

Feb. 20, 1923.

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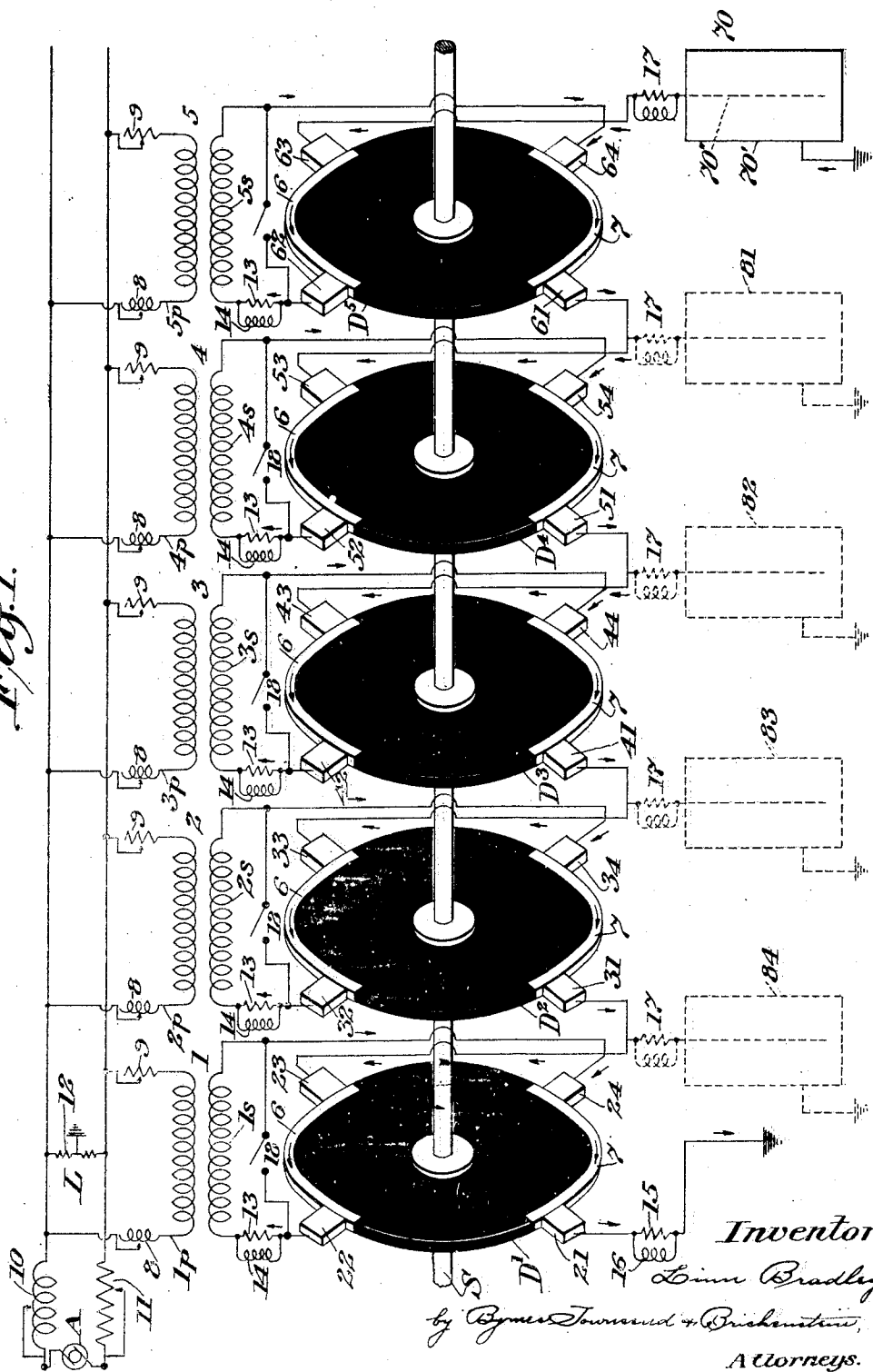
L. BRADLEY

RECTIFYING SYSTEM

Filed May 2, 1919

3 sheets-sheet 1

Fig. 1.



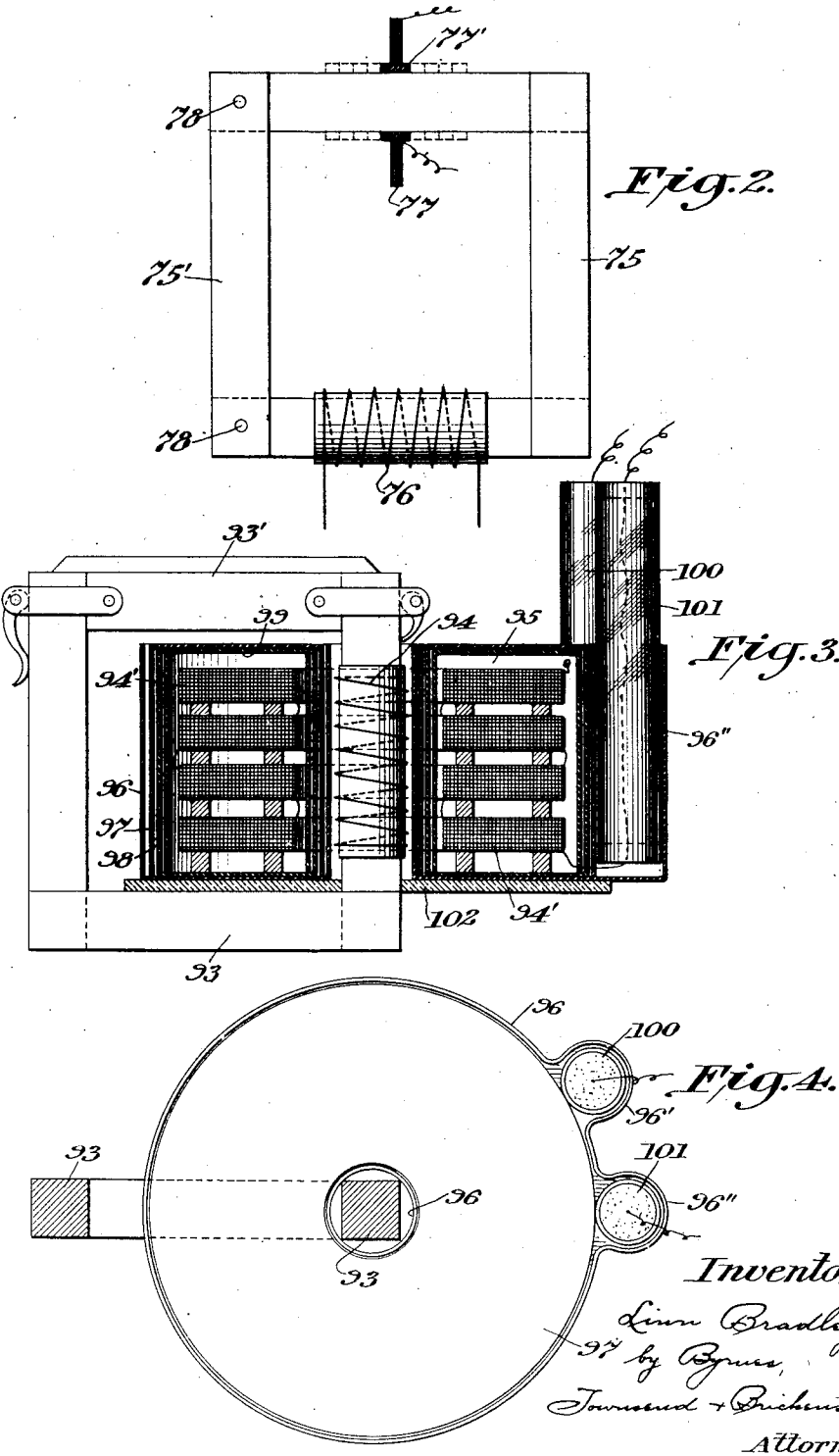
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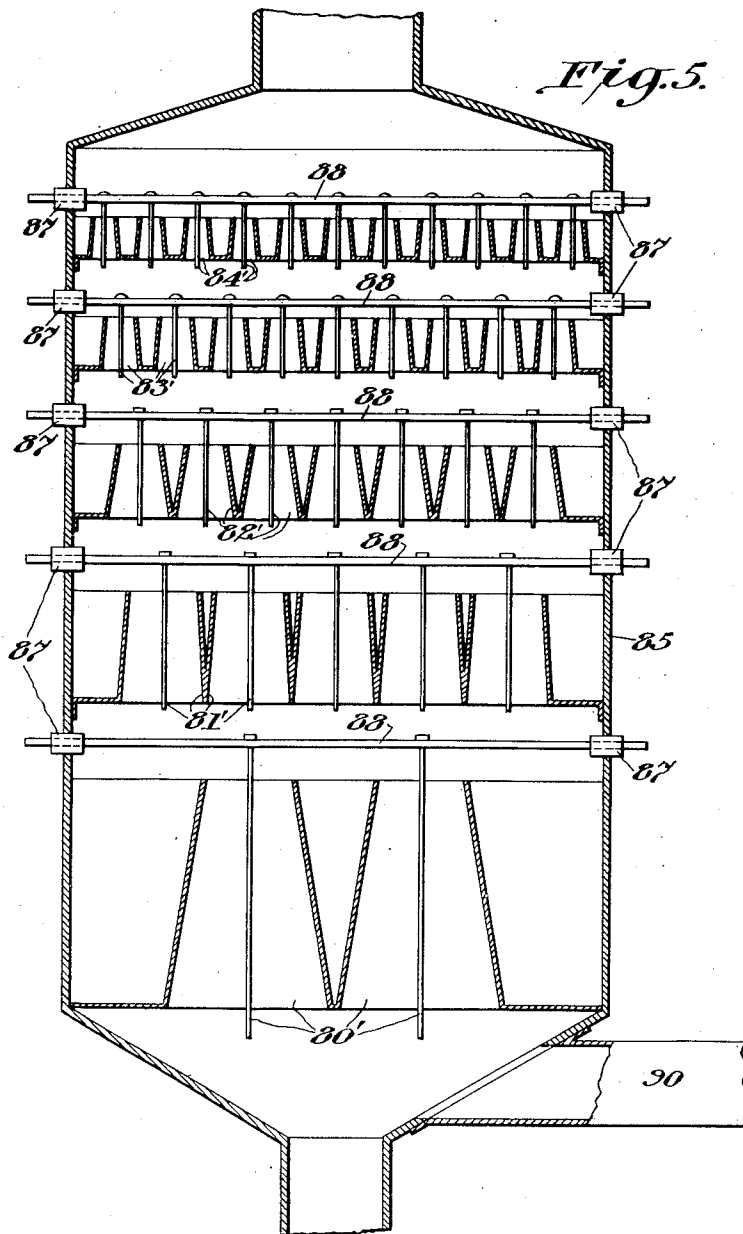
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## UNITED STATES PATENT OFFICE.

LINN BRADLEY, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO RESEARCH CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

## RECTIFYING SYSTEM.

Application filed May 2, 1919. Serial No. 294,229.

*To all whom it may concern:*

Be it known that I, LINN BRADLEY, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Rectifying Systems, of which the following is a specification.

The present invention relates to a system for rectifying alternating currents and more particularly to that type of apparatus which are generally designated as mechanical rectifiers.

Ordinarily a rectifier is connected to the secondary side of a transformer of the usual design. When the transformer is disabled or becomes inoperative in some way, which is not at all an unusual occurrence, the plant must be shut down long enough to find the cause of the break-down and make the repairs which necessitates as a rule the taking apart of the transformer structure, and in most cases the sending of the transformer to the factory. The only way to avoid the risk of an extended shut-down is to keep a spare transformer of the required capacity in reserve, which means a considerable expense.

Applicant proposes a system of rectifying alternating current which is free of the difficulties above noted, avoids the danger of an extended shut-down and at the same time makes the alternative of a spare transformer unnecessary.

The invention, briefly stated, consists in employing a plurality of separate transformer units and a plurality of commutator units connected to the secondaries of the transformers so as to place them in series relation.

The significance of this arrangement, its function and result will be more apparent from the detail description in connection with the accompanying drawings, in which—

Figure 1 is a diagrammatic view of the general arrangement embodying the invention.

Figs. 2, 3 and 4 are sectional views of transformer units especially adapted for the purposes of the invention; and

Fig. 5 is a sectional view of an electric precipitator which may advantageously be used in connection with the invention.

In Fig. 1, L represents a single phase line connected to an alternating current generator A. Transformers 1, 2, 3, 4 and 5 have

their primaries 1<sup>p</sup>, 2<sup>p</sup>, etc., connected across the line L, while the secondaries 1<sup>s</sup>, 2<sup>s</sup>, etc., are connected to rectifier disks D<sup>1</sup>, D<sup>2</sup>, D<sup>3</sup>, D<sup>4</sup> and D<sup>5</sup> respectively which are mounted on the same shaft S. The disks which are made of the usual insulating material, such as micarta, glass, etc., are provided at the periphery with the usual contact segments 6 and 7. Stationary contacts are supported adjacent the periphery of the disks in the customary way to establish by contact with the rotating disks electrical connection between the source of current and the load device. The relation of the segments 6 and 7 and the contacts is such, the disks being driven in synchronism with the generator, that the current flow to the load device is unidirectional, as is well understood.

Contact 21 is connected to ground, contacts 22 and 24 to the secondary of the transformer 1, contact 23 to contact 31 belonging to disk D<sup>2</sup>. Contacts 32 and 34 are connected to transformer 2. Contact 33 is connected to contact 41 of the next commutator set. Similarly contacts 42 and 44 are connected to the secondaries of transformer 3, the contacts 52 and 54 to transformer 4, and contacts 62 and 64 to transformer 5, while connection of the various commutator sets is continued from contact 43 to contact 51 and from contact 53 to contact 61. The last remaining contact 63 of the last commutator set is finally connected to the discharge electrode 70'' of the precipitator 70, the collecting electrode thereof being connected to ground.

It is thus evident that the secondaries of all the transformer units are connected in series and that the total voltage of the series is applied to the precipitator 70, while the voltage existing across each rectifier disk is only a fraction of this total. The number of disks may of course be increased or decreased. The more transformer units and disks are used, the smaller will be the potential difference across each disk.

In the primary circuit of each transformer unit may be inserted an inductive resistance 8 and a non-inductive resistance 9 so that the transformer units may be adjusted independently of each other. In the line L may be placed an inductive resistance 10 and a non-inductive resistance 11 in order to make the necessary adjustments in the circuit as a whole.

To protect the primary circuit, the line L may be connected to ground through a resistance 12 in the usual manner. Oscillations and surges may be damped by the use of high resistances shunted by inductive resistances. Thus, the secondary circuits may be protected by high ohmic resistances 13 which are shunted by highly sensitive inductive resistances 14. Similarly, a non-inductive resistance 15 and an inductive resistance 16 may be placed in the connection leading from contact 21 to ground and a protecting device 17 of like nature in the connection leading from the contact 63 to the discharge electrode 70'.

The operation of the arrangement so far described is as follows: Assuming that the current is flowing through the secondaries of the transformers in the direction indicated by the arrows and the rectifier disks are in the position indicated, then the current will pass through ground to the collecting electrode 70' of the precipitator 70 and return from the discharge electrode 70' to the terminal 63 of the last rectifier element and successively through the different secondaries.

When the disks  $D^1$ ,  $D^2$ , etc. are in the position at right angle to the position indicated, the current passes through the secondaries in reverse direction, but to the precipitator in the same direction as is well understood.

The terminals of each transformer may be short-circuited by means of a switch 18 so that, if one of the transformer units should be disabled in any way, the remaining transformers may continue in operation. If desired, this switch may be automatically operated by devices such as no-potential and overload relays etc. in the usual manner.

The arrangement indicated shows five transformer units which are wound for a normal secondary voltage of say 10000 volts each. The voltage may of course be raised in the usual manner to say 12500. If one of the transformers is disabled and short circuited by the switch 18, the voltage may be so regulated that the remaining four secondaries produce together the same voltage as previously the five, i. e. 50000 volts. The disabled transformer may then be detached and repaired, whether a spare transformer is substituted for the disabled one or not. It is understood that the additional expense of a spare transformer is relatively low because of the relatively low voltage.

Since the voltage across each rectifier disk is only a small fraction of the total voltage applied to the precipitator, the disks may be made relatively small whereby the peripheral speed is reduced in proportion. At the low voltage, destructive arcing is practically eliminated.

In place of a single precipitator 70 a plu-

ality of treaters may be connected to the system as indicated in dotted lines by the numerals 81, 82, 83 and 84.

These various treater units may be embodied in a single structure as indicated in Fig. 5. In the treater chamber 85 are arranged in different tiers, treater units 80', 81', 82', 83' and 84' each consisting of tubes forming the collecting electrodes and wires or rods forming the discharge electrodes. The connections from the different rectifier sections pass through insulator bushings 87 to bus bars 88. The different treater units are similar in all respects, but differ as to the length and diameter of the 80 tubes.

With this arrangement the gas enters through the inlet 90 whence it passes successively upward through the treater sections 80', 81', 82', 83' and 84'. In the treater unit 80' which corresponds to the precipitator 70 in Fig. 1, the relatively coarse particles are removed. In passing through the other units the finer particles are gradually removed, and in the unit 84' which has the lowest voltage, but the highest potential gradient, the finer dust and fume that may remain at this stage is finally removed from the gas stream.

The current taken by each unit would of course be determined by the characteristics of the unit itself and the transformer capacity would have to be distributed with this point in view. It would not, however, be imperative that individual transformer capacity and individual load demand be made the same. Any current of transformer unit 1 for instance that was not utilized in treater unit 84' would readily pass through the high voltage circuit to a point where it could be utilized. It is thus possible to utilize all transformer capacity under changing load conditions and greater flexibility is attained.

While in the arrangement shown in Fig. 1, the rectified currents are passed in series to the load device for the special purpose of producing a high voltage without destructive sparking at the rectifier, the objects in respect to flexibility of operation and adaptation and security against disruption of service are fully attained by connecting the rectified currents in parallel in the well known manner.

Fig. 2 shows diagrammatically a transformer construction especially adapted for use in connection with the invention. It consists of the usual laminated core 75, a primary winding 76 and a secondary winding 77. The core 75 may be so built that one leg 75' may be removed so that it is possible to readily take out either of the windings for repair. The secondary winding 77 is mounted on a sleeve 77' of insulating material which may be designed for one

particular voltage, say 12500 volts. It is understood that the secondary of the transformer unit 1 must be insulated against a potential difference of about 12500 volts to ground, the transformer unit 2 about 25000 volts, the unit 3 about 37500 etc. In other words, each transformer secondary must be insulated for that potential difference to ground which may exist during the operation of the system. The different transformers are similar in every respect, except that the insulating sleeve 77' increases with the increase of potential difference. Thus in transformer unit 2 the sleeve is twice as long as that in unit 1, in unit 3 it is three times as long and so on, as clearly indicated in dotted lines.

If one of the transformer units breaks down, it is only necessary to take out the bolts 78 and leg 75', take out the secondary winding 77 and insulating sleeve 77', and repair the winding or the insulation or substitute another winding and sleeve for it. The cost of a spare winding or of a spare sleeve is of course extremely small in comparison with the cost of a whole transformer unit built for the full voltage applied to the load device. The iron structure is a relatively small item, while the amount of copper and the insulation at high voltages constitute the most important and most expensive item. Since the length of copper wire per ampere turn in a small transformer is only a small fraction of that necessary in a large transformer and also the amount of insulation is considerably smaller, the separate transformer units of lower voltage can be built at a relatively small cost. The insulation of transformer unit 5 does not present any serious difficulty, because there is considerable space available for it and the sleeve 77' of the requisite length may be easily slipped on the core. The repair may be easily made by an ordinary skilled attendant with very little cost and without interrupting the operation of the system.

The insulating sleeves 77' are normally made of ample thickness to withstand the full potential difference of 50000 volts so that the insulation from ground may be easily changed by merely adding or taking away standard sleeve sections.

It is understood that the transformer units may be varied in different ways and standardized to make them particularly applicable for the purposes of the invention. The cost of building them may be considerably reduced because the ordinary conditions and requirements in transformer design do not exist. The elements of iron, insulation, copper and space may be so comprised and correlated as to produce a relatively cheap structure.

Figs. 3 and 4 show another transformer unit specially adapted for the purposes of

the invention. The leg 93' of the core 93 is removably attached for the purpose previously stated. The primary coil 94 is wound on the core 93 while the secondary coils 94' are contained in a housing 95 composed of a plurality of cup-shaped bodies of insulating material nested within each other. These insulating elements have each an inner wall and an outer wall defining an annular trough. Thus the element 96 receives the inverted element 97 which in turn surrounds the element 98 and the latter receives the inverted element 99. The element 98 is preferably filled with oil. The outside element 96 is formed with two lateral receptacles 96' and 96'' adapted to receive insulator tubes 100 and 101 through which may pass the ends of the secondary. The tubes 100 and 101 may be closed at the top and bottom by a cork to retain therein grease or other suitable material. The insulating elements 96, 97, 98, 99 may be of glass, non-inflammable celluloid, micarta etc. The tubes 100 and 101 may be of glass or porcelain etc. If desired the insulating elements may be supported on a board 102 of insulating material.

To take the transformer thus described apart it is only necessary to remove leg 93, lift out the casing or housing 95 and take the separate insulating elements from their nested position. After the repair is made, the parts are easily assembled.

In the foregoing no attempt has been made to illustrate all the ways in which the standard transformer designs may be modified to carry out the objects of the invention.

I claim:

1. The combination of a plurality of separate transformer units, a rectifier connected to the secondary of each transformer unit, means for interconnecting the rectifiers so that the rectified currents flow in series and a plurality of electrical precipitator units connected across points of different potential difference.

2. The combination of a plurality of separate transformer units, means for connecting the secondaries of the transformer units in series, and a plurality of electrical precipitator units connected across points of different potential difference.

3. A precipitator comprising a plurality of treater units succeeding one another in spaced relation in the path of the gas to be treated, the distance between opposite electrodes in each treater unit decreasing progressively from one end to the other and the distance between opposite electrodes in the several treater units decreasing progressively from the first to the last in the series and means for supplying to the several treater units progressively decreasing potentials.

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4. A precipitator comprising a plurality of treater units succeeding one another in spaced relation in the direction of the gas flow, each unit being composed of a plurality of tapering tubular collecting electrodes  
5 and discharge electrodes passing there-through and the diameter of the said tubes gradually decreasing from one end of the precipitator, and means for supplying to the several treater units progressively decreasing potentials. 10  
In testimony whereof, I affix my signature.

LINN BRADLEY.