

Oct. 29, 1929.

P. M. G. TOULON

1,733,679

ARC RECTIFIER

Filed Dec. 6, 1927

2 Sheets-Sheet 1

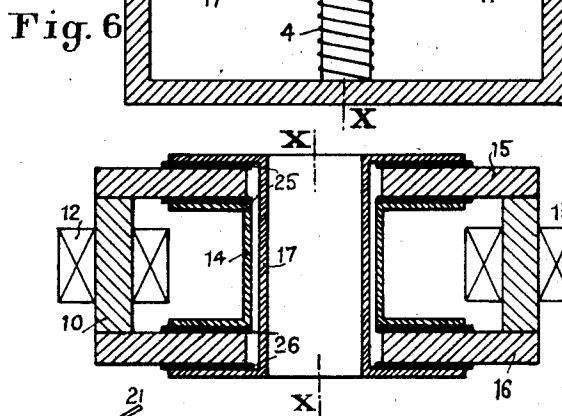
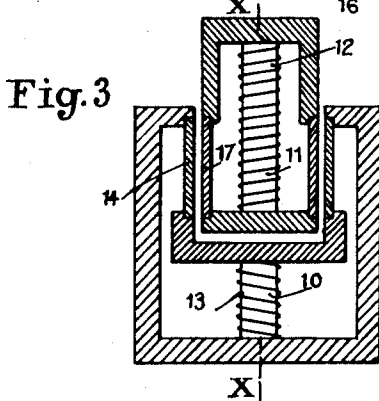
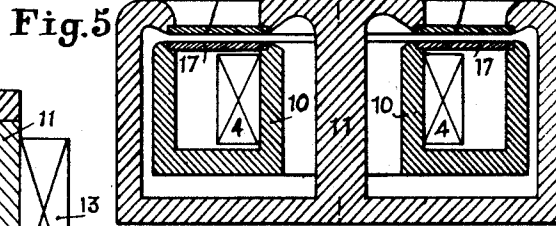
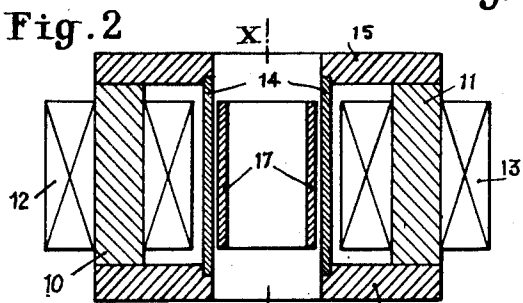
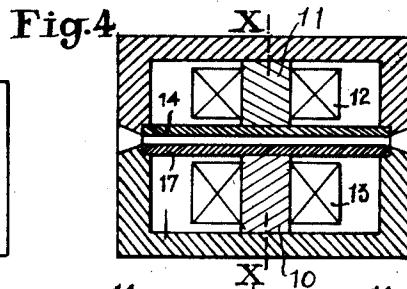
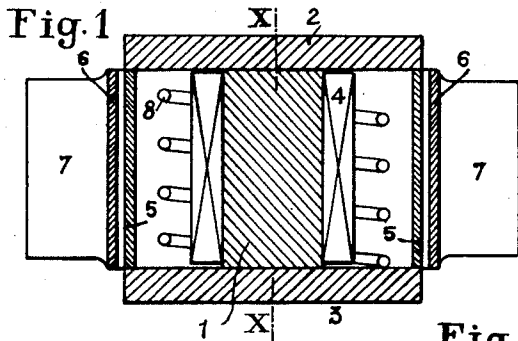
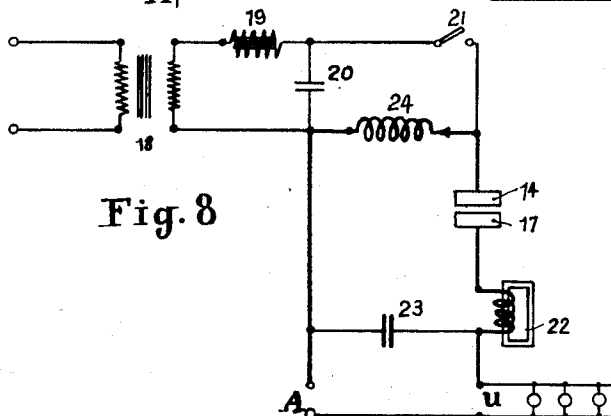


Fig. 7



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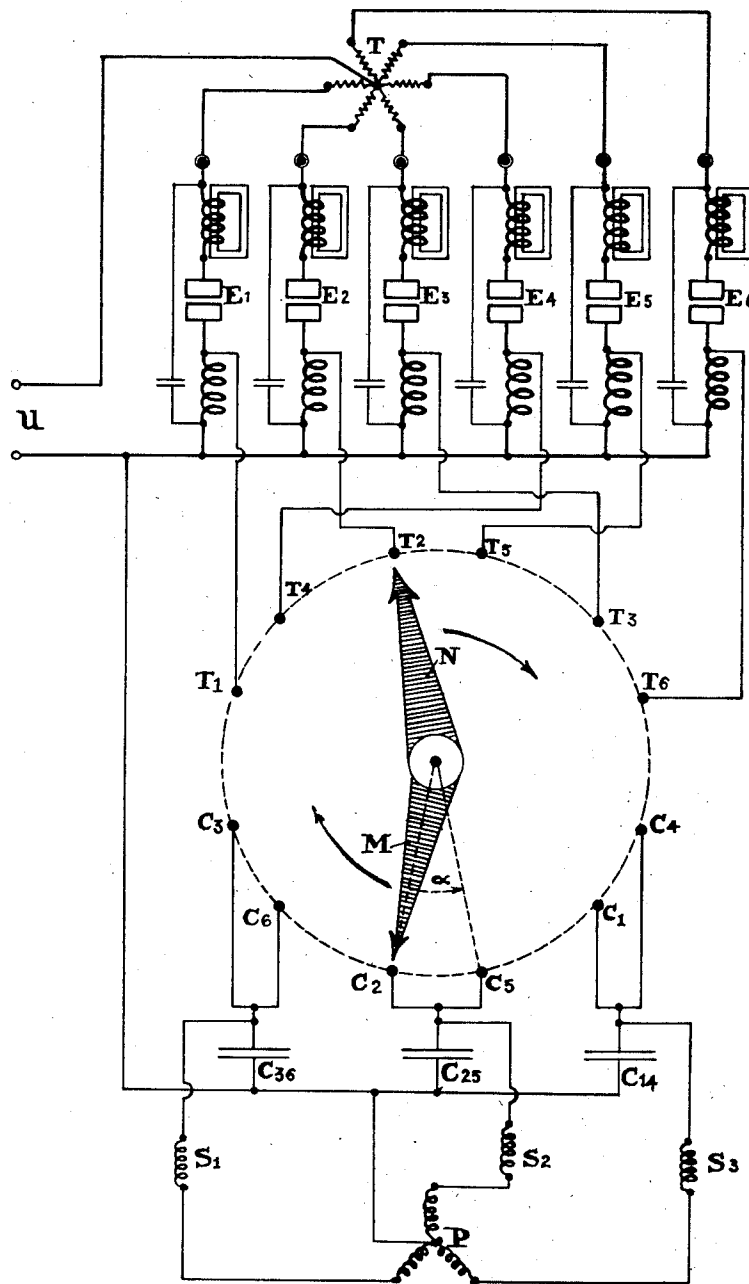
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2 Sheets-Sheet 2

Fig. 9



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ARC RECTIFIER

Application filed December 6, 1927, Serial No. 238,215, and in France December 13, 1926.

My invention relates to a simplified, economical and improved form of execution of the arc rectifier described in my Patent No. 1,668,615 and wherein the arc is caused to travel along a closed path.

In view of diminishing the wear of the electrodes of the rectifying apparatus I have imagined to dispose them in an atmosphere constituted by an inert or reducing gas (illuminating gas, nitrogen, acetylene, carbon dioxide, argon, hydrogen, carbon monoxide and the like) or in an insulating liquid such as alcohol. I may also use cheap metals for the electrodes which have a very high melting point such as iron and steel. The use of such metals shows however some difficulties as they reduce to a considerable extent the magnetic field used for rotating the arc rapidly.

According to my invention I provide on the surface of the metal electrodes of the above-described kind, an intense magnetic field through the thorough saturation of the said electrodes. The magnetic flux passes through the comparatively small section afforded by the latter whereby the lines of force are caused to pass through the point of ignition of the arc which may thus be displaced as required.

In order to ensure the protection of the high tension transformer providing the current used for exciting or igniting the rectifier and to suppress the induction between its several phases, I provide moreover an improved wiring diagram with suitably disposed reactances the circuits of which with the corresponding capacities may be tuned to predetermined resonant value.

In view of applying this device to polyphase devices, I have disclosed hereinbelow an improved arrangement comprising a rotating spark gap feeding the exciting circuits and constituted by two needles making an angle one with the other, this arrangement providing practical advantages to be disclosed hereinafter and chiefly the complete independence of each one-phase elementary rectifier of the complete polyphase rectifier.

Thus an elementary rectifier may be replaced during the working of the other elementary rectifiers after it has been caused to

cease working. This replacement may be made without danger and without the main current being cut through the stopping of the working of the elementary rectifier considered. The whole rectifier may thus be caused to cease working without any high power switching device being required.

I have shown by way of example on appended drawings a form of execution of my invention.

Figs. 1 to 7 relate to the arrangement of electrodes constituted by ferromagnetic metals.

Fig. 8 shows an improved wiring diagram.

Fig. 9 shows an improved sparking gap for exciting the main arc.

In Fig. 1 the electrodes are formed by two coaxial cylinders 5 and 6 of steel, iron or the like. The cylinder 5 which is the cathode for instance is secured to the magnetic circuit comprising the core 1 and the two circular heads 2 and 3. The coil 4 is wound round the core 1 and is disposed in the annular fluid tight space between the core and the cylinder 5. This space may be filled with an insulating liquid such as oil for instance cooled if desired through the cool water circulation in the coil 8. The magnetic field passes through the cylinders 5 and 6 in the direction XX and saturates them whereby the magnetic dispersion in the annular space between the two cylinders is sufficiently strong to cause the arc ignited between them to rotate speedily. I may provide the outer cylinder 6 with cooling fins 7 in view of ensuring an energetic cooling thereof. In the modified form of Fig. 2 the two coaxial cylindrical ferro-magnetic electrodes are shown at 17 and 14. The outer electrode 14 is secured to the heads 15 and 16 connected together through two or more cores 10 and 11 round which the coils 12 and 13 are wound. In such an arrangement the magnetic flux saturates equally both cylinders and forms between them an escape field which is sufficiently intense to rotate the arc.

In Fig. 3 the two cylinders 14 and 17 form as precedently the two electrodes of the apparatus and are saturated by two distinct coils 12 and 13 wound round the respective cores 11 and 10.

Fig. 4 shows the arrangement of two flat electrodes each saturated by a separate coil 12 and 13. The flux passing through the core 11 for instance is closed through the ferro-magnetic disc 14. The arc ignited between the two electrodes is driven by the escape field and caused to rotate round the axis XX.

The electrodes 14 and 17 of Fig. 5 are saturated by the same coil 4, the two magnetic circuits being concentric. The working is the same as in the precedent cases.

In all the arrangements disclosed hereinabove, the ferro-magnetic electrodes are secured directly to the heads of the magnetic circuit if only one circuit is provided or of the two circuits if the circuits are independent. This requires a suitable insulation of the whole apparatus with reference to the ground and of the independent magnetic circuits with reference to each other and to the coils. To suppress this drawback I may adopt the arrangements shown on Figs. 6 and 7 wherein the electrodes 14 and 17 (flat or cylindrical) are insulated with reference to the magnetic circuit through refractory parts 25 and 26. By a suitable size given to the gaps thus provided in view of providing a comparatively low reluctance in these insulating parts and a lesser saturation of the parts of the circuit adjacent thereto, the number of ampere turns required for the coils may not be greatly increased whereas the magnetic part of the apparatus may be grounded and its price greatly diminished thanks to the simplified insulation thus allowed.

In view of protecting the high tension transformer 18 shown on Fig. 8 which loads the condenser 20 the discharge of which provides the exciting spark I may dispose between the transformer 18 and the condenser 20 an induction coil 19 which limits the intensity at the moment of the flashing of the spark.

As shown in the drawing the exciting or pilot spark passing between the contacts of the rotary spark gap 21 provides the discharge through the coil 24 and the condenser 20. If no protecting device were used the high tension transformer 18 would be the seat of high frequency oscillations which would speedily damage it and prevent its working. The coil 19 disposed between the transformer and condenser prevents almost completely these oscillations from reaching the transformer which is suitably protected without requiring the use of energy-wasting resistances. On the other hand this arrangement allows, by using the resonance of the circuit 19—20 to the feed frequency of the transformer, say 50 periods for instance, to increase considerably the voltage at the terminals of the condenser 20 with reference to the output terminals of the transformer whereby the price of the transformer 18 may

be substantially reduced. The connections described for a one-phase rectifier is of particular advantage in the case of a polyphase rectifier as it prevents one phase of the transformer from acting on the other at the moment when the spark flashes through the spark-gap 21.

The connections shown provide a considerable simplification of the wiring diagram of polyphase rectifiers inasmuch as the number of exciting condensers is reduced and a spark-gap rotating at a great speed may be used. This diagram shown on Fig. 9 for a six-phase arrangement is of particular interest in the case of a 50 period polyphase current and a motor rotating at 3000 R. P. M.

On Fig. 9 the spark-gap is constituted by two dissymmetrical rotary needles M and N, needle M being shifted forwards by $180^\circ + \alpha$ with reference to needle N. The pilot spark is provided by the three-phase high tension transformer P the three phases of which are protected by the coils S_1, S_2, S_3 corresponding to coil 19 of Fig. 8. Each phase of the transformer P loads a condenser. The three condensers C_{36}, C_{25} and C_{14} feed the six stationary contacts disposed in front of the path of the end of the rotating needles; C_{36} feeds in parallel C_3 and C_6 ; C_{25} feeds in parallel C_2 and C_5 and C_{14} feeds C_1 and C_4 .

The six exciting circuits for the devices E_1 to E_6 are connected with the stationary contacts T_1 to T_6 . When the needles are disposed as shown in Fig. 9 the spark flashes between the contact C_2 and the needle M on one hand and the needle N and the contact T_2 on the other whereby the main arc is ignited in E_2 . If the needles are caused to rotate in the direction of the arrows, the needle N arrives after a certain time in front of T_5 but no spark is produced as the needle M is not in front of a contact. The next spark flashes when M is in front of C_3 , N being in front of T_3 whereby the arc of E_3 is ignited.

The needle M cooperates only with C_1, C_2, C_3 whereas N cooperates with C_4, C_5, C_6 . It is easy to see that the six exciting sparks flash in succession during one whole revolution of the needles. On the other hand the shifting of needle M by an angle α prevents similar exciting sparks from flashing after a rotation by 180° .

Thus an ordinary three-phase transformer may be used for feeding a six phase exciting circuit, a high speed motor rotating at say 3000 R. P. M. being used for rotating the needles. Moreover the double spark-gap provides a great accuracy of the moment of the excitation. The brushes and frictional contacts are done away with, which minimizes the frictional losses and affords a simplification of the device.

Such a rotary spark-gap may feed any

number of similar one-phase rectifiers constituting a polyphase arrangement feeding a slightly undulating direct current through the terminals U. The complete independence of the igniting and feed circuits of each elementary rectifier of the polyphase arrangement allows each unit such as E₁ to be removed during the working in view of repairs, replacement or the like. For instance each unit may be disposed on slides or rollers with contact jaws or jacks. To ensure the complete opening of the main circuit before removal of the unit the connections may be disposed in a manner such that the exciting circuit is first opened whereby the contact of the main circuit may then be separated without any arc flashing in the said circuit.

A six phase arrangement can continue working with one unit removed and the five remaining units remaining connected. The direct current fed by the arrangement will then be of course a little more undulating than otherwise, but this is no great drawback.

The whole arrangement may be easily controlled, without breaking circuits with strong currents through switches and the like, by acting on the control device constituted by the exciting circuits. It is sufficient to break the primary current feeding the auxiliary transformer P for stopping the working of the arrangement. This can be done by a switch or the like of very small power and adapted to be actuated speedily.

What I claim is:

1. An arc rectifier comprising coaxial electrodes of ferro-magnetic material, a core, a coil wound round the core and adapted to make the arc flashing between the electrodes rotate round the axis thereof, heads closing the magnetic circuit through the core and electrodes, means for feeding the electrodes with alternating current, an exciting circuit for igniting the arc between the electrodes, means for making the said circuit live at predetermined moments and means for receiving the direct current passing out of the rectifier.

2. An arc rectifier comprising coaxial electrodes of ferro-magnetic material, a core, a coil wound round the core and adapted to make the arc flashing between the electrodes rotate round the axis thereof, heads closing the magnetic circuit through the core and electrodes, means for feeding the electrodes with alternating current, an exciting circuit for igniting the arc between the electrodes, means for making the said circuit live at predetermined moments, means for receiving the direct current passing out of the rectifier, a transformer feeding the exciting circuit and an induction coil disposed in the exciting circuit in close proximity to the transformer.

3. A polyphase arc rectifier comprising a plurality of elementary arc rectifiers as claimed in claim 2, a dissymmetric double

needle forming a spark gap constituting the means for making the exciting circuits live, a number of contacts disposed in front of the path of the end of the needles, the number of which is double that of the elementary rectifiers and adapted to be disposed two by two in front of the needle end once and once only for each revolution of the needle, each pair of corresponding contacts being inserted in the exciting circuit of one of the elementary rectifiers and a circuit tuned to the transformer feed frequency comprising an induction coil and a condenser between each double pair of contacts and the corresponding terminal of the transformer common to all the exciting circuits.

In testimony whereof I have affixed my signature.

PIERRE MARIE GABRIEL TOULON.