# United States Patent [19]

**Lingenfelter**

[11] **3,783,206**

[45] **Jan. 1, 1974**


[54] **TAP CHANGING APPARATUS WITH IMPROVED CONTACT STRUCTURE TO ELIMINATE ELECTRICAL FIELDS ACROSS OPEN INTERRUPTER SWITCHES**


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[52] **U.S. Cl.** ..... **200/11 TC,** 323/43.5

[51] **Int. Cl.** ..... **H01h 21/20**

[58] **Field of Search** ..... 200/11 TC; 323/43.5



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*Primary Examiner*—J. R. Scott

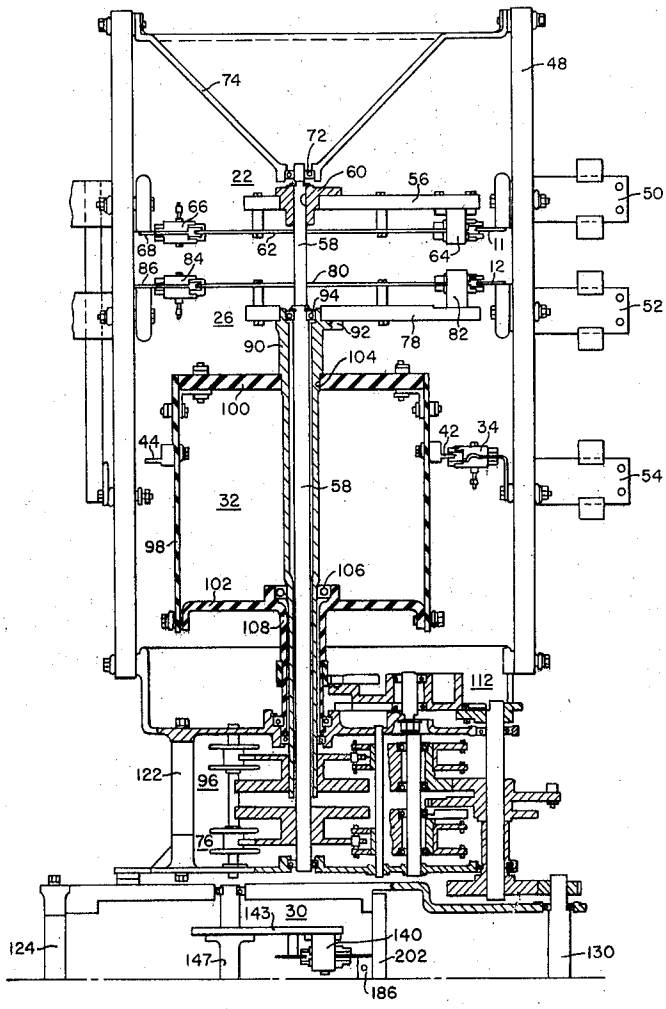
*Attorney*—A. T. Stratton et al.



[57] **ABSTRACT**

Apparatus for providing load tap changes having means for protecting the current interrupting switches from winding surge voltages. Current interrupting switches are connected to stationary contacts of a load transfer switch. Movable contacts of the load transfer switch rotate during a tap change to shunt the open and closed current interrupting switches and to eliminate the electrical fields across open current interrupting switches upon completion of the tap change.


**8 Claims, 10 Drawing Figures**



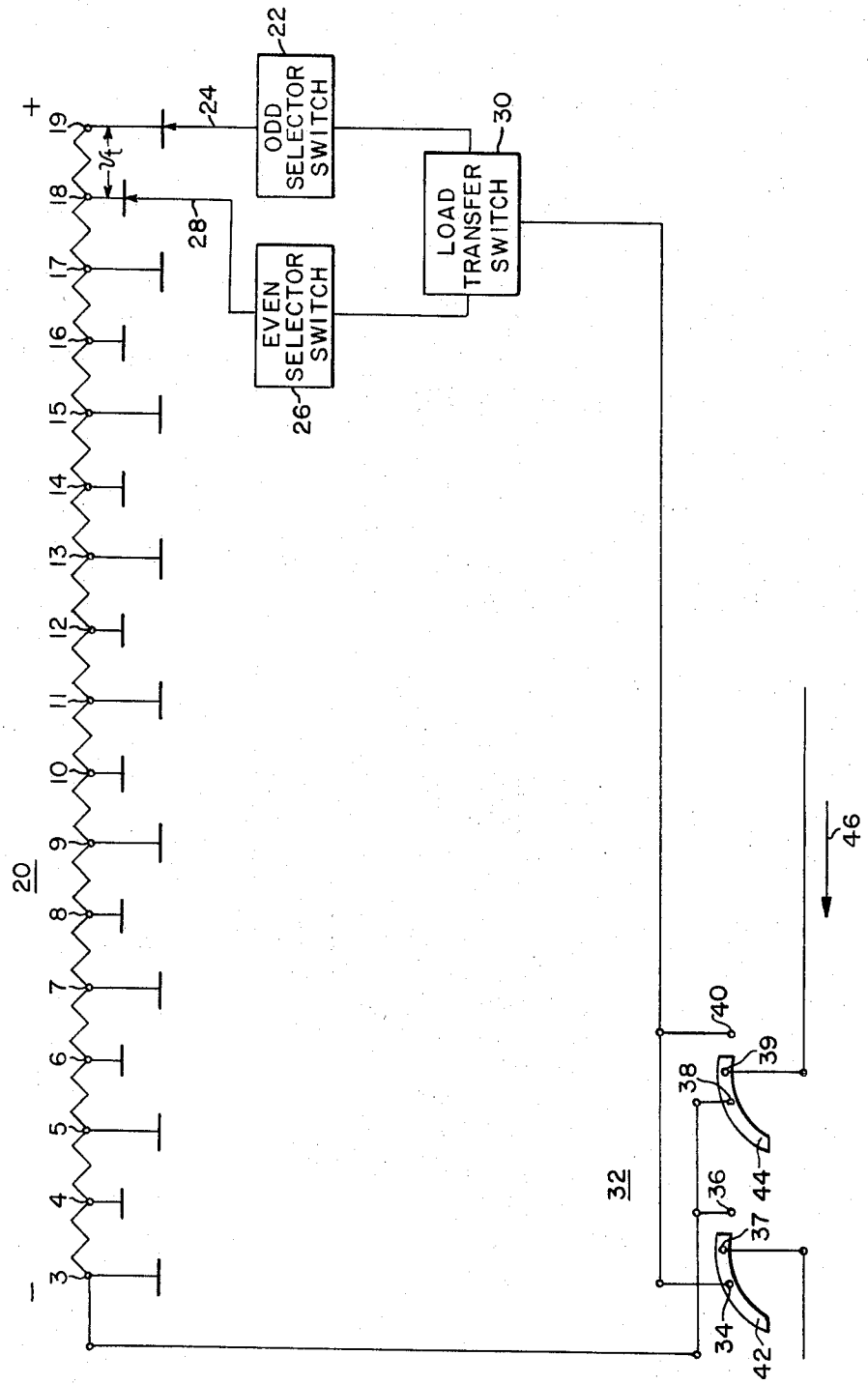

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6
5
4
3
−
20
24
28
22
ODD SELECTOR SWITCH
EVEN SELECTOR SWITCH
26
30
LOAD TRANSFER SWITCH
32
40
39
38
36
37
44
34
42
46

FIG. 1

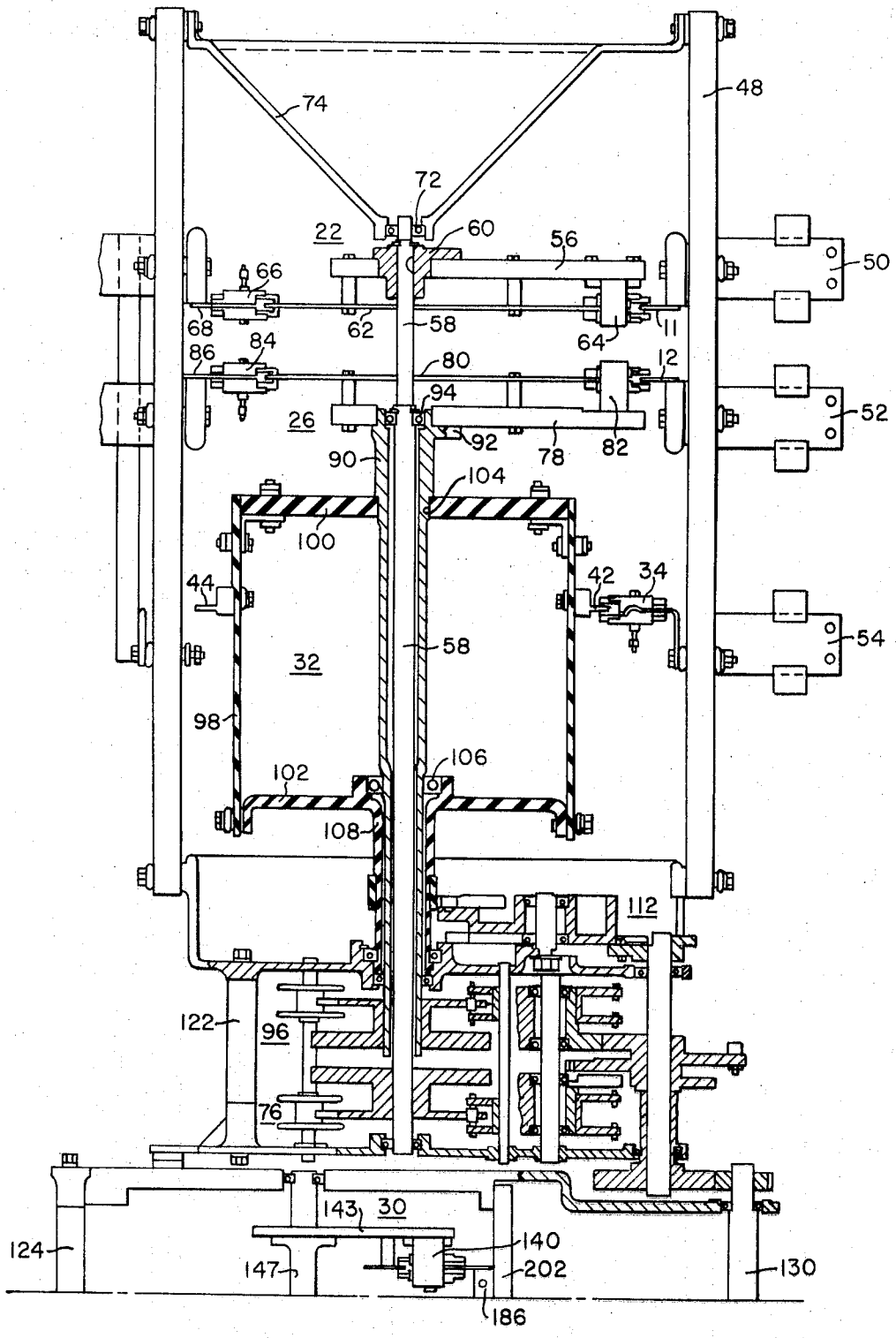

74
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58
64
11
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84
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12
94
26
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92
78
82
90
104
100
44
42
34
54
32
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108
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122
96
76
143
30
124
140
147
202
130
186

FIG. 2A

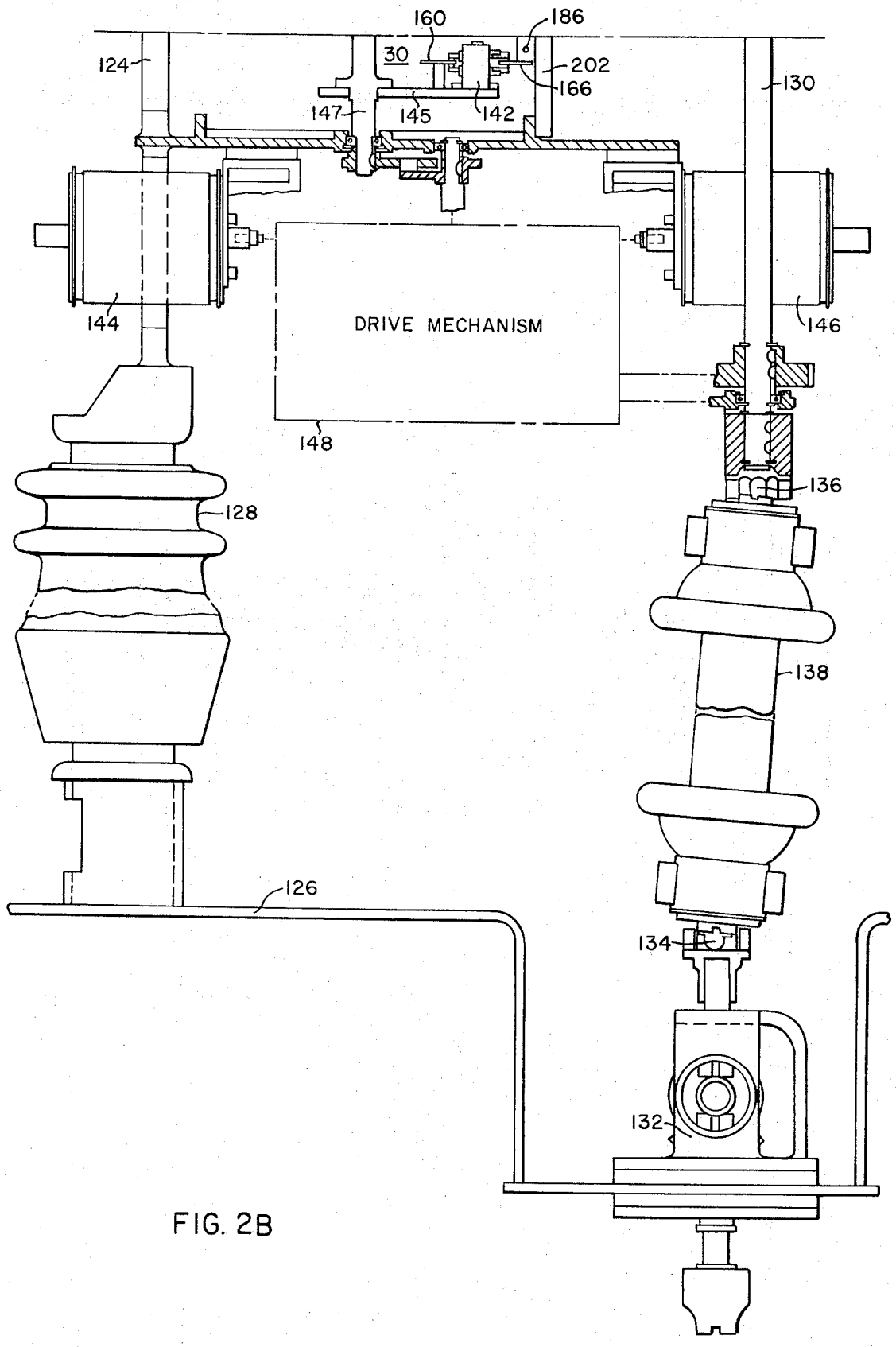

160
186
30
124
202
166
130
147
145
142
DRIVE MECHANISM
144
146
148
136
128
138
126
134
132

FIG. 2B

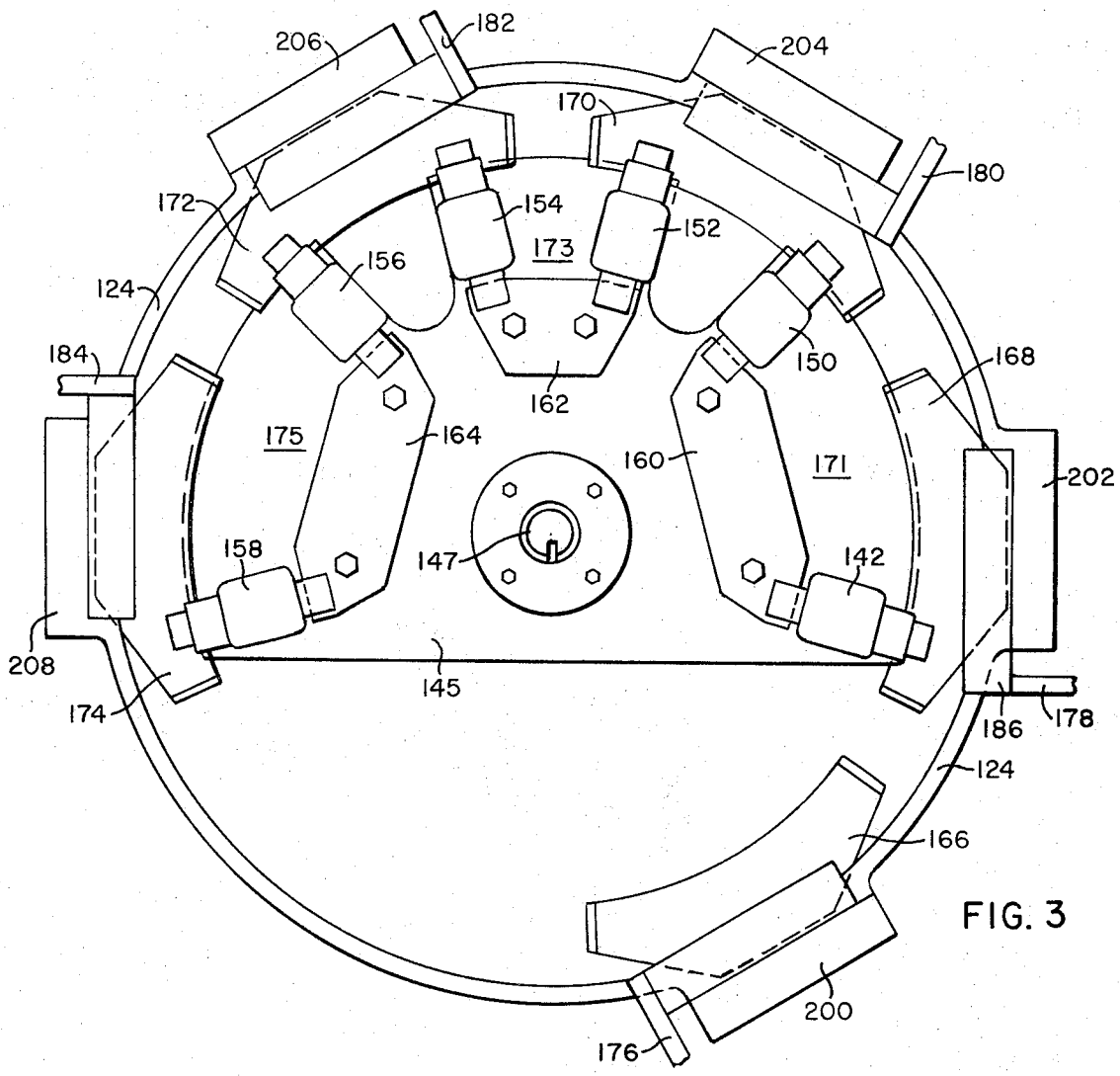



FIG. 3

FIG. 4

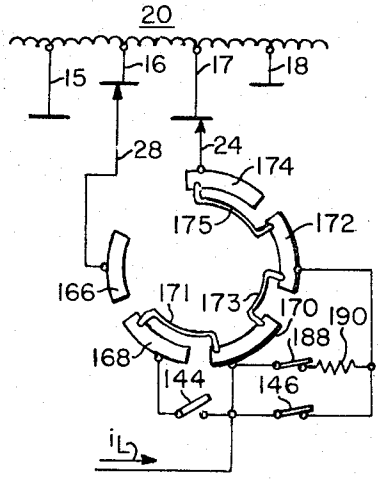



FIG. 5

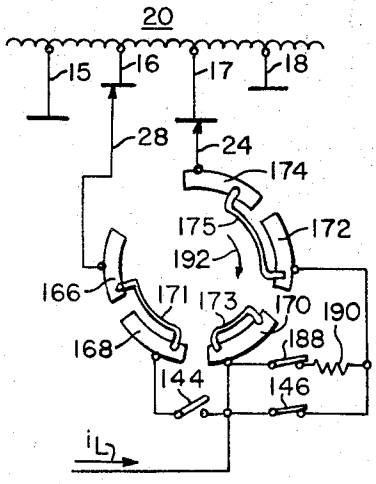


FIG. 6

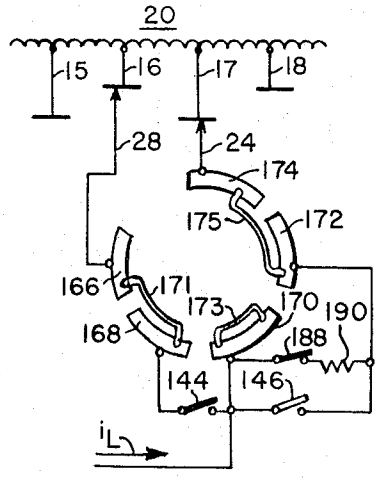



FIG. 7

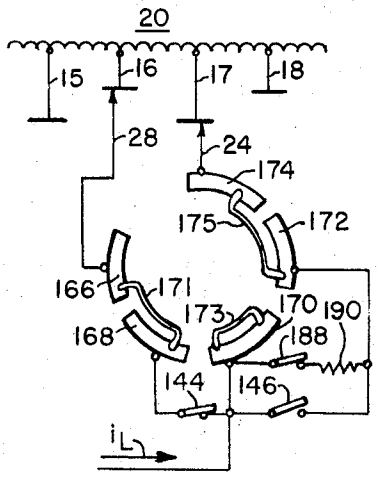



FIG. 8

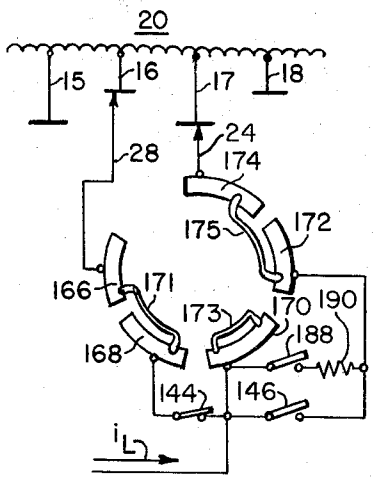
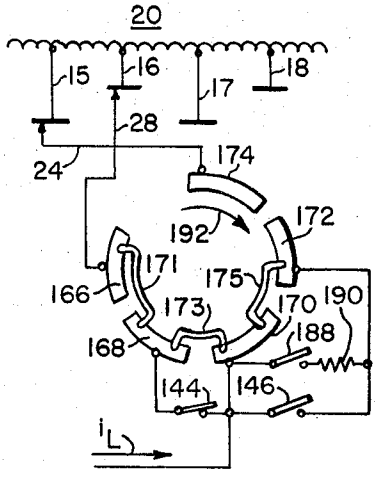



FIG. 9



# TAP CHANGING APPARATUS WITH IMPROVED CONTACT STRUCTURE TO ELIMINATE ELECTRICAL FIELDS ACROSS OPEN INTERRUPTER SWITCHES

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates, in general, to tap changers for electrical apparatus and, more specifically, to tap changer load transfer switches.

2. Description of the Prior Art

Tap changers are usually associated with transformer windings having a plurality of taps thereon. The basic purpose of the tap changer is to connect a load to the tapped transformer winding at the correct tap position. Load tap changers must be capable of changing the tap to which the load is connected while the winding is energized and load current is flowing.

A load transfer switch is used in load tap changers to change the flow path of the load current from one tap to another tap. Vacuum switches are generally used in high-voltage load tap changers to interrupt the load current. The operation of a conventional load transfer switch containing vacuum switches or "bottles" is described in U.S. Pat. No. 3,544,884, which is assigned to the same assignee as is this invention. The patent applications filed on July 6, 1972 and Jan. 9, 1973, Ser. Nos. 269,361 and 322,236 respectively, describe tap changing apparatus suitable for use with this invention.

In conventional tap changing apparatus, the vacuum switches are usually allowed to remain connected to the tapped winding while the switch is open after a tap change. This allows an electric field to exist across the vacuum switch and allows winding voltage surges to be applied to the vacuum switches. Therefore, it is desirable, and it is an object of this invention, to provide a load tap changer wherein open vacuum switches are not connected across the tapped winding after a tap change. It is also desirable, and it is another object of this invention, to provide a load tap changer wherein open vacuum switches are bypassed by the load transfer switch after a tap change, thereby eliminating electric fields across the open vacuum switches.

## SUMMARY OF THE INVENTION

There is disclosed herein new and useful tap changing apparatus which removes the electric field from open vacuum switches and which also provides a bypass current path around the closed vacuum switches. The tap changing apparatus includes a multiple-position load transfer switch having a plurality of stationary and movable contacts. The stationary contacts are connected to vacuum switches and a current limiting impedance element. The movable contacts connect together a pair of stationary contacts. During a tap changing operation, the movable contacts change positions and the vacuum switches open and close in a predetermined sequence. When the tap change is completed, the movable contacts are in positions which bypass the open and closed vacuum switches and which disconnect one tap terminal from the open vacuum switches.

## BRIEF DESCRIPTION OF THE DRAWINGS

Further advantages and uses of this invention will become more apparent when considered in view of the following detailed description and drawings, in which:



FIG. 1 is a schematic diagram of a tapped winding and a load tap changer constructed according to this invention;

FIG. 2A is an elevational view showing the upper portion of a load tap changer constructed according to this invention;

FIG. 2B is an elevational view showing the lower portion of a load tap changer constructed according to this invention;

FIG. 3 is a top plan view of the movable and stationary contacts of a load transfer switch constructed according to this invention;

FIGS. 4—9 are schematic diagrams illustrating different positions of the load transfer switch during a tap changing operation.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Throughout the following description, similar reference characters refer to similar members in all figures of the drawings.

Referring now to the drawings, and FIG. 1 in particular, there is shown a schematic diagram of a load tap changer constructed according to this invention. The tapped winding **20** includes the tap portions or terminals **3** through **19.** An odd selector switch **22** includes a movable contact **24** which may be moved to connect to the odd numbered tap terminals. An even selector switch **26** includes a movable contact **28** which may be moved to connect the even numbered tap terminals. The load transfer switch **30** transfers the load from one selector switch to the other selector switch during a tap change. The reversing switch **32** includes the stationary contacts **34, 36, 37, 38, 39** and **40** and the movable contacts **42** and **44.**

The function of the load transfer switch **30** is to connect the reversing switch **32** to either the odd selector switch **22** or to the even selector switch **26.** The load transfer switch **30** must be capable of interrupting the current flowing to one selector switch and transferring the flow of load current to the other selector switch.

FIG. 2A shows the upper portion and FIG. 2B shows the lower portion of a load tap changer constructed according to this invention. The tap changing apparatus includes a support member **48** which may be constructed of an insulating material. The odd tap contacts, such as contact **11,** the even tap contacts, such as tap contact **12,** and the reversing switch stationary contacts, such as contact **34,** are attached to the support member **48.** The contacts **11, 12** and **34** include connectors **50, 52** and **54,** respectively, which are suitable for connecting the necessary electrical leads to the contacts.

The odd selector switch **22** includes the insulated arm **56** which is attached to the shaft **58** by the collar **60.** A contact plate **62** is attached to the arm **56** and is constructed of a conducting material. The finger contact structure **64** is also attached to the insulated arm **56** and electrically connects the contact plate **62** to the tap terminals, such as tap terminal **11.** A finger contact structure **66** is attached to the stationary terminal **68** and provides contact between the contact plate **62** and the stationary terminal **68.** Stationary terminal **68** is electrically connected to the transfer switch **30** by suitable electrical conductors.

The shaft **58** extends through the bearing **72** which is secured by the end hood **74.** The shaft **58** is rotated

by the odd selector switch drive mechanism **76.** As the shaft **58** is rotated, the insulated arm **56** and the contact plate **62** rotate to change the tap terminal which is connected to the stationary terminal **68.** The drive mechanism **76** is constructed to rotate the shaft **58** in the proper direction and at the proper time in sequence with the other moving parts of the tap changing apparatus.

The even selector switch **26** includes the insulating arm **78,** the contact plate **80,** the finger contact structures **82** and **84,** and the stationary terminal **86,** all of which are constructed similar to the components of the odd selector switch **22.** The insulating arm **78** is attached to the shaft **90** by the collar **92.** Shaft **90** is coaxially positioned around the shaft **58** and is secured by the bearing **94.** The shaft **90** is rotated by the even selector switch drive mechanism **96.** As shaft **90** rotates, the insulated arm **78** and the contact plate **80** rotate to change the tap terminal which is connected to the stationary terminal **86.** The stationary terminal **86** is electrically connected to the transfer switch **30** by suitable electrical conductors.

The reversing switch **32** includes a drum support **98** which is attached to the drum braces **100** and **102.** The drum brace **100** contains an opening **104** through which the shafts **58** and **90** extend. The drum brace **102** is supported from the shaft **90** by the bearing **106.** The drum brace **102** includes a shaft **108** which is positioned coaxially with the shafts **58** and **90.** The shaft **108** is rotated by the reversing switch drive mechanism **112.** Satisfactory construction materials, such as a conducting material for the drum brace **102** and the shaft **108,** and an insulating material for the drum brace **100** and the drum support **98,** may be used.

The support member **48** is secured to a housing structure **122** which houses the lower ends of the shafts **58, 90** and **108** and the drive mechanisms **76,96** and **112.** The housing structure **122** is mounted on top of the frame structure **124** which, as shown in FIG. 2B, is supported from the transformer casing **126** by suitable insulators, such as the insulator **128.** The input shaft **130** controls the drive mechanisms **76,96** and **112** and is rotated by a prime mover through the gear box **132,** the universals **134** and **136,** and the coupling insulator **138.** Thus, the potential on the portion of the tap changing apparatus which is located above the insulators **128** and **138** is isolated from the transformer casing **126.**

The transfer switch **30** is physically positioned within the frame structure **124.** The transfer switch **30** in this embodiment includes a plurality of finger contact structures, such as the finger contact structures **140** and **142.** The finger contact structures are attached to base plates **143** and **145** and are electrically connected in parallel circuit relationship with each other to provide adequate current capability.

FIG. **3** is a top plan view of the lower portion of the transfer switch **30.** The base plate **145** is constructed of an insulating material and is attached to the shaft **147.** The finger contact structures **142, 150, 152, 154, 156** and **158** are attached to the base plate **145** and engage with the conductor bars **160, 162** and **164.** The finger contact structures **142** and **150** and the conductor bar **160** form a movable contact **171** which is moved when the shaft **147** is rotated. The other finger contact structures and conductor bars form additional movable contacts **173** and **175.**

Stationary contacts **166, 168, 170, 172** and **174** are constructed of conductor blades which are attached to contact mounting members, such as member **186.** The electrical leads **176, 178, 180, 182** and **184** electrically connect the stationary contacts to other components of the tap changer. The contact mounting members are constructed of a conducting material and are attached to the insulating supports **200, 202, 204, 206** and **208.** Respective stationary contacts in the upper and lower portions of the transfer switch **30** are connected together by the contact mounting members.

The transfer switch **30** also includes current interrupting means such as the vacuum switches **144** and **146** and an additional vacuum switch **188** which is not illustrated in FIG. **2B.** The vacuum switches and the movable contacts of the transfer switch **30** are moved by the drive mechanism **148** which is driven by the rotation of the shaft **130.** The mechanical motion provided by the drive mechanism **148** moves the components of the transfer switch **30** in the proper sequence with the other moving parts of the tap changer. FIGS. **4–9** illustrate schematically the operation of the transfer switch **30** during a tap change.

Referring to FIG. **4,** the even selector switch is on tap terminal **16** of the tapped winding **20.** The odd selector switch is on tap terminal **17.** The sequence of operations described herein changes the tap position from tap terminal **17** to tap terminal **16.**

In tap position **17,** the load current $i_L$ flows through the stationary contact **170,** the movable contact **173,** the stationary contact **172,** the movable contact **175,** the stationary contact **174** and the odd selector switch movable contact **24** to tap terminal **17.** Some load current flows through the vacuum switch **146** and a small amount of load current flows through the vacuum switch **188** and the impedance **190,** which may be a power resistor. It is pointed out that the vacuum switch **144** is disconnected from tap terminal **16** and is shunted by the movable contact **171.**

The first step in providing a tap change is to rotate the base plate to which the movable contacts **171, 173** and **175** are attached in the direction indicated by the arrow **192** to provide the second position of the multiple position load transfer switch **30.** Although the operation is described with reference to the lower base plate and contacts, the operation of the upper base plate and contacts is similar. Upon rotation, the movable contact **173** disconnects the stationary contact **170** from the stationary contact **172.** In addition, the movable contact **171** disconnects the stationary contact **168** from the stationary contact **170** and connects the stationary contact **166** to the stationary contact **168.** In this configuration, as shown in FIG. **5,** the load current is mainly flowing through the vacuum switch **146,** the stationary contact **172,** the movable contact **175,** the stationary contact **174,** and the contact **24** of the even selector switch to tap terminal **17.** A small amount of current flows through the vacuum switch **188** and the impedance **190.**

FIG. **6** illustrates the next position of the load transfer switch **30** in providing a tap change. Vacuum switch **146** is opened and the load current flows through the vacuum switch **188,** the impedance **190,** the stationary contact **172,** the movable contact **175,** the stationary contact **174,** and the movable contact **24** to tap terminal **17.** Then, vacuum switch **144** is closed as shown in FIG. **7.** With this configuration, the load current flows

mainly through the vacuum switch **144**, the stationary contacts **166** and **168**, the movable contacts **171** and **28**, to tap terminal **16**. Tap-to-tap current is limited by the impedance **190**. The vacuum switch **188** is then opened as shown in FIG. **8**. This configuration eliminates the tap-to-tap currents completely.

FIG. **9** illustrates the final position in providing a tap change. The movable contacts **171**, **173** and **175** have been rotated in the direction indicated by the arrow **192** from the position shown in FIG. **8**. In addition, the movable contact **24** of the odd selector switch has been moved from tap terminal **17** to tap terminal **15** in preparation for the next tap change. It is pointed out that vacuum switches **146** and **188** are disconnected from tap terminal **15** and are shunted by the movable contact **175**.

When the tap changer has completed a tap change, the electric field across all of the vacuum switches is eliminated. The next tap changing operation is performed by the same load transfer switch movements, except that they are in reverse sequence. Thus, during tap changes, the load transfer switch rotates in an oscillating manner, that is, it rotates in one direction during one tap change and in the opposite direction during the next tap change.

Since numerous changes may be made in the above described apparatus, and different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all of the matter contained in the foregoing description, or shown in the accompanying drawings, shall be interpreted as illustrative rather than limiting.

I claim as my invention:

**1.** Tap changing apparatus comprising:

first and second tap selecting means;

first, second and third current interrupting means each having first and second terminals;

means for opening and closing said first, second and third current interrupting means;

first, second, third, fourth and fifth stationary contacts, said first stationary contact being connected to said first tap selecting means, said fifth stationary contact being connected to said second tap selecting means, the second terminal of said second current interrupting means being connected to said second stationary contact, the second terminal of said third current interrupting means being connected to said fourth stationary contact, and the first terminals of said first, second and third current interrupting means being connected to said third stationary contact;

impedance means electrically connected between said second stationary contact and the second terminal of said first current interrupting means;

first, second and third movable contacts; and

means for moving said first, second and third movable contacts in unison to first, second, third, fourth and fifth positions, said movable contacts connecting together appropriate stationary contacts in each position to maintain a current path between one of said tap selecting means and the first terminals of said first, second and third current interrupting means.

**2.** The tap changing apparatus of claim **1** wherein the first tap selecting means moves to a different tap terminal when the movable contacts move from the fifth position to the sixth position.

**3.** The tap changing apparatus of claim **2** wherein, when the movable contacts are in the first position, the first movable contact electrically connects together the first and second stationary contacts, the second movable contact electrically connects together the second and third stationary contacts, the third movable contact electrically connects together the third and fourth stationary contacts, the first and second current interrupting means are closed, and the third current interrupting means is open.

**4.** The tap changing apparatus of claim **2** wherein, when the movable contacts are in the second position, the first movable contact electrically connects together the first and second stationary contacts, the third movable contact electrically connects together the fourth and fifth stationary contacts, the first and second current interrupting means are closed, and the third current interrupting means is open.

**5.** The tap changing apparatus of claim **2** wherein, when the movable contacts are in the third position, the first movable contact electrically connects together the first and second stationary contacts, the third movable contact electrically connects together the fourth and fifth stationary contacts, the first current interrupting means is closed, and the second and third current interrupting means are open.

**6.** The tap changing apparatus of claim **2** wherein, when the movable contacts are in the fourth position, the first movable contact electrically connects together the first and second stationary contacts, the third movable contact electrically connects together the foruth and fifth stationary contacts, the first and third current interrupting means are closed, and the second current interrupting means is open.

**7.** The tap changing apparatus of claim **2** wherein, when the movable contacts are in the fifth position, the first movable contact electrically connects together the first and second stationary contacts, the third movable contact electrically connects together the fourth and fifth stationary contacts, the first and second current interrupting means are open, and the third current interrupting means is closed.

**8.** The tap changing apparatus of claim **2** wherein, when the movable contacts are in the sixth position, the first movable contact electrically connects together the second and third stationary contacts, the second movable contact electrically connects together the third and fourth stationary contacts, the third movable contact electrically connects together the fourth and fifth stationary contacts, the first and second current interrupting means are open, and the third current interrupting means is closed.

* * * * *