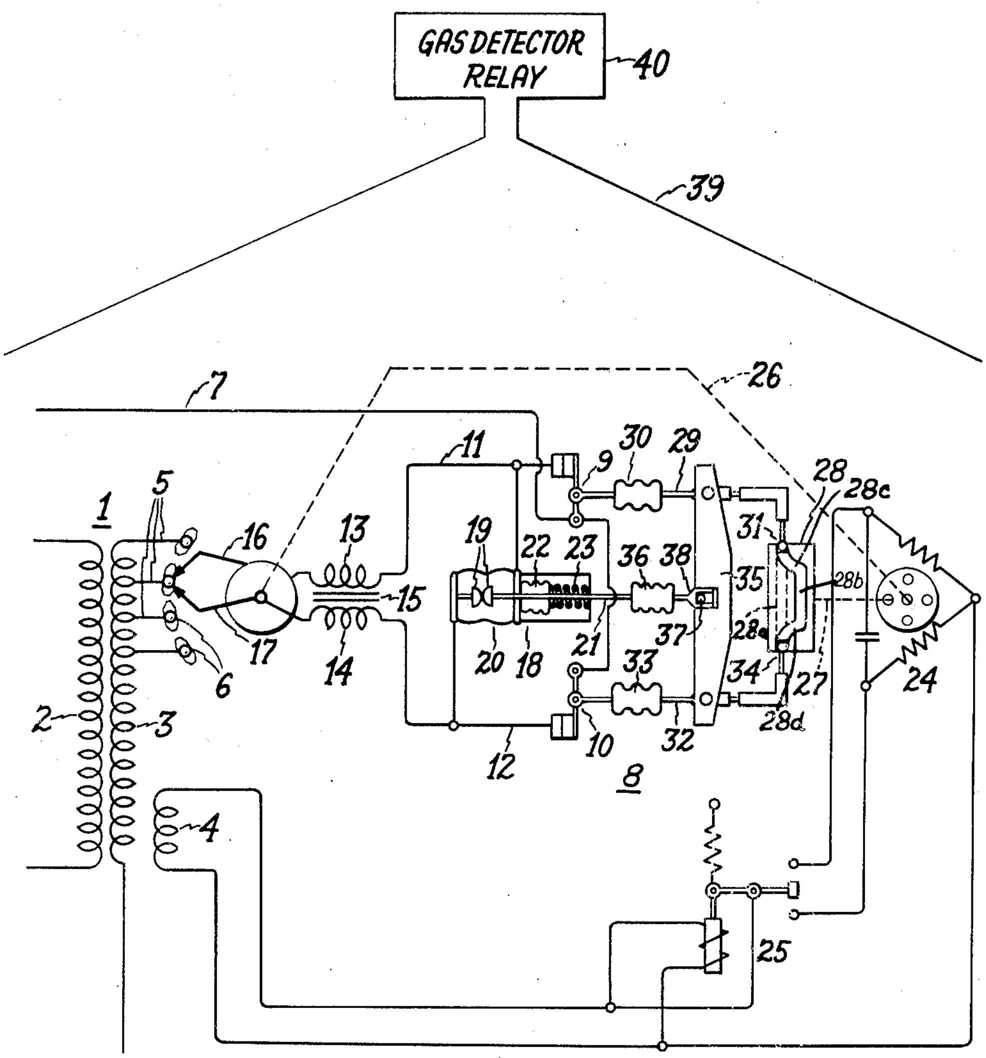
Sept. 14, 1965

O. P. McCARTY

3,206,580

FLUID IMMERSED TAP CHANGING SWITCHING SYSTEM FOR TRANSFORMERS

Filed Aug. 28, 1962



Inventor,
Orin P. McCarty,
by Gilbert P. Tarleton
His Attorney.

United States Patent Office 3,206,580
Patented Sept. 14, 1965

1

3,206,580
FLUID IMMERSED TAP CHANGING SWITCHING SYSTEM FOR TRANSFORMERS

Orin P. McCarty, Pittsfield, Mass., assignor to General Electric Company, a corporation of New York
Filed Aug. 28, 1962, Ser. No. 219,901
2 Claims. (Cl. 200—144)

This invention relates to apparatus for transformer tap changing under load and is in the nature of an improvement over that shown in Patent 2,246,182, granted June 17, 1941, on an application filed jointly in the name of the present inventor and Arthur Palme and assigned to the present assigne.

More particularly the invention relates to apparatus of this type using a vacuum switch as the arcing contactor component. Such a contactor contains the arc completely, removing it from the usual liquid or gaseous insulation environments associated with transformers and thereby eliminates many of the design and maintance problems resulting from arcing these environments.

Arcing in air requires expensive arc chutes, or compressed air systems, and relatively long insulation paths which require protection from contamination by arc byproducts, moisture, dust and the like. Arcing in oil produces hydrogen and hydrocarbon gases, carbon particles, tungsten carbide and copper particles. These byproducts are detrimental to the insulating qualities of the oil and to the mechanical gears and bearings of the operating mechanism and require expensive materials and shields to give adequate insulation creepage and strike paths.

Arcing in askarel produces carbon, and hydrochloric acid, which is highly corrosive and detrimental to the insulating qualities of the askarel and solid insulation. Arcing in askarel can only be permitted when interrupting very small magnetizing currents and then only with use of inhibitors added to the askarel. Arcing in gases such as sulfur hexafluoride generates undesirable quantities of white powdery by-products from the decomposition of the gas. This powdery material prohibits reasonable mechanical and insulation designs.

The elimination of these many problems by the use of a vacuum switch as the arcing contractor produces numerous highly desirable results such as virtually maintenance free load tap changing entirely within the main transformer tank or in an external compartment of much smaller dimensions, reduced insulation distance resulting in smaller size equipment, simpler mechanical systems requiring less motive power (a vacuum switch requires only an eighth of an inch gap compared with a two and one-half inch gap for arcing contractors under oil), greatly reduced costs because of smaller size and simplified construction and substantially reduced size and cost of the arcing contractor when mounted on the line end of a high voltage bushing such as in the system to which Patent 2,306,147, granted October 10, 1944, on an application filed in the name of the present inventor and assigned to the present assignee, is directed.

An object of the invention is to provide a new and improved apparatus for transformer tap changing under load.

Another object of the invention is to provide a simpler, more reliable apparatus for tap changing under load which is characterized by the use of a single arcing duty vacuum switch.

The invention will be better understood from the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Referring now to the drawing, which is a diagrammatic

2

illustration of a presently preferred embodiment of the invention, there is shown therein a transformer **1**, for use in power supply transmission or distribution circuits, having main windings **2** and **3**, and a control supply winding **4**. As all of these windings are closely inductively coupled, as is the practice with such transformer, they all have the same volts per turn. For regulating the voltage of the transformer **1**, the winding **3** is provided with a plurality of taps **5** connected respectively to spaced tap contacts **6** which may conveniently be arranged on the arc of a circle. For changing connections between a main circuit conductor **7** and the taps **5** there is provided a tap changing apparatus indicated generally at **8**.

As shown, the apparatus **8** comprises a pair of non-arcing duty selector switches or contactors **9** and **10** for controlling the connections between the main circuit conductor **7** and a pair of branch circuit conductors **11** and **12** which are respectively connected through the halves **13** and **14** of a preventive reactor **15** to the individual contact fingers **16** and **17** of a double finger non-arcing duty ratio adjuster switch, movable between tap contacts **6**. Inter-connecting the branch circuit conductors **11** and **12** is an arcing duty vacuum switch contactor **18** having a pair of normally closed contacts **19** in an evacuated envelope **20**, one of the contacts **19** being movable relative to the other by means of an operating rod **21** passing through the wall of a flexible diaphragm or bellows **22** which is sealed to the envelope **20** for maintaining its vacuum. A spring **23** maintains the contacts **19** of the vacuum switch normally closed. The entire system **8** is physically located in a common ambient insulating medium such as an oil or askarel and the various switches and contractors are all mechanically interconnected and operated in a predetermined cycle by a reversible motor such as capacitor motor **24**, under the control of a voltage regulating relay **25**, both of these elements being energized from across the control supply winding **4**.

With the parts in their illustrated positions, the voltage to be regulated is normal as indicated by the position of the voltage regulating relay **25**. If the voltage departs sufficiently in either direction from the normal value, the voltage regulating relay will complete one or the other of an operating circuit for the motor **24** causing it to rotate in the forward direction or the reverse direction, as the case may be. Mechanical operating connections of conventional type indicated by the dashed line **26** causes the motor to operate the contact fingers **16** and **17** in either direction from the position shown, and a shaft **27** from the motor **24** drives a scroll cam **28** for causing proper cyclic and sequential operation of the non-arcing duty contactors **9** and **10** and vacuum switch contactor **18**.

The contactor **9** is operated by a push-pull rod **29**, which includes an insulator **30**, by means of a scroll cam follower **31** and the contact **10** is operated by means of a push-pull rod **32**, which includes an insulator **33**, by means of a scroll cam follower **34**. The followers **31** and **34** engage the scroll cam **28** at diagrammatically opposite points thereon. The rods **29** and **32** are shown parallel to each other and are interconnected by a lever arm **35** pivotally connected at its ends to the rods **29** and **32**.

The operating rod **21** for the vacuum switch **18** is connectea through an insulator **36** to the midpoint of the lever **35** by means of a lost motion connection, shown for example as a pin **37** in the lever **35** and a slotted member **38** attached to the insulator **36**.

The actuating cam **28** is illustrated by way of example as a rotatable cylindrical member having a peripheral camming slot within which are slidably positioned the cam followers **31** and **34**. The camming groove is formed of a semi-circular circumferential land portion **28***a* (shown in dotted lines) extending for at least 180 degrees around the surface of the cam cylinder. Opposite ends of the land portion **28***a* are connected around the other side of the cam cylinder by a portion of the slot having a central circumferential dwell portion **28***b* axially offset from land portion and connected at its ends to opposite ends of the land portion by oppositely inclined rise portions **28***c* and **28***d*. In the normal closed position of the selector switches **9** and **10**, the slotted cam **28** is positioned as shown in the drawing with the cam followers **31** and **34** located at opposite ends of the 180 degree land portion **28***a* of the cam slot.

It will be evident that in operation of the cam **28** a single 180 degree rotation from the position shown in either direction causes one or the other of the cam followers to move to the right as shown in the drawing thereby to open the associated selector switch **9** or **10**. The cam follower which was thus moved into the dwell portion **28***b* of the cam slot remains momentarily in this position and then returns to its normal switch closing position in the land portion of the cam, all while the other cam follower remains in the land portion of the slot. During the next 180 degree rotation in the same direction, the other cam follower is similarly displaced and returned while the first follower remains stationary in the land portion of the cam. Thus in a complete single revolution of the cam **28**, the cam followers **31** and **34** and their connected selector switches **9** and **10**, respectively, are displaced to switch-opening position and returned in non-overlapping sequence.

The operation of the illustrated embodiment of the invention is as follows:

With the parts in their illustrated positions, the circuit for the tapped winding **3** is from the main circuit conductor **7**, through the contactors **9** and **10** in parallel through the branch circuit conductors **11** and **12** in parallel, through the two halves **13** and **14** of the reactor **15** in parallel, and through the contact fingers **16** and **17** in parallel to one of the tap contacts **6** on the winding **3**. Due to the electrical symmetry of this circuit, the load current divides equally through the contactors **9** and **10**, the windings **13** and **14** and the contact fingers **16** and **17**. The windings **13** or **14** are interleaved or interlaced and are so connected that the magnetizing effects the load currents through them create cancel each other so that they interpose only neglible leakage reactance to the flow of load current. The vacuum switch **18** is vertually short circuited and carries no current.

If now voltage conditions change to such an extent that the relay **25** calls for a tap change, the motor **24** will start to rotate in the proper direction. This will first cause either scroll cam follower **31** or scroll cam follower **34** to open contactor **9** or **10**, depending upon the direction of rotation of the scroll cam **28**. Opening of contactor **9** or **10** will cause no arcing at its contacts because the closed vacuum switch **18** provides a current conducting path between the branch circuit conductors **11** and **12**, so that if contactor **9** opens, the current from the contact fingers **16**, flowing in the branch circuit conductor **11**, will flow through the vacuum switch **18**, to the branch circuit conductor **12**, so that all of the load current will then be carried through the contactor **10**. Likewise if the contactor **10** opens, the current in the contact finger **17** and the branch circuit conductor **12**, will be diverted through the vacuum switch **18**, to the branch circuit conductor **11**, so that all the load current will flow through the contactor **9**.

The cam motion causing opening motion of the contactor **9** or the contactor **10** will also pivot the lever **35** around its connection to the operating lever **32** or **29**, whichever remains stationary, thus moving the lost motion pin **37** to the right as viewed in the drawing. As this motion continues, the pin **37** reaches the end of the slot in the member **38** and vacuum switch contacts **19** are pulled apart, but such motion does not occur until after opening of the contactor **9** or **10** as the case may be. These contacts need be only separated physically by a relatively small distance in order to interrupt current and because they are completely sealed in the evacuated envelope **20** the interruption of current cannot contaminate the ambient insulating medium of the system with any deleterious products of the arcing. As soon as the vacuum switch **18** opens, current flow is interrupted in one or the other of the contact fingers **16** or **17** and this operation is so timed that after it occurs, the contact finger which carries no current moves out of engagement with a tap contact **6** and into engagement with the next adjacent tap contact **6**. This is a so-called bridging or half-cycle position of the ratio adjuster switch which is followed immediately by the closing of the vacuum switch **18** due to the scroll cam **28** approaching the completion of the half revolution followed by the closing of whichever contactor **9** or **10** had been opened so that after one-half revolution of the scroll cam **28** the cam followers **31** and **34** will be returned to the positions illustrated. Consequently the lever **35** and the contactors **9** and **10** and the vacuum switch **18** will be returned to the positions illustrated.

Under these conditions load current will divide between the contact fingers **16** and **17**, but the flow of substantial circulating current produced by the tap to tap voltage difference between fingers **16** and **17** will be inhibited, because any such circulating current will flow through the halves of the reactor **15** in series, so that their magnetizing effects will be cumulative and the reactor **15** will interpose high reactance to the flow of circulating current.

In the half cycle or bridging position, the voltage of the main circuit conductor **17** will correspond to a voltage half-way between that of the two tap contacts **6** which are bridged by the contact fingers **16** and **17**.

The tap change is completed by another half revolution of the scroll cam **28** in which the above sequence of operations is repeated, except that if contactor **9** had previously opened, then it will be contactor **10** which opens and vice versa. Such opening being followed by the opening of vacuum switch **18** due to the pivoting of the lever arm **35**, and, as soon as the vacuum switch **18** interrupts current flow, the contact finger **16** or **17**, as the case may be, will be moved to the next adjacent contact **6**, so that both contact fingers **16** and **17** will be engaging the next tap contact **6**, after which the scroll cam re-closes the vacuum switch **18** and whichever contactor **9** or **10** is opened, so that after a complete revolution of the scroll cam **28** the parts will return to the positions shown in the drawing, except that the contact fingers **16** and **17** both will be engaging a next adjacent tap contact **6**. It will be seen that the lever **35** with its pin **37** and the slotted member **38** constitute a unitary double acting lost motion mechanical operating connection for the vacuum switch **18** from the operating means for the non-arcing duty contactors **9** or **10**.

While a vacuum switch made with quality control should retain its vacuum and remain operative for many years, it is conceivable that it could fail in either closed position or its open position. If it should fail in its closed position throughout the tap changing cycle, then as the contactor **9** or **10** opens and diverts current through the vacuum switch, the latter will not subsequently interrupt current through one or the other of the contact fingers of the ratio adjuster switch and such finger will then draw an arc and produce a gas bubble in the insulating liquid as it interrupts current in its branch circuit on moving to the next tap position. On the other hand if the vacuum switch should fail open, the result will be that when contactor **9** or **10** opens it will draw an arc and produce a gas bubble as it interrupts the current flowing through its respective contact finger. In order to detect such failures, there is provided a shed type barrier or hood **39** above the load tap changing system to collect this gas. A standard gas detector relay **40** such as is used on most power transformers will then give an alarm after very few tap changes and before any appreciable pitting has occurred on the normally non-arcing duty contacts of the fingers **16** or **17** or contactors **9** or **10**.

While there has been shown and described a particular embodiment of the invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention, and therefore it is intended by the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

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

1. In a transformer tap changing under load system, a main circuit conductor, a pair of branch circuit conductors for respective connection through the halves of a preventive reactor to the contact fingers of a double finger non-arcing duty ratio adjuster switch movable between spaced fixed tap contacts, non-arcing duty selector switching means for normally connecting said main circuit conductor to both branch circuit conductors simultaneously and for selectively disconnecting either branch circuit conductor from said main circuit conductor while maintaining a connection between said main circuit conductor and the other branch circuit conductor, a single normally closed arcing duty vacuum switch connected between said branch conductors and positioned physically adjacent to and in the same ambient medium as said non-arcing duty selector switching means, and means including a unitary double acting lever pivotally connected at opposite ends to said selector switching means and having a central lost motion connection to said vacuum switch for opening said vacuum switch only after said switching means has disconnected either one of said branch circuit conductors from said main circuit conductor.

2. In a transformer tap changing under load system, a main circuit conductor, a pair of branch circuit conductors for respective connection through the halves of a preventive reactor to the contact fingers of a double finger non-arcing duty ratio adjuster switch movable between spaced fixed tap contacts, non-arcing duty selector switching means for normally connecting said main circuit conductor to both branch circuit conductors simultaneously and for selectively disconnecting either branch circuit conductors from said main circuit conductor while maintaining a connection between said main circuit conductor and the other branch circuit conductor, operating means for said selector switching means comprising a pair of parallel push-pull rods operatively connected to said selector switching means and a single scroll cam engaged by said rods at diametrically opposite points of said cam, a single normally closed vacuum switch connected between said branch circuit conductors, and means including a lost motion mechanical connection to said operating means for opening said vacuum switch only after said selector switching means has disconnected either one of said branch circuit conductors from said main circuit conductor, said lost motion connection comprising a lever arm pivotally connected at its ends to said parallel push-pull rods and an operating rod loosely connected between said lever and said vacuum switch.

References Cited by the Examiner

UNITED STATES PATENTS

1,361,966	12/20	Colby	200—153
1,392,160	9/21	Hipple	200—153
1,642,405	9/27	Buchholz	200—61.03
2,112,064	3/28	Blume	323—43.5
2,246,182	6/41	Palme et al.	323—43.5
2,360,147	10/44	McCarty	323—43.5
2,469,203	5/49	Palme et al.	200—146

BERNARD A. GILHEANY, *Primary Examiner.*

ROBERT K. SCHAEFER, *Examiner.*