} = \frac{1.5}{1.72} = 0.87$$

relationships up to 0.65 occur in practice and this most adversely affects the ray output of the X-ray tube. According to the invention, these unwanted high-voltage variations can be avoided, with a device of the kind described above, by connecting a series combination of an ohmic resistor and a capacity to the high-voltage terminals.

In order that the invention may be more clearly understood and readily carried into effect, a device according to the invention will now be described more fully with reference to the accompanying drawing, which illustrates improvements of the device and in which:

Fig. 1 shows the circuit diagram of a high-voltage device according to the invention,

Figs. 2, 3, 4 and 5 show several voltage diagrams,

Fig. 6 relates to the star-point circuit-arrangement of the high-voltage transformer for measuring the operating current.

Referring now to Fig. 1, each phase of the star-connected three-phase high-voltage transformer is connected via two oppositely arranged recti-

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fiers 4-5, 6-7, 8-9 to each of the terminals 11 and 12 in a manner such that electrodes of like nature of the rectifiers are connected to the same terminal. The load 10 is connected across the terminals 11 and 12. The star point 13 is connected to earth potential via a choke 18, the voltages between the positive terminal 12 and earth and those between the negative terminal 11 and earth varying between the full phase voltage and half the phase voltage. Fig. 2 in which the terminal voltage is plotted as a function of time, shows that if the voltage at one terminal is a maximum the voltage at the other terminal is half as high. If the voltages were to increase and decrease regularly, the voltage across the terminals would vary between $\sqrt{3}$ and 1.5 times the maximum phase voltage. It is known that when the transformer supplies current, distortion of the voltage curve occurs under the influence of the leakage fields of the transformer windings. Observations made with the use of the oscillograph reveal that in addition upon passage of current from one phase to another a damped oscillation occurs. This oscillation is attributed to the leakage fields and the presence of capacities. On connection of an X-ray apparatus 10 to the device capacities of this kind are formed by the high-voltage cables which connect the X-ray tube to the terminals of the high-voltage device. In Fig. 1 these cable capacities are represented by capacitors 14 and 15.

Fig. 3 shows the variation of the direct voltage across the high-voltage terminals under the influence of the above-mentioned phenomena. The damped oscillation produced may have different frequencies which depend on the value of the external capacity and hence in the case of X-ray apparatus essentially on the cable length. The total voltage consequently varies with the cable length. It is also found that the highest voltage variation occurring across the high-voltage terminals is higher than may be deduced from Fig. 2.

According to the invention, a series combination of the capacitors 16 and a resistor 17 is connected across the high-voltage terminals 11 and 12. It has been suggested before to connect in parallel capacitors for suppressing the voltage variations across the terminals but this has a limitation in that on the device being connected into circuit a starting phenomenon occurs which brings about a powerful voltage peak. The variation of the terminal voltage then occurring is illustrated in Fig. 4. The addition of the resistor 17 to the series combination exercises a highly

favourable influence on the voltage variation. A proper choice of the ohmic resistor and of the capacity provides a potential variation as shown in the oscillogram of Fig. 5. The most suitable values are 50,000 ohms for the resistor and 0.015 μ f. for the capacity.

It was already observed hereinbefore that upon connection of the star point of the transformer to earth the voltage of the high-voltage terminals in relation to earth varies considerably. In order to mitigate this disadvantage the star point may be decoupled so that its potential is allowed to be adjusted freely. This results in that the insulation of the parts at high voltage is loaded less intensely. So long as merely current is taken from across the high-voltage terminals an alternating voltage of three-fold frequency, which is low as compared with the direct voltage, will occur. If however, a supplementary current starts to flow due to a disturbance at one of the terminals, for example consequent upon the breakdown of one of the cables or upon a breakdown in the tube sheath, the full voltage is applied between the other high-voltage terminal and the grounded parts, with the result that the potential of the star point rises up to half the high voltage. This impairs the insulation of the entire device and the measure can therefore not be adopted.

The use of the invention permits of this difficulty being obviated. For this purpose the star point of the high-voltage transformer is connected via the choke 18 of suitable value to an earthed point of the series combination with respect to which resistor and capacities which connect this point to each of the high voltage terminals are symmetrical. The series combination comprises the resistor 17 and the two capacitors 16. The resistor 17 is earthed in its midpoint, the potential of which has consequently a fixed value and the presence of the choke 18 enables the potential of the star point to vary without obstruction. The star point alternating voltage is applied to the choke 18. The frequency of this voltage is three times the mains frequency and its maximum value is about $\frac{1}{3}$ of the direct voltage supplied. It is thus ensured that the direct voltage is distributed symmetrically about the high-voltage terminals, each terminal having half the voltage in relation to earth.

If for some reason a momentary short-circuit is formed, for example consequent upon breakdown of one of the high-voltage terminals against earth, the increase of the star point voltage is delayed by the choke to such an extent, that the voltage peak occurring is not detrimental. Since however, the choke constitutes a short-circuit for the direct-current component of the short-circuit current it is possible to cause this current to energise a relay by which the apparatus is disconnected. The operating winding of such a relay may be connected in series with the choke.

With X-ray apparatus the load current is generally measured with the use of a measuring instrument which is arranged in the switch desk which is slightly spaced apart from the device. It is therefore necessary to provide for the circuit leading to the measuring instrument to be earthed. For this purpose it is the standard practice to rectify and measure the current of one or more of the phases leading to the star point. Fig. 6 shows a circuit-arrangement for measuring the rectified star point current, the measur-

ing instrument 20 being connected to earth potential and the star point being connected to earth via chokes 18 and 19. The currents in the phases 1, 2 and 3 are rectified by the rectifiers 23—21, 22—23, 24—25 which connect each phase in an identical sense to the end of each of the chokes. The two choke windings are connected in series and arranged on the same iron core. The connection between the chokes includes the measuring instrument 20 a terminal of which is connected to earth potential. As far as the load current is concerned the two windings are connected in series so that the inductances balance each other. In relation to the star point alternating current the coils are connected in parallel. One half wave of this current passes through coil 18 and the other half wave through coil 19. Both coils are seated on the same core so that the effect as a choke is not changed thereby.

What I claim is:

1. A high-voltage power supply comprising a three-phase transformer having three windings, a pair of output terminals, a first set of three rectifiers each connecting one end of a respective winding to one of said terminals, a second set of three rectifiers each connecting said one end of a respective winding to the other of said terminals, a choke coupling the other ends of the windings of said transformer to a point of ground potential, and a resistance-capacitance series network connected across said output terminals, the point of electrical symmetry of said network being connected to said point of ground potential.

2. A high-voltage power supply comprising a star connected three-phase transformer having three windings, a pair of output terminals, a first set of three rectifiers each connecting a respective winding to one of said terminals, a second set of three rectifiers each connecting a respective winding to the other of said terminals, a choke connecting said star connection to a point of ground potential, a resistance capacitance series network connected across said output terminals, the point of electrical symmetry of said network being connected to said point of ground potential.

3. A high-voltage power supply comprising a three-phase transformer having three windings, a pair of output terminals, a first set of three rectifiers each connecting one end of a respective winding to one of said terminals, a second set of three rectifiers each connecting said one end of a respective winding to the other of said terminals, first and second chokes, a third set of rectifiers each connecting the other end of a respective winding through said first choke to a point of ground potential, a fourth set of rectifiers each connecting in a direction opposing said third set, the other end of a respective winding through said second choke to said point of ground potential, said first and second chokes being constituted by two coils wound on a common iron core, and a current indicator interposed between said point of ground potential and said second choke.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,567,761	Slepian	Dec. 29, 1925
2,282,998	Edwards	May 12, 1942
2,289,000	Faudell	July 7, 1942
2,424,344	Veinott	July 22, 1947
2,476,804	Boykin	July 19, 1949