March 28, 1939. G. W. FYLER 2,152,472

PROTECTIVE EQUIPMENT

Original Filed Aug. 14, 1935 3 Sheets-Sheet 1

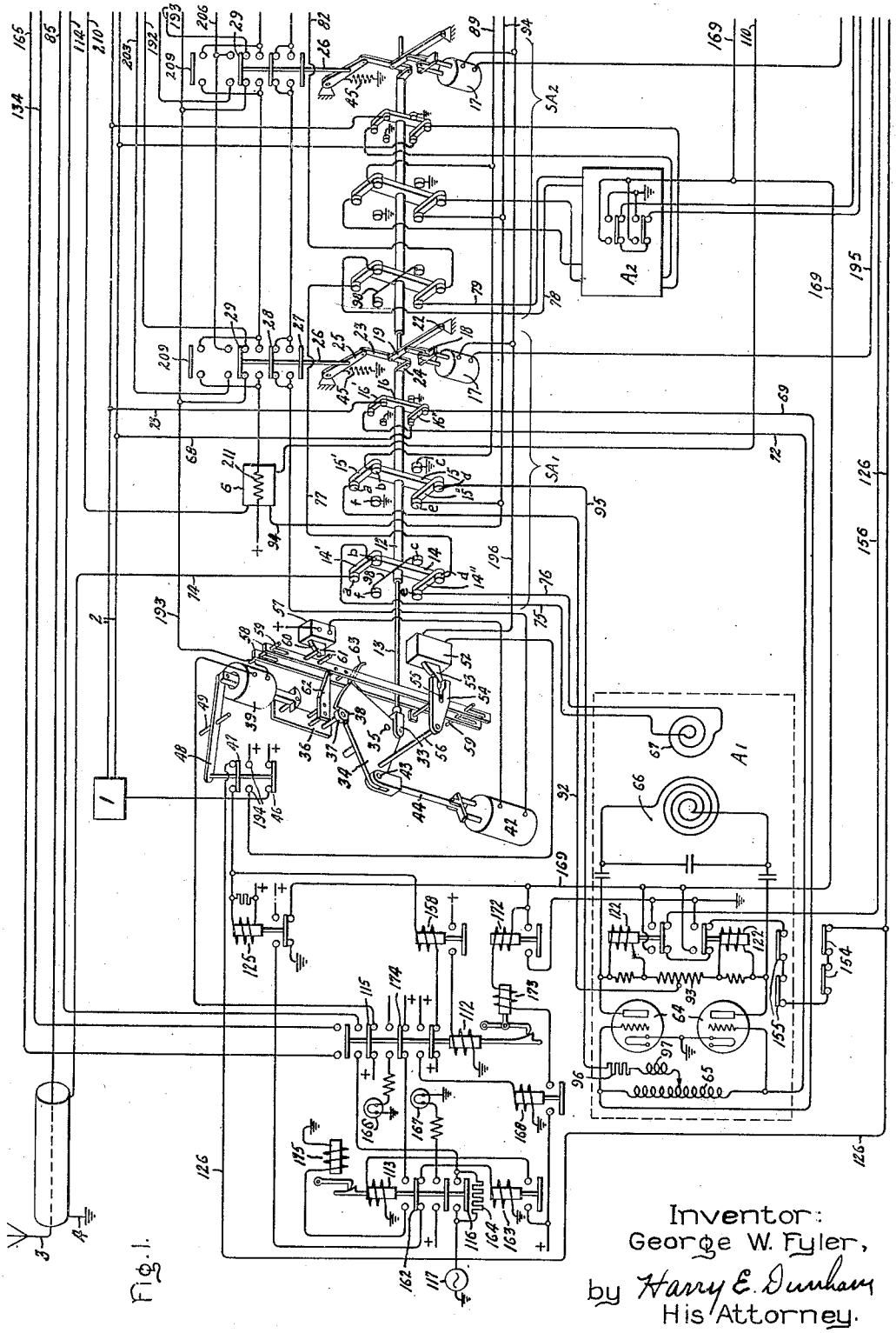


Fig. 1.

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PROTECTIVE EQUIPMENT

Original Filed Aug. 14, 1935 3 Sheets-Sheet 2

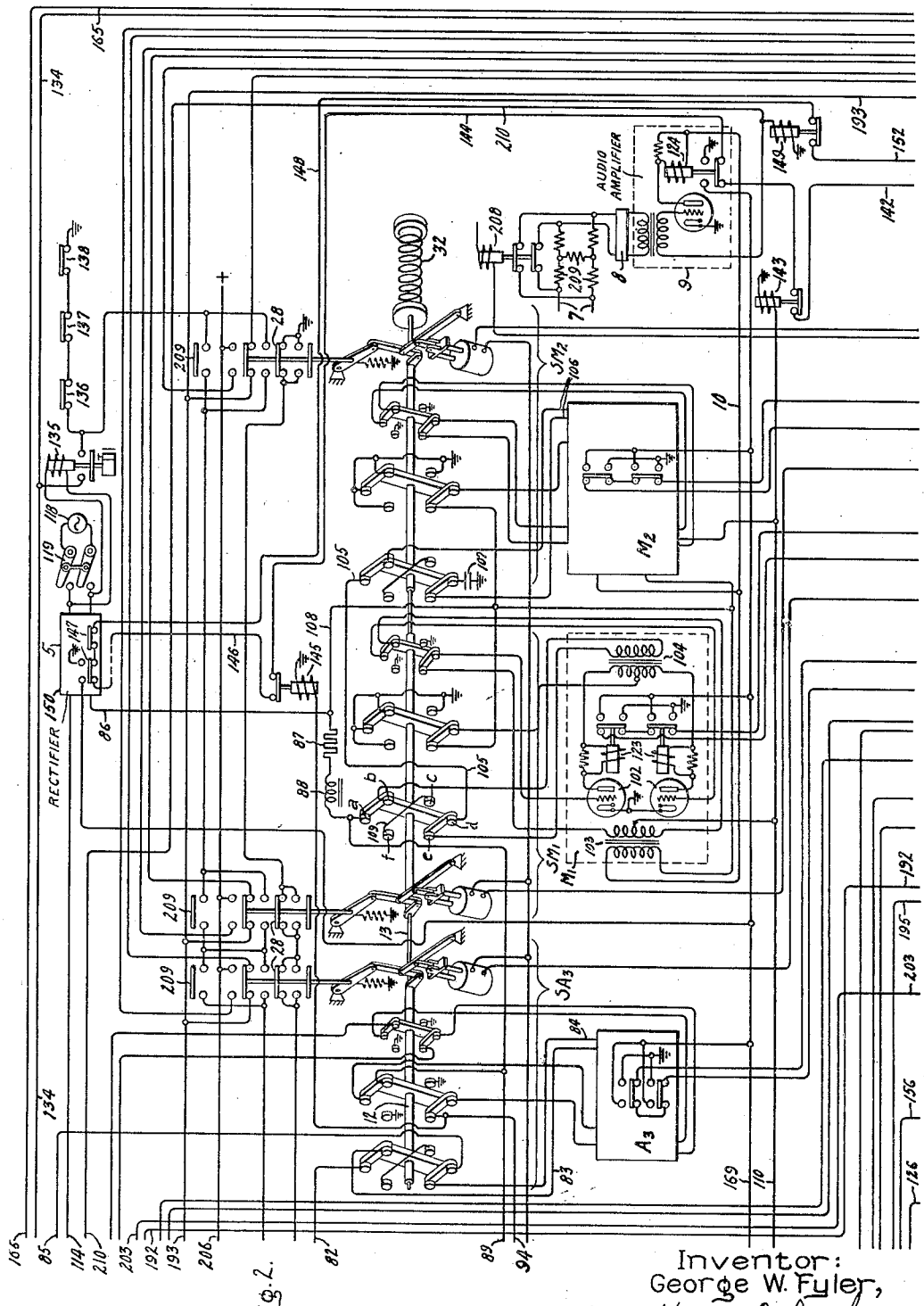


Fig. 2.

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PROTECTIVE EQUIPMENT

Original Filed Aug. 14, 1935 3 Sheets-Sheet 3

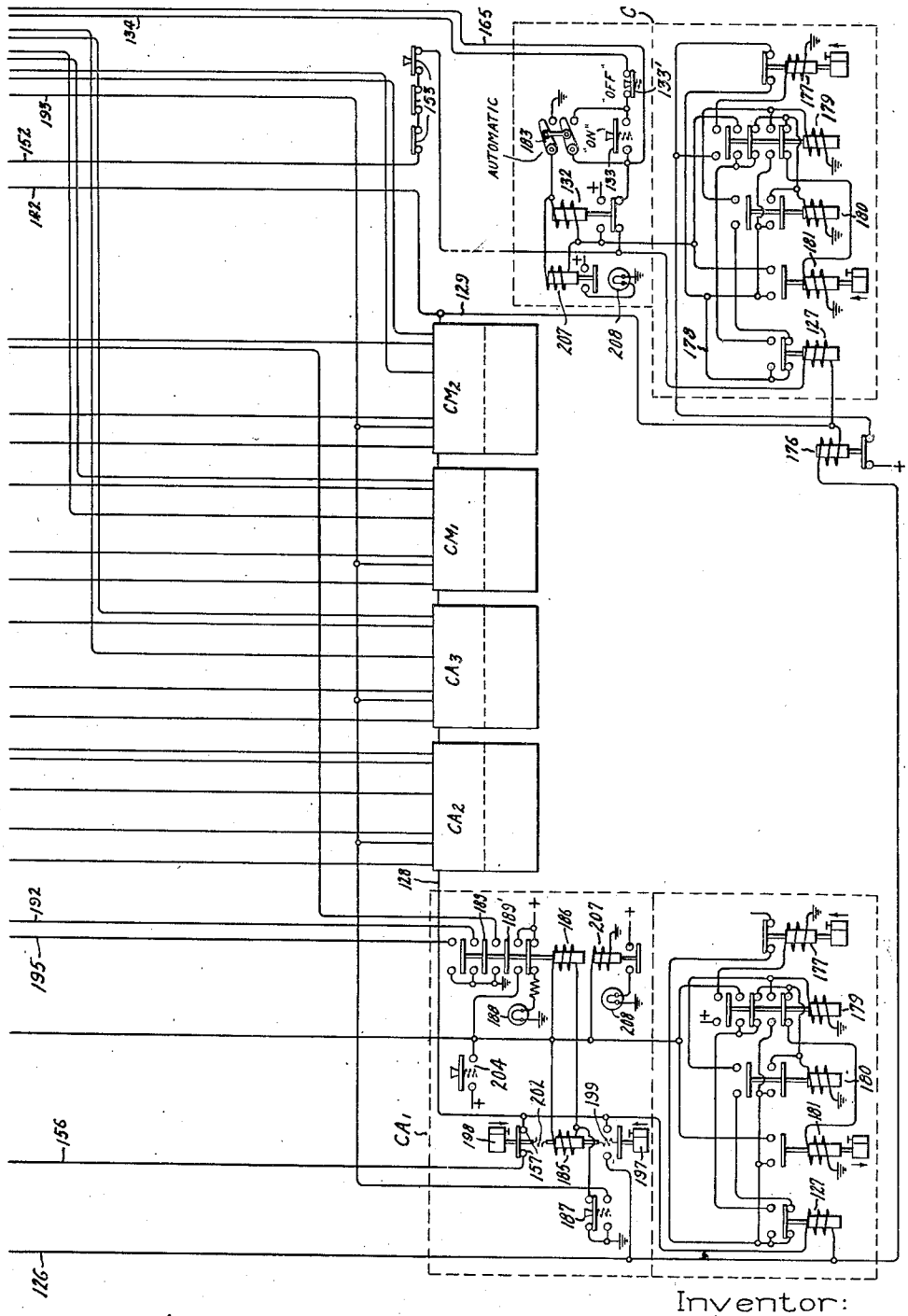


Fig. 3.

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Patented Mar. 28, 1939

2,152,472

UNITED STATES PATENT OFFICE

2,152,472

PROTECTIVE EQUIPMENT

George W. Fyler, Stratford, Conn., assignor to General Electric Company, a corporation of New York

Application August 14, 1935, Serial No. 36,157
Renewed December 31, 1938

18 Claims. (Cl. 250—17)

My invention relates to protective apparatus and more particularly to apparatus for protecting the individual units of electrical apparatus of a multiunit system from faults while maintaining in service those units of the system which are free from fault.

While my invention is not limited thereto I contemplate its use more particularly in connection with high frequency apparatus such as carrier wave signal transmitters and amplifiers. It has for one of its objects to provide a novel and improved form of protective system for such apparatus.

In connection with high power broadcast transmitters, such as are used for radio program broadcasting, the continuity of service of the transmitting equipment is of extreme importance. If, by reason of a fault in an apparatus unit, such as an amplifier of said equipment, the transmitter cannot be continued in service at its normal rated capacity, it is important to continue it in service at lower than normal capacity. In this way a large portion of the total area served by the transmitter may be afforded service which is substantially free from interruptions due to faults in the transmitter equipment.

In copending application Serial No. 36,752, filed August 17, 1935, for E. A. Leach and which is assigned to the same assignee as my present application, is shown a high frequency transmitting system in which the individual operating units may be disabled and removed from service in response to a fault therein while the remainder of the equipment is continued in service. Thus, for example, the transmitter may comprise a plurality of amplifiers any one of which may fail at any time. Means are provided automatically to remove an amplifier in which a fault occurs from service and to establish connections whereby the other amplifiers are continued in service.

My present invention relates to systems of the type illustrated and described in the said application of E. A. Leach and it has for one of its objects to effect certain improvements in such apparatus whereby it is rendered more practicable.

A further object of my invention is to provide means whereby, while the different operating units are individually protected from instantaneous faults occurring therein, they are selectively removed from service only in dependence upon the nature of the fault. That is, they are removed from service, for example, if the fault be of greater than a predetermined duration or recurs within a predetermined interval. In this way, in accordance with my invention, removal from service of a unit in response to faults of a transient nature is avoided while at the same time the unit is protected from such a fault by being deenergized in response thereto and for the duration of the fault, and then is automatically restored to service.

In connection with equipment of the type referred to, there are certain apparatus units, such as power supply equipment, and audio amplifiers, which are essential to any operation of the system. One of the objects of my invention is to provide means whereby in response to a fault of either the continuous, or recurrent character referred to, in such units the entire apparatus is deenergized.

Still another object of my invention is to prevent deenergization of certain of the operating units which are free from fault in response to a fault condition produced in the power supply equipment by reason of a fault which exists in an operating unit supplied with power thereby.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings in which Figs. 1, 2, and 3 taken together represent an embodiment of my invention.

These drawings may best be read by placing Fig. 1 at the left of Fig. 2 and Fig. 3 below Fig. 2 and spaced to align the lines extending from Fig. 2 to the other figures.

General

The drawings represent my invention as applied to a high frequency signal transmitter having three output high power amplifiers indicated by the rectangles A_1, A_2, and A_3 on the drawings, and two modulators M_1 and M_2. The amplifiers A_1, A_2, and A_3 are excited with high frequency oscillations supplied thereto by an exciter **1**, the input to each of the different amplifiers being connected across the output circuit **2** of the exciter for parallel operation. The output circuits of all of these amplifiers are connected in a series circuit extending from antenna **3** to ground **4**, which circuit may readily be traced on the drawings but which will later be described. Anode potential for operation of all the amplifiers as well as the modulators M_1 and M_2 is supplied by a rectifier **5**. Similarly bias potential for all of these units is supplied by a bias supply system **6**.

Signals to be transmitted are impressed upon line conductors **7** amplified by low power audio amplifiers **8** and supplied to the input of high power audio amplifier **9**, the output of which is supplied through a conductor **10** to the input of each of the modulators M_1 and M_2.

All of the amplifiers A_1, A_2, and A_3 and the modulators M_1 and M_2 are connected in operating

circuit relation with each other and have operating potential supplied thereto through respective portions of a common isolation switch mechanism indicated on the drawings directly above the rectangles representing these amplifiers and modulators. By means of this switch mechanism and the control circuits provided therefor, which will later be described, any one of these units may be automatically removed from service in response to a fault occurring therein while the remainder of the units are continued in service. In response to an instantaneous fault in any unit means are provided whereby all of the units are deenergized for the duration of the fault. If the fault, however, persists for more than a predetermined interval, or if it recurs within a predetermined time, even though the original fault and its recurrence be but instantaneous, the respective unit in which the fault occurred is automatically removed from service by the switch mechanism. Faults may likewise occur in the rectifying apparatus **5** and in the audio amplifier **9** as well as in the bias supply system for the different amplifiers. Means are also provided whereby a persistent or repeated fault in either of these units causes power to be removed from the entire apparatus.

Switch structure

Having now very generally indicated the character of system to be described, I shall first describe more in detail the switch structure shown in Figs. 1 and 2 whereby the desired isolation of the different units is effected. I will then describe in detail the circuits in which this isolation switch is connected, and later explain the operation thereof.

This isolation switch comprises a number of sections each of which controls the circuits of a respective apparatus unit A_1, A_2, A_3, M_1, M_2, these sections being indicated on the drawings by the brackets and reference characters of the respective apparatus unit preceded by the letter S. All of the different sections of the switch may be alike in construction and are represented by similar conventions on the drawings. Accordingly, I shall describe but a single section and will refer particularly to section SA_1. This section, it will be observed, comprises a sleeve **12** arranged for rotation on a shaft **13**. This shaft **13** extends throughout the length of the switch and the sleeves **12** of all of the different sections of the switch are arranged for rotation thereon and, of course, are suitably spaced in accordance with the position of the different apparatus units which are controlled by the respective section of the switch. Each of these sleeves has mounted thereon three non-conducting cross-arms **14**, **15**, and **16** each of which corresponds with a respective bank of six spaced contacts, these contacts in each of the different banks being designated by the letters *a* to *f* respectively. Each cross-arm has mounted at each of its opposite ends a conducting bridge member **14'**, **14''**; **15'**, **15''**; **16'**, **16''**; these conducting bridge members being arranged when the switch is in its normal condition, which is that shown in the drawings, to bridge a pair of contacts in the respective contact bank. For example, each of the bridge members **14'**, **15'**, **16'** are shown as bridging the contacts *a* and *b* of its respective bank, whereas the bridge members **14''**, **15''**, and **16''** are shown as bridging the contacts *d* and *e* of its respective bank.

It will be noted that the contacts of each bank are arranged in a circle, the contact *c* being positioned between contacts *b* and *d*, and the contact *f* being positioned between contacts *a* and *e*. Each of the sleeves **12** is arranged to be rotated as previously stated upon the rod **13** to a position such that the bridge members **14'**, **15'**, and **16'** bridge contacts *a* and *f* of their respective banks, whereas bridge members **14''**, **15''**, **16''** bridge contacts *c* and *d* of their respective banks. To effect this rotation of the sleeves **12** in each section of the switch a suitable actuating mechanism **17** is provided. While this mechanism may be of any suitable type, I prefer to employ a mechanism of the type shown, for example, in United States Patent No. 7,935,432 issued November 14, 1933 to Lawrence Bourst and entitled Electrohydraulic operating mechanism. Such a mechanism is commonly referred to as a Thrustor.

This mechanism comprises a motor operated pump which forces a suitable fluid, such as oil, from one side of a piston to the other, thereby actuating the piston in a certain direction. The return stroke of the piston may be caused by external force applied to the piston or by means biasing the piston to the normal position, the return movement being damped by the flow of oil through an orifice back to the original side of the piston.

The member **18** is reciprocated by the piston of the Thrustor and is attached to a lever **19** at an intermediate point thereof. This lever is pivoted at the point **22** and is connected at its opposite end through an intermediate member **23** to an arm **24** which is attached to the sleeve **12**. Thus when the Thrustor **17** is energized and its member **18** is actuated upwardly, the sleeve **12** is rotated about the rod **13** thereby carrying the different cross-arms to a position such that the bridge members **14'**, **15'**, **16'** engage the contacts *a* and *f* of their respective banks, and similarly the bridge arms **14''**, **15''**, and **16''** bridge contacts *c* and *d* of their respective banks.

The upper end of the intermediate member **23** is also connected to the end of a lever **25** which is pivoted at its opposite end. A switch member **26** carrying a number of movable switch contacts **27**, **28** and **29** is connected to an intermediate point on the lever **25** whereby the contacts carried by this member are reciprocated between different positions in accordance with the rotation of the sleeve **12**. The purpose of these contacts will later be indicated.

The return of a section of the switch from the alternate position to the normal position is effected at a time when the rotator **17** is deenergized, the rotation being caused by the bias of the piston of the rotator, aided, if desired, by spring **45** shown on the drawings.

It is necessary, however, prior to any rotation of any section of the switch that the movable contacts thereof be first disengaged from the respective stationary contacts, and further, that the rotation shall be completed prior to reengagement of the movable contacts with the respective stationary contacts. At least, pressure between the stationary and movable contacts should be removed before any rotary movement occurs and should be reapplied only after the rotary movement is completed. To effect this operation of the different sections of the switch the rod **13**, which extends through all of the sections, is arranged for longitudinal movement and to carry therewith the movable elements of

all of the different switch sections. Thus when shaft 13 is actuated to the right, the movable contacts of all the switch sections are operated to the right into disengaged relation with the stationary contacts. Any one or more sections of the switch may then be rotated to the alternate position when the shaft 13 may again be actuated to the left bringing the movable contacts into engagement with corresponding stationary contacts. When in the alternate position this engagement of the contacts retains the switch in position since the bias of the piston and spring 45 are insufficient to overcome friction between the contacts.

To effect this actuation of shaft 13 it is biased to the right by means of a spring 32 attached to the right end of the rod 13. The left end of the rod is attached at a point 33 to a cam 34. This cam is arranged for rotation about the pivot 35 above the point 33 whereby as the cam is reciprocated about this pivot it causes reciprocal longitudinal motion of the rod 13. The cam is restrained in the position shown against the tendency to counterclockwise motion under influence of the spring 32 by means of a latching device 36. This latching device has a roller 37 which normally lies behind a shoulder 38 of the cam whereby the cam is restrained against counterclockwise rotation.

The latching device 36 is attached to the armature of a latch magnet 39 whereby when this magnet is energized the latch is lifted to release the cam and the cam is then rotated under influence of the spring 32. If the magnet be then deenergized, the roller 37 falls upon the periphery of the cam and is thus held in an upward position. If the cam be now rotated in a clockwise direction to its final position, which is that shown in the drawings, the latch 36 again falls, the roller 37 dropping behind the shoulder 38 and restraining the cam in the position shown. To effect clockwise rotation of the cam an actuating mechanism 42, which may be of the same type as the actuating mechanism 17, is provided, this device being attached to the cam at the point 43 whereby when its piston actuated member 44 is operated upwardly the cam is rotated in a counterclockwise direction.

It will be understood that all of the mechanisms 17 and 42 serve an important function not only when energized to effect rotation of the respective section of the switch, or the cam 34, but also when deenergized to permit opposite rotation of the respective elements of the switch under influence, for example, of spring 45 or 32. Their function when deenergized is to damp the motion of the spring by reason of oil within the Thrustor flowing through an orifice, as previously explained, thereby to avoid abrupt, violent, or jerky, motion of any of the switch members, likely to impair any portion of the mechanism.

It will be observed that each section of the switch is provided with its respective auxiliary switches 27, 28, and 29. Certain additional auxiliary switches common to the entire switch are also useful in effecting its desired operation. Certain of these auxiliary switches comprise the armatures 46 and 47 which are connected at one end of a lever 48 which is pivoted at 49, the opposite end being connected to the armature of the latch magnet 39 whereby these switches are actuated in accordance with the energization of the latch magnet. These switches open when the latch magnet is energized and close only when the magnet has been deenergized and the roller 37 falls behind shoulder 38 of the cam. An additional auxiliary switch 52, which may be of the tumbler type, is actuated in accordance with the position of the cam 34. This switch has a control member 53 which is straddled by the bifurcated end of a lever 54 which is pivoted at an intermediate point 55. The opposite end of the lever is attached by rod 56 to a suitable point on the cam whereby the left end of the lever 54 is raised and lowered as the cam 34 is rotated. Thus when the cam rotates in a counterclockwise direction the control member 53 is raised to close the switch, and when the cam is rotated in a clockwise direction the member 53 is lowered to open the switch. The arrangement is such that the contacts of switch 52 are closed early in the counterclockwise rotation of the cam 34 and they remain closed until late in the clockwise rotation thereof.

An additional auxiliary switch 57, likewise of the tumbler type, and having a control member, or handle 60, is provided, together with means properly to time its operation with that of movement of the cam. This means comprises a rack made up of a pair of parallel bars 58 connected together, somewhat in the manner of the side rails of a ladder, and arranged for motion longitudinally of themselves upon a pair of supports 59 which extend through longitudinal slots in the ends of the parallel members. The control member 60 of switch 57 is preferably positioned between rungs of the ladder to be operated upwardly and downwardly thereby, but for clearness of illustration is shown as operated by prongs 61 projecting from one of the side rails of the ladder. This ladder comprising the bars 58 is arranged to be operated upwardly by means of a tail member 63, which is attached to the cam 34 and positioned to engage one of the rungs of the ladder during the counterclockwise motion of the cam and to lift the ladder to such a position that the lower prong 61 engages the handle 60 of the tumbler switch and causes the switch to close late in the counterclockwise motion of the cam. During the clockwise motion of the cam the tail member 63 moves downwardly but the ladder remains suspended by upper prong 61 engaging the member 60 since the weight of the ladder is not sufficient to operate the tumbler switch 60, which is, of course, spring biased to both positions and arranged for snap action as by means of a toggle. When the cam 34 reaches its final position, however, and roller 37 on latch 36 drops behind shoulder 38 of the cam, a member 62 carried by the latch falls upon a rung of the ladder with sufficient force to force it to its lower position causing the switch 59 to open its contacts.

Amplifier circuits

I shall now proceed to describe the circuits in which the switch structure already described is connected. In the first place, the amplifiers A_1, A_2, and A_3 may be of any suitable construction. These amplifiers may, for example, comprise a pair of electron discharge devices 64 connected in push pull relation, the grids being connected together by means of a suitable inductance coil 65 and the anodes being connected together by means of a tuned circuit 66 to which is coupled an output coil 67.

As previously stated, the inputs of the different amplifiers are excited in parallel from the exciter 1. This circuit for the amplifier A_1 extends from the output circuit 2 of exciter 1

through conductor 68, bridge member 16'' of section SA_1 of the switch in its normal position, and conductor 69 to one terminal of the inductance coil 65 and thence from the opposite terminal of this coil through conductor 72, bridge member 16' of section SA_1 of the switch, and conductor 73 to the opposite side of the output circuit to exciter 1. A similar circuit for each of amplifiers A_2 and A_3 may also be traced on the drawings.

As previously stated, the outputs of each of the different amplifiers are connected in series between antenna 3 and ground 4. This circuit extends from ground 4 through conductor 74, bridge member 14' of section SA_1 of the switch, conductor 75, output 67 of amplifier A, conductor 76, bridge member 14'', conductor 77, bridge member 14' of section SA_2 of the switch, conductor 78, output of amplifier A_2, conductor 79, bridge member 14'' of the switch, conductor 82, bridge member 14' of section SA_3 of the switch, conductor 83, output of amplifier A_3, conductor 84, bridge member 14'' of section SA_3 of the switch, conductor 85 and antenna 3. It will thus be seen that the outputs of all of the amplifiers are connected in series.

Anode potential for operation of the different amplifiers is obtained from the rectifier 5 through a circuit comprising conductor 86, resistance 87, modulation reactor 88, conductor 89, and thence through bridge members 15' of each of the different sections SA_1, SA_2, and SA_3 to the different amplifiers, this connection for the amplifier SA_1 comprising conductor 92 which extends to an intermediate point on a series of resistances 93 connected between the two anodes of the discharge devices 64.

Grid bias for the different amplifiers is supplied from a suitable bias source represented by the rectangle 6 to a common bias bus 94, the bias connection from this bus to each of the amplifiers extending through bridge member 15'' of the respective section of the switch, this connection for the amplifier A_1 comprising conductor 95, resistance 96 and inductance 97 to the midpoint of grid inductance 65 of the amplifier.

It will thus be seen that the grid connections to each amplifier extend through the contacts controlled by the cross-arms 16 of the respective switch section. The output circuits are controlled by the cross-arms 14, and the connections for supplying operating potentials are controlled by the cross-arm 15.

If a section of the switch corresponding to one of the amplifiers A_1, A_2, A_3 be rotated to a position such that its bridge members 14', 15', 16' engage contacts *a* and *f*, whereas the bridge members 14'', 15'', and 16'' engage contacts *d* and *c*, then the following changes in the circuits are effected. The output circuit 2 of the exciter is disconnected from the respective amplifier. The grids of the respective amplifiers are grounded at the contacts *f* and *c* of the right-hand bank of the respective section of the switch through conductors 72 and 69 respectively. The output circuit of each of the amplifiers is disconnected from the remainder of the apparatus at contacts *b* and *e* of the left-hand bank of the switch and a short circuit comprising conductor 98 extending between contacts *f* and *c* of the respective bank is substituted in the antenna circuit in its stead. The anode circuit for the respective amplifier is interrupted at contact *b* of the middle bank of the respective section of the switch, and the anode is grounded at contact *f* of that bank. The grid bias circuit is interrupted at contact *e* of this bank of the switch and the grids of the discharge devices are grounded at contact *c* thereof.

Thus it will be seen that with any section of the switch corresponding to one of the amplifiers A_1, A_2, and A_3 rotated to the position previously referred to, the corresponding amplifier is completely removed from its operating circuit relation with the other units, its grids and anodes are grounded, and an operating connection completed for the remaining units.

Modulator circuits

Now considering the sections of the switch corresponding to modulators M_1 and M_2, these modulators are likewise shown to be of the push-pull type, each comprising a pair of discharge devices 102. The grid circuits of these discharge devices are controlled by bridge members 16' and 16'', the grid of the upper discharge device 102 being connected to the input transformer 103 of the respective modulator through bridge member 16'' and the grid of the lower discharge device being connected to the input transformer through bridge member 16'. The outputs of these modulators are connected in series in the circuit extending from the left-hand terminal of the modulation reactor 88 through bridge member 14' of section SM_1 of the switch thence through output coil 104 of modulator M_1, bridge member 14'', conductor 105, bridge member 14' of switch section SM_2, output 106 of modulator M_2, bridge member 14'', and condenser 107 to ground, it of course being understood that the opposite end of the modulation reactor 88 is also grounded for signal currents.

Anode potential for operation of the different modulators M_1 and M_2 is supplied from rectifier 5 through conductors 86 and 108, and thence through bridge member 15'' of section SM_1 to modulator M_1 and bridge member 15'' of section SM_2 to modulator M_2. Bias potential for the operation of the modulators is not supplied through the switch but is supplied from a common modulator bias bus 110 which extends to the bias source 6.

If one of the sections SM_1 or SM_2 be rotated from the position shown to its alternate position, it will be observed that the circuit of the input transformer of the respective modulator is interrupted at contacts *e* and *b* of the respective section of the switch and the grids of this modulator are grounded at contacts *c* and *f* of this bank. The circuit for supplying anode potential to the modulator is interrupted at contact *e* of the middle bank of the respective section of the switch and the anodes of the modulator are grounded at contact *c* of this bank. The output transformer 104, or 106, is disconnected at contacts *b* and *e* of the left-hand bank of the respective section of the switch and instead thereof a short circuit comprising conductor 109 extending between contacts *c* and *f* of this bank is substituted in the series modulator circuit in its stead thereby to complete the operating circuit connection to the other modulator.

It will of course be understood that the circuits indicated in the rectangles A_1 and M_1 are incomplete and illustrated only with such detail as to present a full understanding of my present invention.

Control circuits

To effect the desired control of the switch in response to faults in any of the different apparatus units, certain control circuits are provided, these control circuits including a pair of main circuit breakers 112 and 113 whereby, among other things, the application of power to the rectifier 5 is controlled. This rectifier 5 may be of any suitable type, but preferably is one of the polyphase type having an alternating current supply circuit, which I have conventionally indicated on the drawings by the single line conductor 114, which extends through armature 115 of circuit breaker 112 when in its upper position, and armature 116 of circuit breaker 113 when in its upper position to source 117 of polyphase alternating current. These circuit breakers together with the Thrustors 17 and 42 are all controlled in response to certain protective relays in the different apparatus units, and throughout the equipment. These relays comprise, for example and among others, relays 122 in the circuits of each of the amplifiers, only the contacts thereof being shown in amplifiers A_2 and A_3; relays 123 in modulators M_1 and M_2, only the contacts thereof being shown in modulator M_2; and relay 124 in high power audio amplifier 9. These relays are all connected in the anode circuits of the different discharge devices and respond to a current of abnormally large magnitude to attract their armatures to positions opposite to those shown in the drawings. There are a large number of additional switches, relays and interlocks whereby the main circuit breakers 112 and 113 are controlled as will presently be explained.

To effect the desired selective operation of the switch in response to faults in the different apparatus units and at the same time to avoid operation of the switch in response to faults of a merely transient character, a group of control relays is provided for each section of the isolation switch, this group of control relays being represented at the lower portion of Fig. 3 of the drawings by the rectangles bearing the reference characters of the apparatus units to which they correspond preceded by the letter C. These groups of relays CA_1, CA_2, CA_3, CM_1, CM_2, are identical in construction and the circuit details of only one, namely, CA_1 are illustrated on the drawings. These units bring about the deenergization of all of the apparatus units in response to a fault of a persistent or repeated character in any apparatus unit, the isolation of the apparatus unit in which the fault occurred and reenergization and reconnection of the remaining units in operating circuit relation thereby to permit the transmitter to remain in service with reduced power output.

An additional system of control relays represented by the parallelogram C corresponding to the main rectifier 5 and audio amplifier 9 is also provided, this system of control relays being similar to that represented by the other rectangles of Fig. 3 but is not arranged to bring about the isolation of any unit. This is by reason of the fact that this group responds to faults in apparatus units essential to any service of the transmitter. The function of this group of relays is to remove power from the transmitter, upon the occurrence of certain faults in the audio amplifier or rectifier, or upon the occurrence of certain other conditions incompatible with operation of the transmitter.

All of the relay groups shown in Fig. 3 are arranged to respond to conditions in a single series control circuit which I shall now describe. This circuit extends from the positive side of a source of potential at the lower terminal of the winding of relay 125, through winding of relay 125, armature 47 in its upper position, conductor 126, relay 127 in control unit CA_1, conductor 128, thence through a similar relay in each of units CA_2, CA_3, CM_1, CM_2, in series to conductor 129, winding of relay 127 in relay group C, lower contacts of relay 132 in group C, "on" switch 133, "off" switch 133', conductor 134, contacts of time delay relay 135 and a series of contacts 136, 137, 138, etc. to ground.

The winding of each of the different relays 127 in the different relay control units is normally short-circuited through a circuit which includes desired series connected protective switches. This circuit in shunt with relay 127 of relay unit C comprises conductors 129 and 142, contacts of modulator bias protective relay 143, lower contacts of audio amplifier overload relay 124, conductor 144, contacts of amplifier bias protective relay 145, conductor 146, a group 147 of series connected contacts in rectifier 5, conductor 148, contacts of audio amplifier bias protective relay 149, conductor 152, and an additional group of contacts or switches 153 back to the opposite terminal of the winding of relay 127 of group C.

It will be noted that the bias protective relays 143, 145 and 149 are connected directly between the respective bias supply conductor and ground whereby these relays are normally energized but are deenergized upon removal of bias voltage such as might injure an apparatus unit to which bias from the respective conductor is supplied. The contact group 147 in the rectifier 5 may comprise any desired number of overload relays, either alternating current or direct current, an emergency shutdown switch, door interlocks, or any desired device in response to which it is desired that the apparatus should be shut down. Similarly the contact group 153, which may be arranged upon the control panel may comprise a door interlock, certain overload relays, emergency shutdown switch, and any additional switches which open upon a condition incompatible with continuance of service of the apparatus.

The short circuit across relay 127 for group CA_1 will also be traced. This circuit extends from conductor 126 through two groups of series contacts 154 and 155, normally closed contacts on relays 122, conductor 156, normally closed contacts on relay 157 to the opposite side of the winding of conductor 127. The groups of contacts 154 and 155 may comprise door interlocks corresponding to the respective amplifier, temperature relays responsive to the cooling system of the different amplifiers, water flow interlocks, or additional over load relays if additional discharge devices be employed, or any other switch responsive to a fault in the particular apparatus unit A_1 in response to which it is desired to isolate that unit from the other units and remove it from service.

It is necessary to operation of the apparatus that this series control circuit comprising the short-circuits across relays 127 shall be continuous from ground at the right-hand contacts of switch 138, to positive voltage at the lower terminal of the coil of relay 125, thereby energizing relay 125. If any one of the switches previously referred to as connected in the branches shorting the relays of winding 127 be opened.

the corresponding relay 127 becomes energized which in turn causes operation of the corresponding group of control relays to perform its desired protective function.

In addition, if any of the switches 136, 137, 138 opens, power is immediately removed from the transmitter and cannot be reapplied so long as any one of these switches is open. Relay 135 is a time delay relay, the winding of which is connected in shunt to the cathode supply to the rectifier 5 and the contacts of which close only after these cathodes have been heated to a desired operating temperature, which may require an interval of a half hour, for example. Its purpose is to prevent application of anode voltage to the equipment during this interval. Switches 136, 137 and 138 represent desired water temperature and flow interlocks for the different discharge devices, door interlocks, or any other switch which opens in response to a condition incompatible with further operation of the transmitter.

Operation

A further understanding of my invention may now best be had by reference to its operation. The apparatus is shown in its normal deenergized condition. Let us suppose that switch 119 is operated to its closed position to supply filament power to the rectifier 5. The winding of relay 135 is then energized, which after a predetermined time operates to close one break in the previously traced series control circuit, this time being sufficient to permit the filaments of the rectifiers to heat. Certain additional control operations by the operator, which are not related to my invention, may also be necessary to place the apparatus in condition, but assuming that these operations have been effected, the transmitter may then be placed into service by operation of the switch 133 thereby completing the series control circuit previously traced, and causing the energization of relays 125 and 158 in parallel, the latter winding being energized through the lower contacts of main circuit breaker 112. Relay 158 operates and energizes the winding of circuit breaker 112, which in turn operates all of its armatures to the upper position. Alternating current power is now supplied from the alternating current source 117 through resistance 164 to the alternating current bus 114 and rectifier 5. By means of its upper contacts and conductors 134 and 165 circuit breaker 112 short-circuits the switch 133. The circuit of relay 158 is broken by the lower contacts of circuit breaker 112, a circuit for relay 168 is completed, which relay operates and prepares a trip circuit for circuit breaker 112, a break is produced by contact 115 in the circuit of latch magnet 39, and an indicator lamp 166 is lighted.

Relay 125 operates and by means of its upper contacts completes a circuit for plus voltage through armature 162 on circuit breaker 113 in its lower position and winding of relay 163. Relay 163 operates and completes the closing coil circuit for circuit breaker 113 which in turn energizes and latches itself closed thereby short-circuiting the resistor 164. This resistor is provided for the purpose of limiting the starting transient current in the power supply circuit. This breaker also opens the circuit of relay 163 causing deenergization of that relay, prepares a circuit for trip coil 175, and energizes an indicator lamp 167. Power is now supplied to all of the different apparatus units and the transmitter is in normal operation.

In the event that any contact in any of the branch circuits shunting relays 127 be opened for any reason, relay 125 is immediately deenergized. The winding of relay 125 and the resistance in shunt therewith, however, pass sufficient current to energize the more sensitive relays 127 in the control relay groups with the result that the corresponding latter relay operates. Considering first the effect of relay 125, this relay 125 by means of its lower contacts applies ground to trip circuit conductor 169 thereby energizing relay 172 and trip coil 173 of circuit breaker 112 through the contacts of relay 168. Since relay 158 is deenergized, the closing coil of circuit breaker 112 is deenergized, with the result that this circuit breaker opens in response to energization of its trip coil 173. Its contacts 174 then complete a circuit for trip coil 175 of circuit breaker 113, the closing coil of which was deenergized by relay 163. Thus this circuit breaker also opens and all of the apparatus units are deenergized.

This tripping of the circuit breakers is sufficiently rapid for all faults except certain overload conditions. To protect against these overload conditions quick acting direct current protective relays 122, 123, 124 in the amplifiers and modulators, and additional alternating and direct current relays in the rectifier 5, the armature of one of which is indicated at 150 are provided with a pair of normally open contacts. These contacts are arranged, when closed, to connect conductor 169 to ground thereby to energize trip coil 173 exactly as was done by relay 125, but in more rapid response to the overload. Thus the trip circuit conductor 169 is grounded by relays 122, 123, 124 and also by relay 125. The latter relay serves as a check on the first mentioned relays to assure that the trip circuit conductor is grounded.

Thus opening of any contact in the series protective circuit trips the main circuit breakers. In the event that the fault be an instantaneous one, or one of duration less than a predetermined interval, such as 5 seconds, the circuit breakers are again closed when the fault clears and the respective contact in the protective circuit, which was opened thereby, closes. This, of course, causes energization of relays 125 and 158 which operate as before to close the main circuit breaker.

To describe the operations which occur in response to relays 127 let us first refer to relay group C.

The energization of relay 127 in response to the fault closes a circuit which extends from plus voltage through the contacts of relay 176, contacts of relay 177, conductor 178, upper contacts of relay 127, middle armature of relay 179 in its lower position, lower contacts of relay 179 and the winding of relay 181. This relay requires 5 seconds to close its contacts and since it is assumed that the fault cleared in less than 5 seconds, this relay does not operate. The winding of relay 180, however, is energized in parallel with winding of relay 181. This relay operates and by its lower contacts completes a holding circuit for itself through the contacts of relays 177 and 176. By means of its upper contacts it prepares a circuit for the winding of relay 179. This winding is energized when the fault clears and relay 127 deenergizes, the circuit being through the contacts of relays 176 and 177, lower contacts of relay 127, upper contacts of relay 180, and winding of relay 179. Relay 179 then energizes and completes a holding circuit for itself through its lower arma-

ture in its upper position and the contacts of relays 177 and 176. By its upper contacts it completes a circuit for the winding of relay 177 through the contacts of relay 176. Relay 177 is slow acting and requires approximately 1 minute before its contacts open. If no further fault occurs within this period of 1 minute the contacts of relay 177 open at the end of that period, thereby deenergizing relay 179 which operates and, in turn, causes the deenergization of relays 180 and 181 thereby restoring all of the relays to normal.

If a second fault occurs within the period of 1 minute, however, a circuit is completed by relay 127, which extends from plus voltage through the contacts of relays 176 and 177, upper contacts of relay 127, middle armature and upper contacts of relay 179, winding of relay 132 and switch 183 which is normally in its closed position. Relay 132 then operates, completing a holding circuit for itself through its upper contacts and by its lower contacts permanently opening the series protective circuit, thereby preventing any further automatic application of power to the equipment. That is, power is now "locked off".

After the fault has been cleared, however, the operator may again apply power to the equipment by operating switch 183 to the open position, thereby deenergizing relay 132 which closes its lower contacts. The equipment may now be placed in service by closing switch 133.

Relay 132 would also have become energized had the first fault which occurred been of a duration greater than 5 seconds, thereby causing the operation of time delay relay 181, the contacts of which directly energize the winding of relay 132 through the contacts of relays 177 and 176, thereby causing the series protective circuit to be opened.

The effect of "off" switch 133', "on" switch 133 and "automatic" switch 183 may now be better understood. Switch 133' is biased to the closed position and is used to stop the transmitter. Switch 133 is biased to the open position and is pressed to the closed position to start the transmitter. Switch 183 remains in either position to which it is operated. If switch 133 be pressed to start the transmitter it becomes short-circuited by the upper contact on circuit breaker 112, when that circuit breaker closes. If "automatic" switch 183 be open any fault causes the transmitter automatically to shut down. If "automatic" switch 183 be closed, power is removed only for the duration of the fault unless the fault be of the continuous or recurrent type previously referred to, when power is permanently locked off by relay 132. To shut down the transmitter, "off" switch 133' may be pressed. This opens the series protective circuit causing circuit breaker 112 to open thereby removing the short circuit from switch 133. Thus when switch 133' is released the series protective circuit is open at the contact of switch 133. In starting the transmitter switch 183 should first be opened to deenergize relay 132, if then energized.

It will be noted that each of the parallelograms CA_1, CA_2, CA_3, CM_1, CM_2, and C are divided into two rectangles by the dotted line. The relays in the lower of the two rectangles operate in exactly the same way as has been described in connection with group C. In place of the relay 132 of the upper rectangle representing group C two relays 185 and 186 are employed in the upper portion of the rectangles CA_1, CA_2, CA_3, CM_1, CM_2, and connected to control the isolation switch. The windings of these relays are energized through a switch 187 in response to a fault in the respective unit of greater than the duration determined by the relay 181 of the respective group, or to two faults within an interval determined by relay 177 of the respective group. Relay 186 is quick acting and immediately deenergizes lamp 188 and by means of its lower armature establishes a holding circuit for relays 185 and 186. By means of its armature 189 it completes a circuit extending from ground through said armature 189, conductor 192, auxiliary switch 29 of section SA_1 of the isolation switch, conductor 193, latch magnet 39 and armature 115 of circuit breaker 112 to the positive side of the source of potential. Latch magnet 39 is now energized and by means of armature 47 opens the series protective circuit. This assures against any operation of the isolation switch with power applied to the transmitter. Armature 47 also bridges contacts 194 to prepare a circuit for rotator 17. Armature 46 opens the power supply circuit for exciter 1 thereby removing excitation from amplifiers A_1, A_2, and A_3. The latch magnet also lifts the latch 36 thereby releasing the cam 34 which starts its counterclockwise rotation under influence of spring 32.

Relay 186 also by means of its upper contacts connects ground through conductor 195 to the rotor 17 of switch section SA_1. After a slight longitudinal movement of the shaft 13 sufficient to release its movable contacts from the stationary contacts, auxiliary switch 52 closes completely the circuit for the rotator through conductor 196, and switch 52 to positive potential at the middle contacts 194 of the switch 47.

Relay 185 has two pairs of contacts, the upper pair of which is normally closed, quick to open, and slow to close, the lower pair of which is normally open, quick to open, and slow to close. This is represented by time delay devices 197 and 198 attached respectively to the movable contacts, these contacts being indicated as connected by means of springs 199 and 202 to opposite ends of a reciprocating core in the winding. The time delay devices retard the movement of the contacts only in one direction as indicated by the arrows and hence upon energization of the winding the upper contacts quickly open and the lower contacts slowly close, and on deenergization the lower contacts quickly open and the upper contacts slowly close. It will be understood, however, that this showing of this instrumentality of the system is but schematic and symbolic and for purposes of explanation only. Any suitable device may be employed for the purpose. The upper contacts are connected in the shunt protective branch corresponding to amplifier A_1 and thus this branch is now held open by relay 185. The lower contacts are connected in shunt with the winding of relay 127 and the interval required for closing of these contacts is sufficiently great to assure that relay 186 has time to operate its contacts and to permit operation of latch magnet 39 to operate armatures 46 and 47.

The rotator 17 now rotates switch section SA_1 to its alternate position. At the beginning of this movement armature 28 makes a break in the circuit of main Thrustor 42. Armature 29 opens the circuit of latch trip magnet 39 thereby causing the latch to fall upon the cam. Just prior to completion of this movement armature 27 again closes the break in the circuit of main actuating mechanism 42 and armature 29 bridges its upper contacts to prepare a circuit through conductor

203 to control group CA_1 for a purpose later to be described. When the cam 34 has almost completed its counterclockwise motion auxiliary switch 57 closes thereby completing a circuit from plus voltage through switch 57, main Thrustor 42, armature 27, which is now in its upper position, and armature 28 of each of the other switch sections to ground. The main Thrustor now operates the cam 34 in a clockwise direction thereby again moving shaft 12 to the left and closing all of the switches. Just before it completes this movement switch 52 opens thereby deenergizing the rotator 17 and when this movement is finally completed latch 37 drops, locking the cam in the position shown and switch 57 opens, deenergizing the main Thrustor. Simultaneously switches 46 and 47 close, switch 46 again energizing exciter 5 and switch 47 closing the series protective circuit. Switch section SA_1 is now retained in the position to which it has been actuated by friction between its stationary and movable contacts. Amplifier A_1 is now disconnected from the system, and since the lower contacts of relay 185 are closed thereby short-circuiting the respective branch of the series protective circuit, this circuit becomes completed as soon as armature 47 engages its upper contacts. Relays 125 and 158 immediately close the circuit breakers, thereby applying power to the remainder of the equipment. The transmitter now is again energized for operation with the exception that the amplifier A_1 is disconnected and deenergized. The signal voltage, however, which is supplied to the modulator is now reduced, this having been effected by armature 189' of relay 186 which causes the energization of relay 208 through an obvious circuit.

This relay operates and inserts in the input circuit of the amplifier 8 an attenuation pad thereby to reduce the applied signal voltage. Obviously, the voltage applied to the antenna is now also reduced.

It will, of course, be understood that the same operation occurs in connection with each of the other amplifiers, or modulator units whereby any one or more of these units may be automatically removed from service in response to a sustained or repeated fault therein.

The time required for operation of the isolation switch and during which the transmitter is deenergized, i. e. "off the air", may be in the order of four seconds. Thus the service of the transmitter, for all purposes of the broadcast listener, is continuous even though faults occur requiring isolation of certain of the apparatus units.

It sometimes happens in the operation of the transmitter that it is desirable to shut the transmitter down completely, the control circuits being deenergized, and then again to replace the transmitter in service with the isolation switch in the same condition in which it was prior to the shutdown. When the control circuits are deenergized relays 185 and 186 corresponding to an isolated unit are actuated to the deenergized position. To energize these relays corresponding to an isolated unit, when the transmitter is again put in service, the upper contacts, cooperating with armature 29 in the different switch sections, and conductors 203 and 206 are provided, the latter being connected to positive potential. Thus when voltage is again applied to conductor 206 it is supplied through armature 29 of an isolated unit and conductor 203 to the windings of relays 185 and 186, whereby these relays are again energized.

An isolated unit may again be restored to service by operating switch 187 to its lower position. This switch deenergizes relays 185 and 186 and by means of its lower contacts connects ground to conductor 193 thereby again energizing the latch trip magnet. This, of course, initiates the cycle of operations of the main Thrustor but since relay 186 corresponding to the isolated unit is deenergized, the rotator of that unit is likewise deenergized. Accordingly, as soon as pressure is released between the stationary and movable contacts of the isolated switch section, that section returns under influence of the bias of the Thrustor aided by spring 45 to the normal position. Upon substantial completion of this motion the main Thrustor is again energized and all of the switches are closed.

If it be desired manually to isolate any particular apparatus unit even though that unit be in serviceable condition, this may be effected by pressing switch 204. This switch energizes the windings of relays 185 and 186 which in turn brings about the isolation of the corresponding unit in the manner already described.

It will be noted that a relay 207 is connected in shunt with the relays 185 and 186 of apparatus unit CA_1 and a similar relay is connected in shunt with relay 132 of unit C. These relays energize when the corresponding relays with which they are in shunt become energized, and when operated energize a lamp 208'. These lamps may, of course, be located as desired, as for example, within the housing of the isolated apparatus unit thereby to illuminate that particular unit.

It sometimes happens that a fault in one of the amplifier or modulator units may produce an overload in the rectifier unit 5, which overload would be removed upon isolation of the amplifier or modulator unit in which the fault occurred. If, however, the overload relays of unit 5 operate in response to such a fault therein and cause operation of the relay group C, power will be locked off from the equipment by relay 132 in the manner that has already been described. This is undesirable and to avoid it relay 176 is employed, this relay being connected between conductors 126 and 129 and hence in shunt with all of the protective branches corresponding to units to be isolated. Thus this relay is short-circuited except when a fault occurs in one of the units capable of isolation. When this occurs relay 176 becomes energized and opens the energizing circuit for all of relays 177, 179, 180, 181, and 132 in the control group C. Thus this group is disabled during the period in which isolation of any apparatus unit is being effected by the other control units CA_1, CA_2, CA_3, CM_1, CM_2.

On the drawings immediately above each of the auxiliary switch groups 27, 28, 29, is shown a switch 209. These switches represent door interlocks on the housing of the different units capable of isolation. All of these switches are normally closed, connected in series, and arranged to control the bias source 6. This source, for example, may comprise a plurality of motor generator sets, each of which supplies a corresponding bias bus 94, 110, 210 with voltage of suitable value. The exciting windings of these generators are represented by the element 211 in the rectangle 6, this element being shown as connected between plus voltage and ground through the different door interlocks 209. When a unit has been isolated the auxiliary switch 28 of the respective switch section short-circuits the corre-

sponding door interlock. Thus the compartment occupied by the isolated apparatus unit may be entered without affecting the operating units.

The relay groups shown in the lower rectangles respectively control units C, CA_1, CA_2, CA_3, CM_1, CM_2, may conveniently be mounted on individual panels and arranged for plug and jack connection with the rest of the apparatus. These units may then be removed for repair while the remaining equipment is in service and without affecting any of the remaining equipment. Care should be taken, however, when any such relay group is removed, to open switch **183**, thereby to avoid successive operation of the main circuit breakers in response to a fault in the unit corresponding to the removed group. This may occur by reason of the short circuit across switch **133** if switch **183** be closed.

In the drawings the different isolation switch sections are shown by identical symbols. It may occur, however, in connection with the grid circuits of the modulators, for example, that to shorten the leads, the switch necessary to alter the modulator connections should be located somewhat closer to the modulator unit than the isolation switch structure can be placed. This may readily be effected by utilizing conventional knife blade switches in the apparatus unit and operating this switch from the sleeve of the respective switch section through a suitable lever arrangement.

It will be understood that while I have described my invention with particular reference to a high frequency transmitter, that its utility is in nowise limited to such application, and that I contemplate its use generally in connection with multiple unit electrical apparatus.

While I have shown a particular embodiment of my invention it will be understood that I am not to be limited thereto since it is capable of many modifications both in the circuit arrangement and in the instrumentalities employed. I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The combination, in a multiunit electrical apparatus, of means connecting the different units of said apparatus in operating circuit relation with each other, additional means to energize each unit, means responsive to a fault in any unit for deenergizing all of said units while maintaining the connection of said units in circuit relation with each other, and means responsive to continuation of said fault for more than a predetermined interval to disconnect the unit in which said fault occurred from operating circuit relation with the other of said units.

2. The combination, in a multiunit electrical apparatus, of means connecting the different units of said apparatus in operating circuit relation with each other, additional means to energize each unit for operation, means responsive to a fault in any unit for deenergizing said unit while maintaining the connections of said units in circuit relation with each other, and means responsive to recurrence of said fault within a predetermined interval to disconnect the unit in which said fault occurred from operating circuit relation with the other of said units.

3. The combination, in an electrical apparatus comprising a plurality of operating units connected together for operation, of switching means whereby any of said units may be disconnected from the other of said units and the other of said units reconnected for operation, and means responsive either to continuation of a fault for more than a predetermined interval, or to occurrence of more than a predetermined number of faults within a predetermined interval in any unit to operate said switching means to disconnect the unit in which said fault occurred from said other units and subsequently to reconnect said other units together for operation.

4. The combination, in an electrical apparatus comprising a plurality of operating units connected in circuit relation to each other, of means responsive either to continuation of a fault in any unit for more than a predetermined interval, or to occurrence of more than a predetermined number of faults therein within a predetermined interval, to disconnect the unit in which the fault occurred from the other of said units and to maintain in operating circuit relation the other of the units of said apparatus.

5. The combination, in an electrical apparatus comprising a plurality of operating units connected in circuit relation to each other, of means responsive to a fault in any unit to deenergize all of said units for the duration of said fault, and to reenergize said units in response to removal of said fault and means responsive to continuation of said fault beyond a predetermined time interval to prevent reenergization of the unit in which said fault occurred and to permit reenergization of the other of said units by said first means.

6. The combination, in an electrical apparatus comprising a plurality of operating units connected in circuit relation to each other, of means responsive to a fault in any unit to deenergize all of said units for the duration of said fault, and means responsive to repetition of said fault within a predetermined time interval to prevent reenergization of the unit in which said fault occurred and to permit reenergization of the other of said units.

7. The combination, in an electrical apparatus, of a plurality of operating units connected in operating circuit relation to each other, an additional unit common to said first units, the operation of said first units being dependent upon the operation of said additional unit, and means responsive to a fault in any of said units to deenergize all of said units for the duration of the fault, to reenergize said units after termination of said fault if it be of less than a predetermined duration, and to prevent reenergization of all of said units if said fault be in said additional unit and continuous for more than a predetermined interval.

8. The combination, in an electrical apparatus, of a plurality of operating units connected in operating circuit relation to each other, an additional unit common to said first units, the operation of said first units being dependent upon the operation of said additional unit, means responsive to a fault in any of said units to deenergize all of said units for the duration of the fault, means to deenergize all of said units in response to termination of the fault, and means to prevent reenergization of the unit in which the fault occurred if it be in one of said first units and of greater than a predetermined duration.

9. The combination, in an electrical apparatus, of a plurality of operating units connected in operating circuit relation to each other, an

additional unit common to said first units, the operation of said first units being dependent upon the operation of said additional unit, means responsive to a fault in any of said units to deenergize all of said units for the duration of the fault and to reenergize said units in response to termination of said fault, and means responsive to recurrence of said fault within a predetermined interval if said fault be in one of said first units to isolate said one unit from operating circuit relation with the other units.

10. The combination, in an electrical apparatus, of a plurality of operating units connected in operating circuit relation to each other, an additional unit common to said first units, the operation of said first units being dependent upon the operation of said additional unit, and means responsive to a fault in any of said units to deenergize all of said units for the duration of the fault, to reenergize said units after termination of said fault if it be of less than a predetermined duration, and to prevent reenergization of all of said units if said fault be in said additional unit and recurs within a predetermined interval.

11. The combination, in an electrical apparatus comprising a plurality of units connected in operating circuit relation, of a power supply unit common to said other units, means responsive to a fault in any of said operating units to remove the unit in which the fault occurred from operating circuit relation with the other of said units and to maintain the other of said units in operation, means responsive to a fault condition in said power supply unit to deenergize all of said operating units, and means to prevent operation of said last means in response to a fault condition in said power supply unit created by a fault in one of said operating units.

12. The combination, in a high frequency apparatus, of a plurality of electron discharge devices, a unitary switch structure including switching means connecting the output circuits of said discharge devices in operating circuit relation, and to supply operating potentials to the electrodes of said discharge devices, means responsive to faults in any of said discharge devices to deenergize all of said discharge devices, means responsive to said fault only if it be of predetermined character to disconnect said discharge device from the other of said discharge devices and to then reconnect the other of said discharge devices in operating circuit relation.

13. The combination, in a high frequency apparatus of a plurality of amplifiers, power supply apparatus for said amplifiers, a unitary switch structure extending in proximity to all of said amplifiers, said unitary switch structure including switching means connecting all of said amplifiers in operating circuit relation and to supply operating potential from said power supply apparatus thereto, means responsive to a fault in any of said amplifiers to deenergize said power supply unit, and means responsive to certain of the faults to which said last means responds to operate said unitary switch structure to disconnect all of said amplifiers from each other and then to reconnect said amplifiers other than the one in which the fault occurred for operation while the amplifier in which the fault occurred remains deenergized.

14. The combination, in a high frequency apparatus of a plurality of amplifiers, power supply apparatus for said amplifiers, a unitary switch structure extending in proximity to all of said amplifiers, said unitary switch structure including switching means connecting all of said amplifiers in operating circuit relation and to supply operating potential from said power supply apparatus thereto, means responsive to a fault in any of said amplifiers to deenergize said power supply unit for the duration of the fault and then to reenergize said power supply apparatus, means selectively responsive to certain of said faults to operate said unitary switch structure, while said power supply apparatus is deenergized, to disconnect the amplifier in which the fault occurred from the other amplifiers and to reestablish operative connections for the other of said amplifiers before said power supply apparatus is again energized.

15. In combination, a plurality of high frequency amplifiers connected in circuit relation with respect to currents amplified thereby, means to energize said amplifiers for operation, means responsive to a fault in any of said amplifiers to deenergize all of said amplifiers, and means operative in response to said fault only if it be of predetermined character, to disconnect the amplifier in which the fault occurred from said circuit relation with the other amplifiers with respect to amplified currents and to reconnect the other amplifiers in circuit relation with respect to currents amplified thereby.

16. In combination, a plurality of high frequency amplifiers connected in circuit relation with respect to currents amplified thereby, means to energize said amplifiers for operation, means responsive to a fault in any of said amplifiers to deenergize all of said amplifiers and to reenergize said amplifiers after removal of said fault unless said fault continues for more than a predetermined interval, and means operative upon continuation of said fault for more than said predetermined interval to disconnect the amplifier in which the fault occurred from the other amplifiers while said amplifiers are deenergized, and to then reenergize said other amplifiers.

17. In combination, a plurality of high frequency amplifiers connected in circuit relation with respect to currents amplified thereby, means to energize said amplifiers for operation, means responsive to a fault in any of said amplifiers to deenergize all of said amplifiers and to reenergize said amplifiers after removal of said fault, and means responsive to occurrence of a fault more than a predetermined number of times within a predetermined interval in any amplifier to disconnect the amplifier in which the fault occurred from the other amplifiers while said amplifiers are deenergized and to then reenergize said other amplifiers.

18. The combination, in a high frequency transmitter adapted for operation with a predetermined power output, of means to supply signal currents to said transmitter for transmission thereby, means responsive to a fault in said transmitter to connect said transmitter for operation at less than said predetermined power output, and to produce a corresponding reduction in the intensity of said signal currents supplied to said transmitter.

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CERTIFICATE OF CORRECTION.

Patent No. 2,152,472. March 28, 1939.

GEORGE W. FYLER.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, line 15, for the patent number "7,935,432" read 1,935,432; page 9, second column, line 67, claim 8, for "deenergize" read reenergize; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 16th day of May, A. D. 1939.

(Seal)

Henry Van Arsdale
Acting Commissioner of Patents.

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Acting Commissioner of Patents.