TAP CHANGING FURNACE TRANSFORMER

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Fig. 1

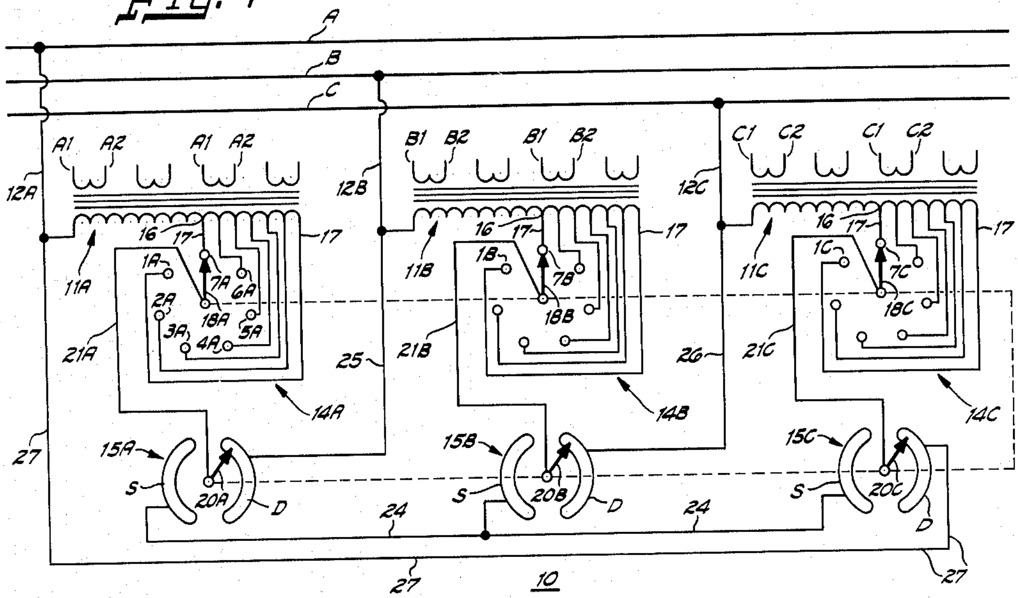


Fig. 4

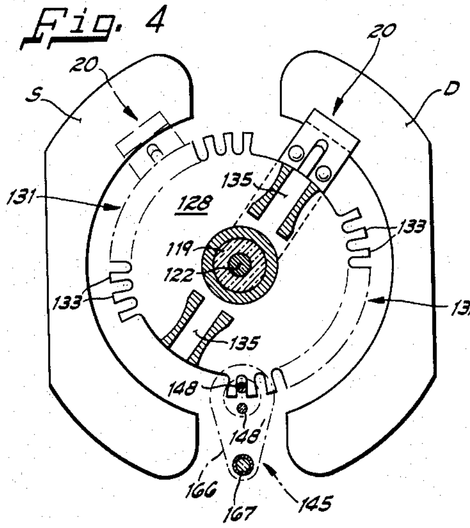


Fig. 5

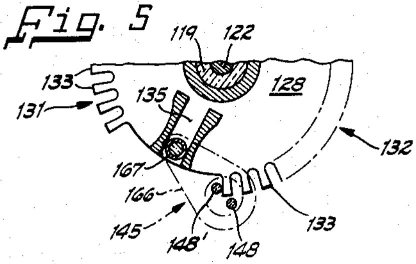
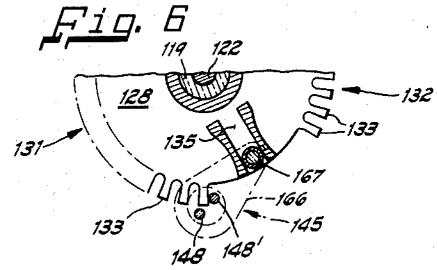


Fig. 6



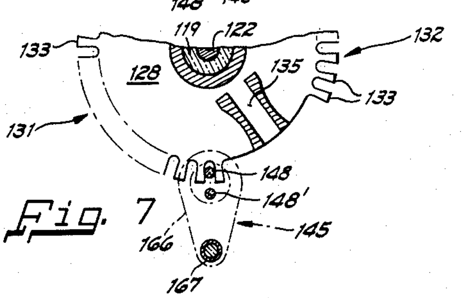


Fig. 7

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TAP CHANGING FURNACE TRANSFORMER

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Fig. 2

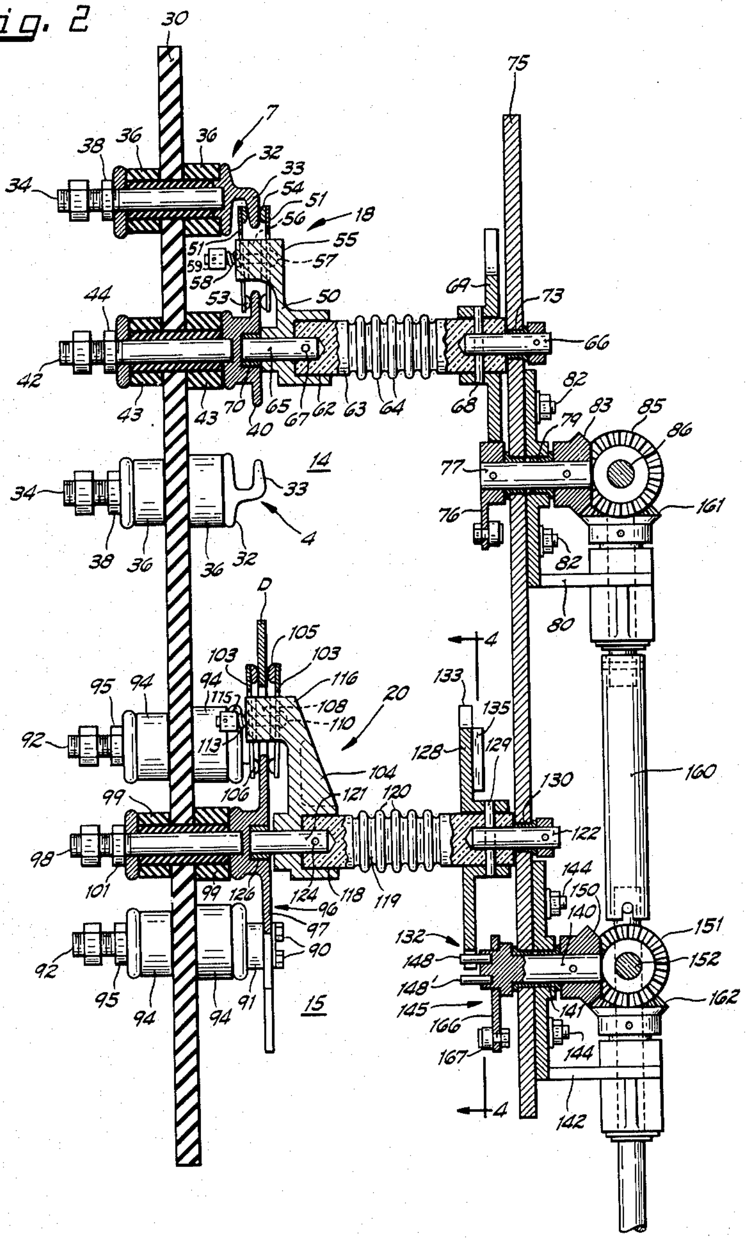

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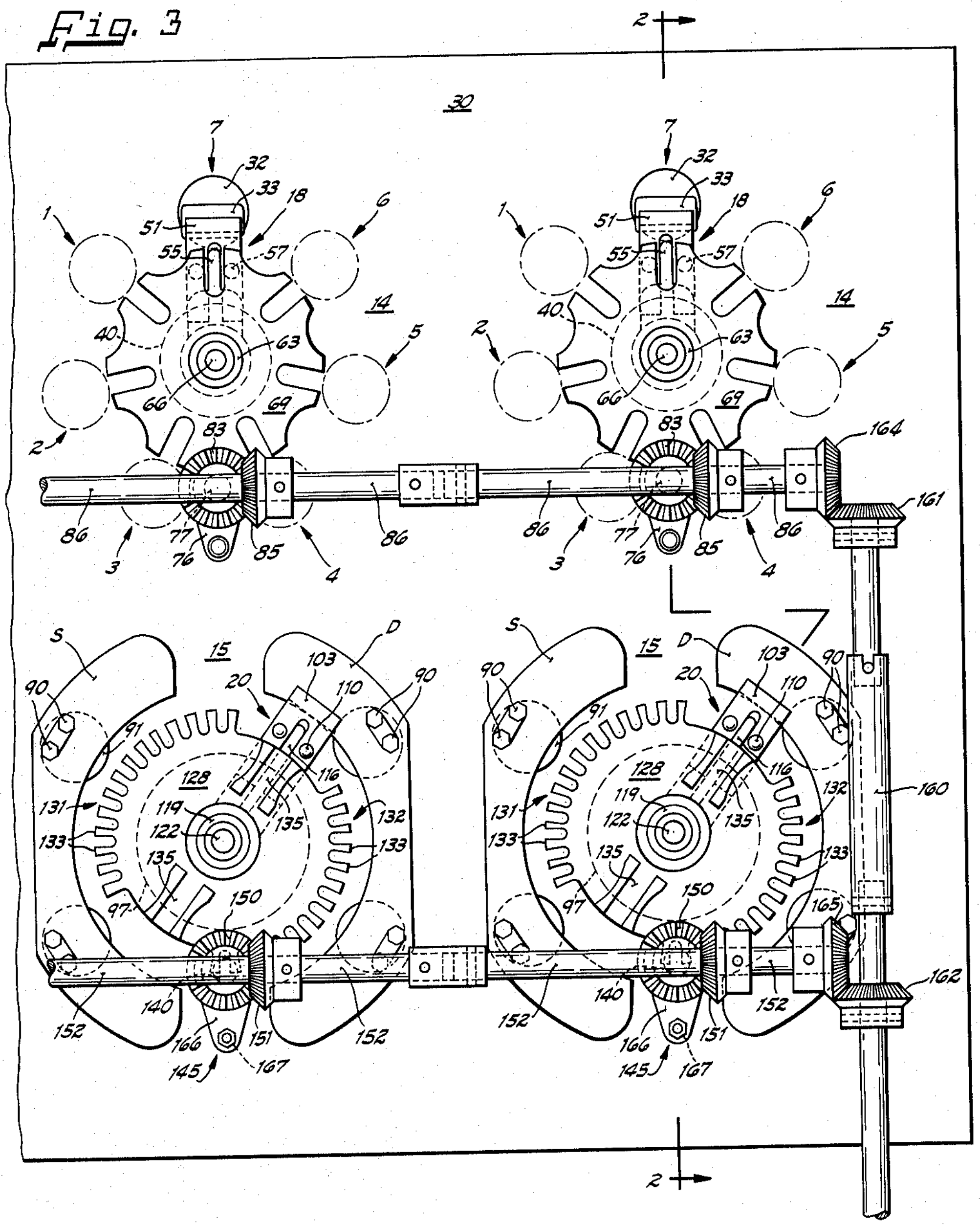
Fig. 3



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3,204,176
TAP CHANGING FURNACE TRANSFORMER

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8 Claims. (Cl. 323—43.5)

This invention relates to electrical power transformers and, more particularly, to furnace transformers having no-load tap-changing equipment.

The ratio of transformation of electrical transformers is usually changed by increasing or decreasing the number of active turns in one transformer winding with respect to another winding. Adjustment of the voltage ratio between the transformer primary and secondary windings is conventionally accomplished by providing one of the transformer windings with a plurality of taps connected to stationary contacts on a multiple position switch having a contact selectively movable into engagement with the stationary contacts to exclude or include a desired number of turns of the tapped winding and thus vary the number of active turns in the winding.

High current stationary induction apparatus such as furnace transformers must supply heavy current at low voltage and be adjustable to deliver such current at a large number of secondary voltage settings. The number of transformer voltage ratios required necessitates the provision of a large number of tap connections in each phase primary winding and means to change the tapped windings between delta and star connections. In a conventional furnace transformer taps are provided in the high voltage phase windings, the tap connections are brought to a terminal board within the transformer casing under the transformer oil, the terminal board is provided with an arrangement of studs and links to permit selection of the desired taps, and electrical connections are brought from the terminal board to a tap changer external of the casing to permit connecting the high voltage windings in star or delta and the selection of a limited number of voltage ratios. When such a furnace transformer is initially placed in service, the desired tap connections and voltage ratios to be available at the external tap changer are selected by properly positioning the links on the terminal board underneath the oil. The external tap changer permits connection of the windings in star or delta and the selection of such limited number of voltage ratios, but if after a period of operation of the furnace transformer a different voltage ratio is desired than that available at the external tap changer, it is necessary to de-energize the transformer and let it cool before the links on the terminal board can be changed. The terminal board is usually accessible through a manhole in the transformer casing cover, and it is necessary to unbolt each link separately under the oil and move it to a newly selected position when it is desired to select other voltage ratios. The operator must enter the transformer through the manhole and manually disconnect the links on the terminal board individually under the oil and reconnect them. It will be apparent that the furnace transformer is out of service for a considerable period of time while the transformer is cooling and the links are being changed on the terminal board.

It is an object of the invention to provide a furnace transformer wherein all of the possible voltage ratios can be selected externally of the transformer casing. It is a further object of the invention to provide a furnace transformer wherein it is unnecessary for an operator to enter the transformer and change links on a terminal board under the oil in order to select all the available voltage ratios. A still further object is to provide such an improved tap changer furnace transformer wherein it is unnecessary to cool the transformer before changing taps and wherein the shut down time in which the transformer is out of service during the tap change is substantially reduced in comparison to prior art construction.

Another object of the invention is to provide a novel indexing mechanism for furnace transformer tap changing equipment.

These and other objects and advantages of the invention will be better understood from the following detailed description when taken in conjunction with the accompanying drawing wherein:

FIG. 1 is a schematic circuit diagram of a preferred embodiment of three phase tap changer furnace transformer of the invention;

FIG. 2 is a section view taken along line 2—2 of FIG. 3 through the tap changing equipment associated with one phase of the furnace transformer of the invention;

FIG. 3 is a partial front view of the tap changing equipment of the invention;

FIG. 4 is a front view taken along line 4—4 of FIG. 2 showing the novel indexing mechanism for the delta star switch, the supporting frame and bevel gears being removed to better illustrate the construction; and

FIGS. 5, 6 and 7 are partial views illustrating the operation of the indexing mechanism shown in FIG. 4.

Referring to the drawings and the circuit diagram of FIG. 1 in particular, a three phase furnace transformer **10** has primary phase windings **11A**, **11B**, and **11C** adapted to receive power from the line conductors A, B, C of a three phase electrical power system and permanently connected thereto by conductors **12A**, **12B**, and **12C** respectively. The letters A, B and C are used as suffixes to reference numerals throughout the description to designate like elements associated with the three phases. Furnace transformer **10** is illustrated as having four low voltage winding sections **A1–A2** associated with primary phase winding **11A**, four low voltage winding sections **B1–B2** associated with phase winding **11B**, and four low voltage winding sections **C1–C2** associated with primary phase winding **11C**. The four low voltage winding sections associated with each phase may be connected in parallel to supply the required heavy current.

Tap changing equipment provided externally of the transformer casing to permit selection of any of the possible transformer voltage ratios by changing tap connections and connecting the primary phase windings **11A**, **11B**, and **11C** in delta or star includes a multiple position tap changing switch **14** and a delta-star switch **15** associated with each phase. Each multiple position switch **14** has seven stationary contacts **1–7** arranged in a circle, and each primary phase winding **11** is provided with seven taps **16** connected by leads **17** to the seven stationary contacts **1–7**. Each multiple positon tap changer switch **14** is provided with a rotatable contact **18** movable sequentially into engagement with the stationary contacts **1–7**.

Each delta-star switch **15** includes a pair of arcuate stationary contacts S and D arranged in a circle and a rotatable contact **20** adapted to engage the arcuate contacts S and D. The rotatable contact **18** of each multiple position switch **14** is electrically connected by a conductor **21** to the rotatable contact **20** of the associated delta star switch. The S stationary contacts of all three delta star switches **15** are commoned by leads **24**.

Stationary contacts D of delta-star switches **15A**, **15B** and **15C** are connected by conductors **25**, **26** and **27** to the phase windings **11B**, **11C**, and **11A** respectively.

Means described hereinafter are provided to simultaneously index the multiple position switch movable contacts **18A**, **18B**, and **18C** between stationary contacts **1–7**, to simultaneously wipe delta-star switch movable contacts **20A**, **20B**, and **20C** across one of the arcuate contacts S or D associated therewith and maintain continuous electrical engagement with said one arcuate contact while the contacts **18** are being indexed between tap positions **1–7**, and to simultaneously actuate delta-star switch movable contacts **20A**, **20B**, and **20C** between the arcuate contacts S and D when the multiple position switch movable contacts **18A**, **18B** and **18C** are operated between predetermined tap positions, preferably when the multiple position switches are stepped between stationary contacts **1** and **7**. When the movable contacts **20A**, **20B**, and **20C** engage arcuate contacts S of the delta-star switches **15**, the transformer primary phase windings **11A**, **11B**, and **11C** are connected in star. Assuming the tap changing switch rotary contacts **18** are on stationary contacts **7** as shown in FIG. 1 and that movable contacts **20A**, **20B**, and **20C** of the delta-star switches engage arcuate contacts S, a portion of the star connection may be traced through two windings beginning from power line conductor A, conductor **12A**, primary winding **11A**, a tap **16**, a conductor **17**, stationary contact 7A, movable contact **18A**, conductor **21A**, movable contact **20A**, arcuate contact S of delta star switch **15A**, conductor **24** which forms the neutral, arcuate contact S of switch **15B**, movable contact **20B**, conductor **21B**, movable contact **18B**, stationary contact 7B, a conductor **17**, a tap **16**, winding **11B**, and conductor **12B** to power line conductor B.

Assuming the delta star switch movable contacts **20** engage arcuate contacts D and multiple position switch movable contacts **18** engage stationary contacts **7**, as shown in FIG. 1, delta connection of the primary windings **11A**, **11B**, and **11C** may be traced from power line conductor A, conductor **12A**, primary winding **11A**, a tap **16**, a conductor **7**, stationary contact 7A, movable contact **18A**, conductor **21A**, movable contact **20A** of delta star switch **15A**, arcuate contact D, conductor **25** to winding **11B** and conductor **12B** to power line conductor B, a tap **16** on winding **11B**, a conductor **17**, stationary contact 7B, movable contact **18B**, conductor **21B**, movable contact **20B**, arcuate contact D of delta star switch **15B**, conductor **26** to primary phase winding **11C** and conductor **12C** to power line conductor C, a tap **16** on winding **11C**, a conductor **17**, stationary contact 7C, movable contact **18C**, conductor **21C**, movable contact **20C**, arcuate contact D of delta-star switch **15C**, and conductor **27** to winding **11A** and conductor **12A** to power line conductor A.

Inasmuch as delta-star switch movable contacts **20** are in continuous electrical engagement with arcuate contacts S or arcuate contact D while multiple position switch movable contacts **18** are indexed into sequential engagement with stationary contacts **1–7**, all fourteen of the possible transformer voltage ratios can be selected externally of the transformer casing.

Referring to FIGS. 2–7, a preferred embodiment of operating mechanism for the multiple position switches **14** and novel indexing mechanism for the delta-star switches **15** are illustrated. The multiple position switches **14** and delta-star switches **15** for all three phases are housed within a compartment on the sidewall of the transformer casing (not shown) having a rear insulating panel **30** through which conductor bolts from the tap changing equipment movable and stationary contacts extend into the oil-filled interior of the transformer casing to connect to conductors **17** (not shown) from the primary winding taps **16** and to conductors **21** and **24–27** (not shown). The multiple position switch **14** for each phase is disposed above the associated delta-star switch **15** for said phase. As illustrated in the drawing each multiple position switch **14** includes seven arcuately disposed stationary contacts **1–7**. Each stationary contact **1–7** includes a metallic member **32** having a radially inward extending flat blade portion **33** and being rigidly secured to a threaded metallic pin **34** extending through an aperture in insulating panel **30**. Insulating collars **36** surround metallic pin **34** on opposite sides of panel **30**, one collar **36** being disposed between panel **30** and stationary contact member **32**. A nut **38** threaded onto pin **34** on the side of the panel **30** within the transformer tank clamps the insulating collars **36** against opposed sides of panel **30** to fixedly mount stationary contact member **32** on panel **30**. Conductors **17** (not shown) from the taps **16** on the associated primary winding **11** are connected to terminal pins **34** within the transformer tank.

Rotatable contact **18** of multiple position switch **14** includes a metallic collector ring member **40** disposed axially of the circle about which the stationary contact members **32** are arranged and rigidly secured to a threaded terminal pin **42** extending axially through an aperture in panel **30**. Insulating collars **43** surround terminal pin **42** on opposite sides of panel **30**, one collar **43** being disposed between panel **30** and collector ring member **40**. A nut **44** threaded onto terminal pin **42** on the side of the panel **30** within the transformer casing compresses the collars **43** against opposite sides of panel **30** and fixedly mounts collector ring member **40** on panel **30**. Conductor **21** (not shown) is connected to terminal pin **42** within the transformer tank.

Multiple position switch rotatable contact **18** is carried by a metallic rotating arm **50** and includes a pair of opposed, radially extending, flat contact members **51** carrying button contacts **53** at the radially inner end thereof which bear against opposite sides of the collector ring member **40** and button contacts **54** at the radially outer end thereof which engage opposite faces of the blade portions **33** of the stationary contact members **32**. The flat contact members **51** are bifurcated and fit over web portions **55** of rotating arm **50** disposed in a plane transverse to the plane of panel **30**. (See FIG. 3.) Registering clearance apertures are provided in the flat contact members **51** and in a web portion **56** of the arm **50** in the plane of the blade portions **33** and disposed between the flat contact members **51**. Headed pins **57** extend through the registering clearance apertures to mount the flat contact members **51** on arm **50**, and the heads on pins **57** bear against one flat contact member **51**. Springs **58** surrounding pins **57** and compressed between the other flat contact member **51** and nuts **59** threadably engaging pins **57** resiliently bias the flat contact members **51** toward each other and urge the contact buttons **53** into high pressure engagement with the collector ring member **40** and urge the contact buttons **54** into high pressure engagement with the blade portions **33** of the stationary contacts **32**.

An axial compartment **62** in rotatable arm **50** receives an insulating shaft **63** having a plurality of circumferential skirts **64** to increase the length of creepage path along the axial length thereof. Axially extending pins **65** and **66** protrude into openings in opposite ends of insulating shaft **63**. A through pin **67** secures axial pin **65**, insulating shaft **63**, and rotatable arm **50** together. Similarly, a through pin **68** rigidly secures axial pin **66**, insulating shaft **63**, and a Geneva gear **69** carried on shaft **63** together. Axial pin **65** is journalled within a bearing **70** disposed in an axial compartment in collector ring member **40** to rotatably support one end of shaft **63**. Axial pin **66** is journalled within a bearing **73** disposed within an aperture in a vertical support panel **75** to rotatably support the other end of shaft **63**.

A Geneva pinion crank arm **76** carried by a rotatable stub shaft **77** is adapted to engage and intermittently rotate Geneva gear **69** when stub shaft **77** is rotated. One revolution of stub shaft **77** actuates Geneva gear **69** to index multiple position switch movable contact **18** between adjacent stationary contact members **32**. Stub shaft **77** is journalled within a bearing **79** disposed in an aperture in support panel **75** and in a support casting **80** secured by bolts **82** to support panel **75**. A bevel gear **83** carried at the end of stub shaft **77** engages a bevel gear **85** affixed to an upper horizontal operating shaft **86**. Horizontal shaft **86** drives the multiple position switches **14A**, **14B**, and **14C** of all three phases and carries three of said bevel gears **85** which engage the bevel gears **83** carried by the three stub shafts **77**. It will be apparent that rotation of upper horizontal operating shaft **86** through 360 degrees will step each movable contact **18A**, **18B**, and **18C** to the succeeding stationary contact and thus accomplish a tap change.

Each delta-star switch **15** includes two flat-spaced apart, arcuate, metallic stationary contacts S and D arranged in a circle. Arcuate contacts S and D are secured by bolts **90** to metallic support members **91** which are rigidly secured to threaded terminal pins **92** extending through apertures in insulating panel **30**. Insulating collars **94** surround terminal pins **92** on opposite sides of panel **30**, one insulating collar **94** being positioned between panel **30** and support member **91**, and a nut **95** threadably engaging terminal pin **92** clamps the insulating collars **94** against opposite sides of panel **30** and rigidly mounts arcuate contacts S and D on panel **30**. Conductors **24**, **25**, **26**, and **27** (not shown) are connected to terminal pins **92** within the transformer casing.

A metallic collector ring member **96** positioned axially of the arcuate contacts S and D and having a circumferential flange portion **97** in the plane of contacts S and D is rigidly secured to a threaded terminal pin **98** extending through an aperture in panel **30**. Insulating collars **99** surround terminal pin **98** on opposite sides of panel **30**, and a nut **101** threadably engaging terminal pin **98** clamps insulating collars **99** against opposite sides of panel **30** and rigidly mounts collector ring member **96** on panel **30**.

Delta star switch rotary contact **20** includes two radially extending flat contact members **103** carried by a rotatable metallic arm **104** and having contact buttons **105** on the radially outer end thereof bearing against opposed sides of the arcuate contacts S and D and contact buttons **106** on the radially inner end thereof engaging opposite sides of the collector ring **97**. Registering clearance apertures are provided in the flat contact members **103** and in a web portion **108** of the rotatable arm **104** in the plane of the arcuate contacts S and D and disposed between the flat contact members **103**. Headed pins **110** extend through the registering clearance apertures to mount the flat contact members **103** on rotatable arm **104**, and the heads of the pins **110** bear against one flat member **103**. Springs **113** surrounding the pins **110** and compressed between the other flat contact member **103** and nuts **115** threadably engaging pins **110** resiliently urge flat contact members **103** toward each other and urge the contact buttons **106** into high pressure engagement with the collector ring **97** and urge the contact buttons **105** into high pressure engagement with opposed faces of the arcuate contacts S and D. The flat contact members **103** are bifurcated and fit over web portions **116** of the rotatable arm **104** in a plane transverse to the plane of panel **30** (see FIG. 3).

An axial compartment **118** in rotatable arm **104** receives an insulating shaft **119** having a plurality of circumferential skirts **120** to increase the length of the creepage path in an axial direction. Axial pins **121** and **122** extend into openings in opposite ends of insulating shaft **119**. A through pin **124** rigidly secures axial pin **121**, shaft **119**, and arm **104** together. Axial pin **121** is journalled within a bearing **126** within an aixal compartment in collector ring member **96** to rotatably support one end of shaft **119**, An index gear **128** surrounds the other end of shaft **119**, and a through pin **129** secures index gear **128**, shaft **119**, and axial pin **122** together. Axial pin **122** is journalled within a bearing **130** within an aperture in support panel **75** to rotatably support the other end of shaft **119**.

Index gear **128** has two circumferentially spaced apart sets **131** and **132** of external teeth **133**, and in the embodiment illustrated in the drawing each set **131** and **132** comprises fourteen teeth **133** with spaces therebetween where teeth are omitted. Index gear **128** also carries in the portions between the tooth sets **131** and **132** a pair of radially extending guideways **135** which are analogous to the slots in a Geneva gear.

A stub shaft **140** is rotatably journalled within a bearing **141** disposed in registering apertures through vertical support panel **75** and a support casting **142** secured to support panel **75** by bolts **144**. Stub shaft **140** carries a pinion **145** for driving index gear **128** and preferably having two driving pins **148** and **148'** extending parallel to the axis of rotation of pinion **145** and disposed on opposite sides of such axis and adapted to engage and displace the teeth **133** on index gear **128** and thus rotate gear **128** when stub shaft **140** is rotated (see FIG. 4). One revolution of stub shaft **140** circumferentially displaces index gear **128** approximately the distance between two teeth **133**, or approximately eighteen degrees, and thus also advances movable contact **20** approximately eighteen degrees along arcuate contact S or D. Arcuate contacts S and D each subtend approximately 150 degrees, and movable contact **20** is wiped across arcuate contact S or D and maintains continuous electrical contact therewith while stub shaft **140** makes seven revolutions and the driving pins **148** and **148'** engage and advance each of the fourteen teeth **133** of a set **131** or **132**.

Stub shaft **140** carries a bevel gear **150** which engages a bevel gear **151** carried by a lower horizontal operating shaft **152**. Shaft **152** is a common driving shaft for all delta star switches **15A**, **15B**, and **15C** and carries three of said bevel gears **151** which engage the bevel gears **150** carried on the stub shafts **140** of the delta star switches **15A**, **15B**, and **15C**.

A veritcal drive shaft **160** rotatably journalled in the support castings **80** and **142** is actuated by a reversible compound wound motor (not shown) of the furnace transformer tap changer control apparatus (not shown) and is rotated through one revolution whenever it is desired to change a tap and vary the voltage ratio of the transformer. Vertical shaft **160** carries two vertically spaced apart bevel gears **161** and **162**. Upper bevel gear **161** engages a bevel gear **164** secured to the upper horizontal operating shaft **86** for indexing all three multiple position switches **14**; lower bevel gear **162** engages a bevel gear **165** secured to the lower horizontal operating shaft **152** for all the delta star switches **15**. Rotation of the compound motor (not shown) in the control circuit to actuate vertical drive shaft **160** through one revolution simultaneously rotates upper horizontal shaft **86** through 360 degrees to index the movable contact **18** of all three multiple position switches **15** between stationary contacts and also actuates lower horizontal shaft **152** through 360 degrees to displace two teeth **133** and advance index gear **128** and movable contact **20** of each delta star switch through approximately 18 degrees while maintaining movable contact **20** in continuous electrial engagement with arcuate contact S or D.

Pinion **145** is affixed to a Geneva pinion, or crank arm, **166** carrying a crank arm pin **167** adapted to enter a slot formed by a guideway **135** and advance index gear **128** through a sufficient angle to disengage one set **131** or **132** of teeth **133** from the pinion driving pins **148** and to bring the other set of teeth **133** into engagement with the driving pins **148** and to simultaneously disengage delta star switch movable contact **20** from one arcuate contact S or D and to bring said movable contact **20** into engagement with the other arcuate contact S or D, thus changing the connection of the primary phase winding **11A**, **11B**, and **11C** from star to delta, or vice versa. Crank arm pin **167** is rotated into slot **135** when the multiple position switch contacts **18** are indexed between predetermined tap positions.

In FIG. 4 the delta star switch movable contact **20** is shown in full lines at rest in engagement with arcuate contact D and driving pin **148** is in engagement with the teeth **133** of set **132**. In FIG. 5 stub shaft **140** and crank arm **166** have been rotated from the rest position of FIG. 4 through approximately 135 degrees to a position wherein crank arm pin **167** has entered a slot **135** on index gear **128** and the succeeding drive pin **148'** has come into engagement with the last tooth **133** of set **132** and begun to displace said tooth circumferentially. FIG. 6 illustrates rotation of stub shaft **140** and crank arm **166** through an additional ninety degrees from FIG. 5 and shows that crank arm pin **167** has displaced index gear **128** from the position shown in FIGS. 4 and 5 to a position wherein tooth set **132** is disengaged from driving pin **148'** and the tooth set **131** has come into engagement with driving pin **148**. FIG. 7 illustrates the novel indexing mechanism after stub shaft **140** and crank arm **166** have been rotated through a complete revolution back to the rest position wherein tooth set **131** is now in engagement with driving pin **148**, movable contact **20** has been disengaged from the full line position on arcuate contact D shown in FIG. 4 and moved to the dotted line position in engagement with arcuate contact S, and crank arm pin **167** is disengaged from index gear guideway **135**.

Delta star switch movable contact **20** is actuated between arcuate contacts D and S whenever the multiple position switch **14** is stepped between predetermined tap positions, preferably when tap changer switch movable contact **18** is indexed between stationary contacts **1** and **7**. It will be apparent that delta star switch movable contact **20** continuously engages and is advanced along an arcuate contact S or D to maintain the star, or delta, connection of the primary windings **11A**, **11B**, and **11C** while the multiple position switch **14** is indexed through seven tap positions, and that between predetermined tap positions **1** and **7** the crank arm pin **167** enters a guideway **135** and steps index gear **128** and delta star switch movable contact **20** through approximately 50 degrees to disengage movable contact **20** from one arcuate contact S or D and engage it with the other arcuate contact, thus changing connections for the transformer primary windings **11A**, **11B**, and **11C** between star and delta. It will be readily apparent that all fourteen possible voltage ratios can be selected by the disclosed tap changer apparatus located exteriorly of the transformer and that it is unnecessary to cool the furnace transformer to permit an operator to enter the transformer casing before tap connections can be changed, thus substantially decreasing the time that the transformer is out of service when making a tap change in comparison to prior art construction and eliminating the danger of the operator dropping tools in the transformer windings and subsequently causing failure of the transformer.

While only a single embodiment of the invention has been illustrated and described, many modifications and variations thereof will be apparent to those skilled in the art, and consequently it is intended in the appended claims to cover all such modifications and variations which fall within the true spirit and scope of the invention.

I claim:

1. A three phase tap changer transformer having associated with each phase a multiple position switch, a delta-star switch, and a phase winding having a plurality of taps, drive means, said multiple position switch having a plurality of spaced apart stationary contacts arranged in a circle and connected to said taps, a rotary contact adapted to sequentially engage said stationary contacts, and a shaft carrying said rotary contact; means actuated by said drive means for intermittently actuating said shafts of all of said multiple position switches simultaneously to index said rotary contacts between said stationary contacts, said delta star switch having first and second arcuate stationary contacts arranged in a circle, a movable contact adapted to engage said arcuate contacts and to be wiped across one of said arcuate contacts in a series of steps while maintaining continuous electrical engagement

therewith and being electrically connected to said rotary contact of the associated multiple position switch, an index gear having a pair of circumferentially spaced apart sets of teeth, a rotatable shaft carrying said delta-star switch movable contact and said index gear, a pinion adapted to engage said teeth on said index gear and rotate said gear to wipe said movable contact through one of said steps across one of said arcuate contacts each time said multiple position switch rotary contacts are indexed between stationary contacts, a crank arm, and an input shaft carrying said pinion and said crank arm; said input shafts of all three delta star switches being actuated simultaneously by said drive means and each said index gear carrying means cooperating with said crank arm when said multiple position switch rotary contacts are actuated by said drive means between predetermined stationary contacts to actuate said gear to disengage one of said sets of teeth from said pinion and said delta star switch movable contact from said first arcuate contact and to engage the other of said sets of teeth with said pinion and said delta star switch movable contact with the second arcuate contact, said first stationary contacts of all of said delta-star switches being commoned and said second stationary contact of each delta star switch being electrically connected to the tapped winding associated with another phase.

2. A three phase tap changing transformer having three phase windings provided with taps and a multiple position switch and a delta star switch associated with each phase and drive means for said switches, said multiple position switch having a plurality of spaced apart stationary contacts arranged in a circle and connected to said taps and a rotary contact adapted to sequentially engage said stationary contacts, means operated by said drive means for intermittently indexing said rotary contacts of all three multiple position switches between said stationary contacts, said delta star switch having first and second arcuate stationary contacts and a movable contact electrically connected to said rotary contact and adapted to alternately engage said first and second contacts and to be wiped across each said arcuate contact in a series of steps while remaining in continuous electrical engagement therewith, said first arcuate contacts of all of said delta star switches being electrically commoned, said second arcuate contact of each delta star switch being connected to said winding associated with another phase, means operated by said drive means for simultaneously actuating said movable contacts of all three delta star switches and for indexing each said movable contact one step across one of said arcuate contacts each time said rotary contacts are indexed to a succeeding stationary contact, whereby said movable contact engages a new point on said arcuate contact each time said multiple position switch is indexed and erosion of said arcuate contacts is minimized, and means operated by said drive means for simultaneously actuating said movable contacts of all three delta star switches between said first and second arcuate contacts once for each revolution of said rotary contacts and when said intermittent indexing means steps said rotary contacts of said multiple position switches between predetermined stationary contacts.

3. A three phase tap changing transformer in accordance with claim **2** wherein said means for simultaneously actuating said delta-star switch movable contacts includes in each delta star switch an index gear coupled to said movable contact and having a pair of circumferentially spaced apart sets of teeth, a pinion adapted to engage said teeth and rotate said gear to wipe said movable contact in a series of steps across one of said delta star switch stationary contacts, a crank arm, a rotary shaft carrying said pinion and said crank arm and actuated by said drive means, and wherein said index gear carries means cooperating with said crank arm when said pinion engages predetermined teeth of said sets to actuate said index gear from a first position wherein one of said sets of teeth engage said pinion and said movable contact engages said first contact to a second position wherein the other of said sets of teeth engage said pinion and said movable contact engages said second contact, and wherein said rotary shaft actuates said pinion to advance said movable contact through one step across one of said delta star switch stationary contacts when said multiple position switch rotary contact is indexed to a succeeding stationary contact and said rotary shaft rotates said crank arm to actuate said gear between said first and second positions when said multiple position switch rotary contact is actuated between predetermined stationary contacts.

4. In combination with a three phase transformer having associated with each phase a delta star switch and a multiple position tap changer switch, drive means, said multiple position switch having an input shaft operated by said drive means and a movable contact carried by said input shaft and said multiple position switch movable contact being adapted to step between tap positions in response to indexing of said input shaft, said delta-star switch including two arcuate stationary contacts arranged in a circle, a rotary contact connected electrically to said movable contact of said multiple position switch and being adapted to engage said arcuate contacts and be stepped across one of said arcuate contacts in a series of steps while maintaining continuous electrical engagement therewith, an index gear having two circumferentially spaced apart sets of teeth, a driven shaft carrying said rotary contact and said index gear, a pinion having two driving pins extending parallel to the pinion axis and disposed away from said axis and adapted to engage said teeth on said index gear and rotate said gear to wipe said rotary contact through one of said steps across one of said arcuate contacts each time said movable contact of said multiple position switch is stepped between tap positions, a crank arm, and a rotatable shaft actuated by said driving means and carrying said pinion and said crank arm; said index gear having a pair of slots adapted to engage said crank arm and said rotatable shaft actuating said crank arm to engage one of said slots and rotate said index gear to disengage one set of said teeth from said driving pins and said rotary contact from one arcuate contact and to engage the other set of said teeth with said driving pins and said rotary contact with the other arcuate contact when said tap changer switch input shaft is actuated by said drive means to index said multiple position switch movable contact between predetermined tap positions.

5. An electrical switch comprising, in combination, a pair of spaced apart arcuate stationary contacts arranged in a circle, a movable contact adapted to alternately engage said arcuate contacts and be wiped across each of said arcuate contacts in a series of steps, an index gear having a pair of circumferentially spaced apart sets of teeth, a rotatable shaft carrying said movable contact and said index gear, an input shaft, a driving pinion affixed to said input shaft and adapted to engage said teeth on said index gear and rotate said index gear to wipe said movable contact in said series of steps across one of said arcuate contacts, a crank arm affixed to said input shaft, said index gear carrying means cooperating with said crank arm when said pinion engages predetermined teeth of said sets to actuate said index gear to disengage one said set of teeth from said pinion and to engage a succeeding set of teeth with said pinion, said movable contact being wiped across one of said arcuate contacts and maintaining continuous electrical contact therewith while said pinion is in engagement with said one set of teeth and being alternately actuated between said arcuate contacts when said crank arm actuates said index gear to disengage said one set of teeth from said pinion and to engage a succeeding set of teeth with said pinion.

6. An electrical switch in accordance with claim **5** wherein said index gear has a plurality of slots equal in number to said sets of teeth and said crank arm carries a crank pin disposed away from the axis of rotation of said crank arm adapted to enter one of said slots and actuate said gear to index said movable contact between said arcuate contacts.

7. In a three phase transformer having a multiple position tap changing switch and a delta-star switch associated with each phase, common drive means for said tap changing switches and said delta-star switches of all three phases, each said tap changing switch including a plurality of stationary contacts arranged in an arc and a rotary contact adapted to sequentially engage said stationary contacts, each said delta-star switch including a pair of arcuate stationary contacts arranged in a circle, a movable contact electrically connected to said rotary contact and adapted to alternately engage said arcuate stationary contacts, an index gear having a plurality of circumferentially spaced apart sets of teeth, a rotatable shaft carrying said movable contact and said index gear, a driving pinion adapted to engage said teeth on said index gear and rotates said gear and said movable contact. said movable contact being wiped across one of said arcuate stationary contacts in a series of steps and maintaining continuous electrical engagement therewith while said pinion is in engagement with one of said sets of teeth, a crank arm, an input shaft carrying said pinion and operated by said common drive means to actuate said movable contact through one of said steps across one of said arcuate stationary contacts each time said multiple position switch rotary contact is actuated between tap positions, said input shaft also carrying said crank arm and said index gear carrying means cooperating with said crank arm when said tap changing multiple position switch rotary contact is actuated between predetermined tap positions by said common drive means to rotate said index gear from a first position wherein one of said sets of teeth engages said pinion and said movable contact engages one of said arcuate stationary contacts to a second position wherein said pinion is disengaged from said one set of teeth and engages a succeeding set of teeth and said movable contact is in engagement with a succeeding arcuate stationary contact.

8. In a three phase transformer in accordance with claim **7** wherein said crank arm carries a crank pin away from the axis of rotation of said input shaft and said index gear has a plurality of slots adapted to receive said crank pin to actuate said index gear between said first and second positions.

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