United States Patent

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[54] **OIL CIRCUIT BREAKER INCLUDING CONTACT BRAKING DEVICE**
1 Claim, 5 Drawing Figs.

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[51] Int. Cl. H01h 33/68
[50] Field of Search .... 200/150 B, 150 D, 150, 34, 148 B, 148; 335/62

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ABSTRACT: An oil circuit breaker includes stationary contacts and a movable contact disposed in an arc-quenching chamber. When the movable contact is separated from the stationary contacts, a braking device coupled to the movable contacts limits the rate of travel thereof through the quenching chamber so that the movable contact remains in an area most suitable for current interruption by oil flow during at least one zero crossing of the current therethrough. The braking device comprises an oil-filled housing including a stationary, inner cylinder, a piston slidable in the inner cylinder which is coupled to the movable contacts, and a spring-loaded, outer cylinder surrounding the inner cylinder. Various apertures are provided in the cylinders and in the piston to furnish a braking action which increases with increases in the rate of initial movement of the movable contact. In any case, once the movable contact has moved out of the area of most suitable current interruption, the braking force exerted on the movable contact is decreased.

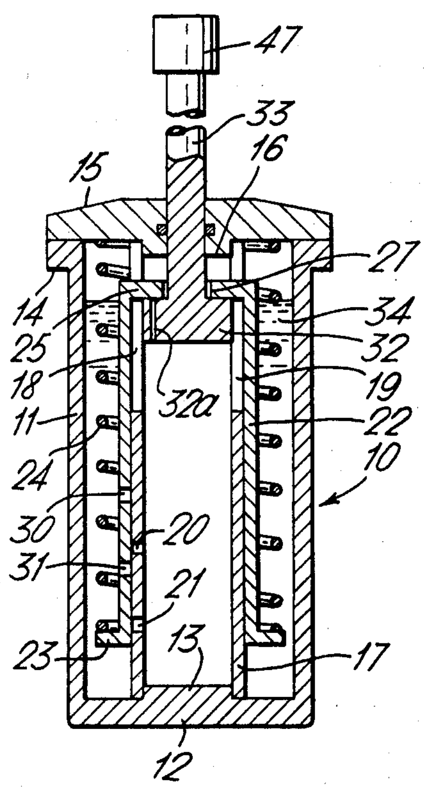

Fig. 1.

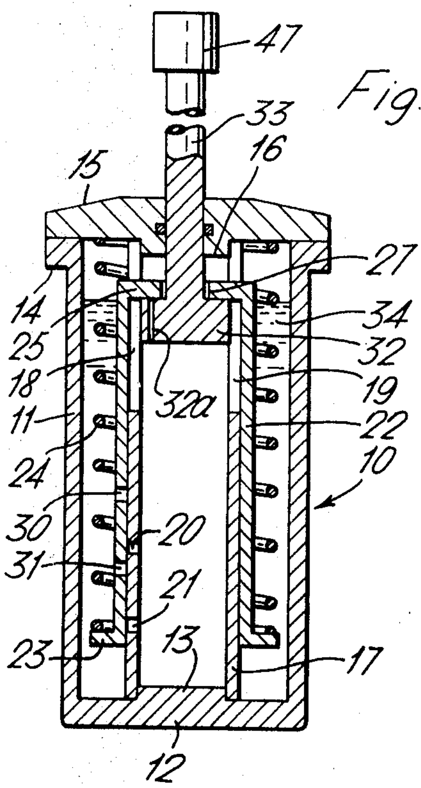

Fig. 2.

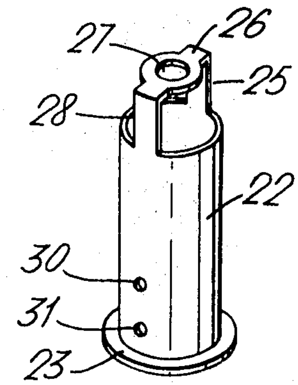

Fig. 3.

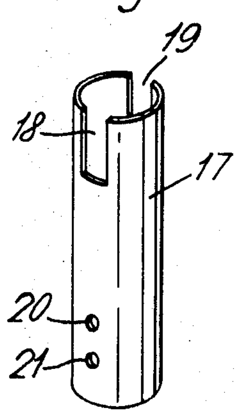

Fig. 4.

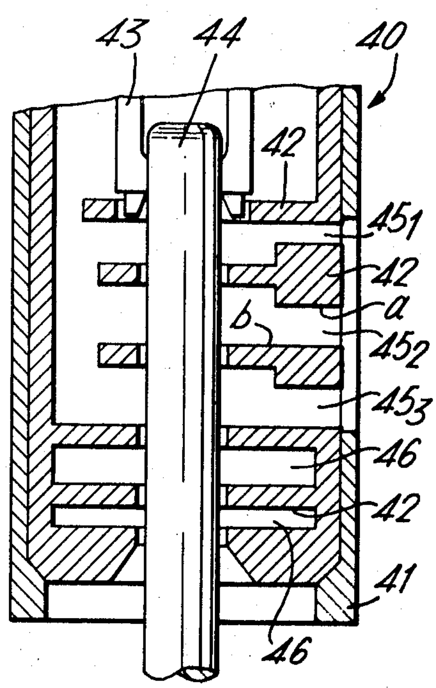

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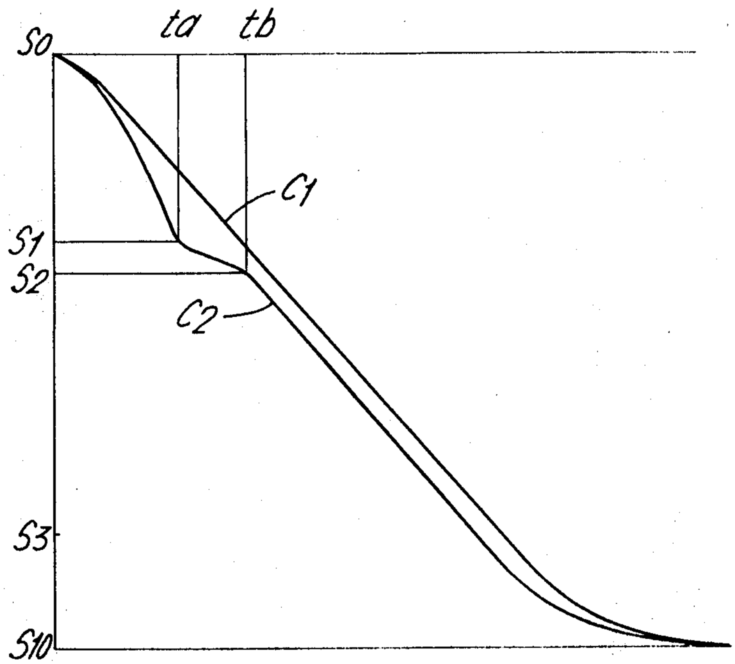
Fig. 5.



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OIL CIRCUIT BREAKER INCLUDING CONTACT BRAKING DEVICE

This invention relates to an oil circuit breaker of the self-quenching type.

It is well known that in this type of oil circuit breaker, current interruption should be finished after the moving contact parted from the stationary contacts but before the moving contact goes out of a quenching chamber. Generally, the quenching chamber is composed so that when the moving contact has separated from the stationary contacts and comes to a most suitable position in the chamber for extinguishing the arc that has arisen between both contacts, interruption of a specified current may be carried out. The position is decided with concern for the frequency of the interrupting current and the parting speed of the moving contact. Interruption is achieved by recovery of the insulation among the stationary and moving contacts at the time of current-zero after opening of the contacts. Recovery of the insulation may be attained when a proper parted distance exists between the contacts and the area around the leaving end of the moving contact has been disturbed by oil-flow. For the parting distance of the poles, proper spaces capable of withstanding the transient recovery voltage between the poles are needed. The parting distance is related to the parting speed of the moving contact. The speed of the moving contact depends on not only the actuating force externally given by the tripping motion but also the self-made gas pressure in the chamber caused by the arcing heat. With increase of gas pressure, the parting speed of the moving contact increases too. Arcing heat is higher when the current becomes larger so that the gas pressure is also higher. For oil-flow to disturb the area about the moving contact end it is necessary to prepare a flowing oil path. As to the oil-flow (blast), generally there are two means to form the oil-path. One is axial-flow by use of pressure differentials gradually becoming smaller toward lower parts of the chamber and the other is crossflow, transverse to the arc length, through openings provided in the sidewall of the chamber. The velocity of oil-flow is naturally increased with increase of pressure owing to the above-mentioned arcing heat. However too high a pressure requires high mechanical strength of the chamber. Arc pressure becomes higher with extension of the arc length. Therefore, it is required to finish the interruption while the arc length does not become too long.

Thus, if zero-current is encountered when the parted distance between the contacts is sufficient for recovery of insulation and the area about the contact end has been surely disturbed by oil-flow, very reliable interruption will be expected And it is desirable that interruption is fulfilled at initial zero-current after opening of the contacts. This is because if interruption at initial zero-current fails, the distance between the separated contacts will be so extended by the further proceeding of the moving contact that at the next zero-current, the moving contact will have passed over the most suitable position or in the worst case may have gone out of the chamber. Extension of the parted distance increases the pressure and also the speed of the moving contact, thus, it will help again the extension of the distance by itself, and it may be a cause to break the quenching by the gas pressure. In failure of interruption at initial zero-current, by use of a longer and stronger chamber, interruption at the next or the followed zero-current may be possible, but it will be uneconomical for use of large-sized chambers and/or large-sized breakers.

The principal object of this invention is to provide a small quenching chamber having reliable interrupting characteristics. Another object of this invention is to give a braking (restraining) action to the moving contact departing from the stationary contacts. This braking action works only in the neighborhood of the most suitable position for quenching in the chamber. By this action, velocity of the moving contact, in the neighborhood of the most suitable position for quenching in the chamber, decreases. In other words, the time required for the contact to pass the prescribed neighborhood in the chamber becomes longer. This means that there will be more than one chance of encountering zero-current. Thus, even if the interruption fails at initial zero-current, transfered distance of the moving contacts in the time to encounter the next zero-current is not long, so that the moving contact is still in the neighborhood of the most suitable position for quenching in the chamber at this time. Therefore without any extension of the chamber length it is possible to get high reliability of interruption.

When made long the time while the moving contact exists in the neighborhood of the most suitable position for quenching in the chamber is made long, it is desirable to bring quickly the moving contact to the above-mentioned neighborhood, in order to increase the chance of encountering zero-current. In this manner, it will be possible to increase the number of times to encounter the first or following zero-current. To increase the initial parting velocity of the moving contact is another object intended for this invention.

After the moving contact passed over the most suitable position for quenching, the motion is released from the braking action and makes the moving contact go out of the chamber swiftly. But just before the end of motion, decreasing of the speed is required for the following reason: The mechanism to stop the motion of the moving contact will receive violent shock, where continued high speed, however it is known that a shock absorber is available in such case. The methods used hitherto to decrease the speed of the moving contacts are not for the purposes to increase the chance of encountering the zero-current at the most suitable position for interrupting in the chamber, but for the purposes as buffer or damping devices.

The invention will be better understood from the following description of a preferred embodiment thereof with reference to the accompanying drawings, wherein:

FIG. 1 is a vertical section of the braking device of the oil circuit breaker of the invention;

FIG. 2 is a perspective view of the external cylinder used in the braking device of FIG. 1;

FIG. 3 is a view similar to FIG. 1 but showing the internal cylinder;

FIG. 4 is a vertical section of the quenching chamber of the circuit breaker; and

FIG. 5 is a graph showing the braking characteristics of the device shown in FIG. 1.

Now referring to the drawing, first to FIG. 1, the braking device of the invention is designated by **10**. A cylindrical case **11** is enclosed by a base **12** which has a projecting part **13**. Upper part of case **11** forms a flange **14**. By means of flange **14** cover **15** is fixed to case **11**. The cover **15** has a projecting part **16** corresponding to base projection **13**. An internal cylinder **17** is fitted to the respective projections **13** and **16** at both ends. The cylinder **17** has a couple of slots **18** and **19** on the upper end, as shown in FIG. 3, and is provided with two holes **20** and **21** for oil path. Around the wall of internal cylinder **17**, an external cylinder **22** is slidably fitted. Lower end of the external cylinder has a flange **23** which supports a coil spring **24** against the cover **15**. The spring **24** biases the external cylinder downward. At its open upper end, the cylinder **22** has a U-shaped bridge **25** with a center hole **27** through which a piston rod **33** passes. In the sidewall of the cylinder **22**, two holes **30** and **31** for oil flow are formed. They are spaced apart the same distance as the two holes **20** and **21** of the internal cylinder. The rod **33** has a piston **32** and projects through the bridge hole **27** and cover **15** upwardly. Within the cylinder case **11** and in the inner space of internal cylinder **17**, damping oil is contained.

FIG. 4 shows the quenching chamber **40**. The chamber is composed of quenching plates **42** of pile assembly inside the cylindrical wall **41**. The quenching plates are so assembled as to provide openings 45_1 to 45_3 for oil-jet along the moving contact route from the bottom end of the stationary contacts. Lower part of cylindrical wall **41** forms a proper pressure cabin **46**. The lower end of the moving contact **44** is jointed mechanically to the coupler **47** on the top of piston rod **33** through a suitable linkage. Thus, the motion of moving contact **44** is transmitted to the piston rod **33**.

Both FIG. 1 and FIG. 4 show the closed position of the breaker. Under the condition as indicated in FIG. 1, piston rod **33** and piston **32** are in the upper limit and is at rest and the external cylinder also is at rest against the spring by fitting of the top end of piston **32** and bridge end **26**.

At first, opening operation without current and small current interrupting action are described as follows:

As the moving contact begins its parting motion, mechanically coupled piston rod **33** and consequently piston **32** descend within the internal cylinder **17**. In the quenching chamber without generation of gas pressure in case of no current opening, or with slight gas pressure in case of small current interruption, the parting speed of the moving contact and consequently the descending speed of the piston are slower than in case of large current interruption. By the action of spring **24**, external cylinder **22** goes down at nearly the same speed as the piston speed. That is, the cylinder **22** goes down following the piston.

When piston **32** proceeds into the internal cylinder **17** the oil contained is compressed. But at the beginning of the piston motion, the oil flows out of the cylinder **22** through the clearances between bridge legs **28** of the cylinder **22** and slots **18** and **19** of the internal cylinder **17** and there is no braking action against the piston motion. When the piston **32** has passed the slots, the external cylinder which is going down following the piston comes to a position at which the two holes **30**, **31** coincide with the two holes **20**, **21** on the internal cylinder and the bottom of the cylinder **22** touches the base surface **12** of the body case **11** to stop further lowering. Under the condition, when the piston goes farther down, the oil in cylinder **17** flows out from the holes **20** and **30** or **21** and **31** so that damping action against the piston motion does not exist. When the piston **32** farther proceeds until its bottom surface goes beyond the position of hole **21**, cylinder oil is compressed and a first weak damping action arises. But this action will rather help weaken the shock of clash against the projection **13**. The moving contact **44** leaves the chamber before the bottom of cylinder touches the base projecting **13**.

When interrupting large current, the actions are as follows:

When the moving contact **44** leaves the stationary contacts, gas pressure is generated by the arc between both contacts and accelerates the lowering velocity of the moving contact. The piston **32** descends faster than the external cylinder does by aid of the spring **24**. Until the piston has reached the lower edge of the slots **18**, **19** the action is similar to the above mentioned for small current interruption. When the piston has passed the slots, the external cylinder has not lowered to such an extent that the holes **30** and **31** coincide with the holes **20** and **21** on the internal cylinder so that the oil in cylinder **17** is ocmpressed by piston **32**, and braking action acts on the piston. The speed of the piston is decreased quickly. This means decrease of the moving contact speed. At this time, the moving contact is situated at the position most suitable for interruption.

In FIG. 4, when the above mentioned braking acts on the moving contact it is going down in the chamber near to the oil-jet opening **45**. At this position, the moving contact has sufficient parting distance from the stationary contact for recovery of the insulation, and by the gas pressure generated by arc heat the oil at the top of the moving contact is disturbed and oil is blown out through the oil-jet openings mainly 45_2 or also 45_1, 45_3 from the chamber. Owing to this braking action, the moving contact takes comparatively long time to pass through the neighborhood of the most suitable position for interruption. Where the moving contact is existing within such position as mentioned above, there are chances to encounter zero-current at least once. Even if the interruption was unsuccessful at the first zero-current, success is expected at the next or following zero-current time. Thus, the reliability to the interrupting capability is increased. Thereafter, piston moves downward successively, and the external cylinder also goes down. When the two holes **30** and **31** coincide with the holes **20** and **21**, the braking action is decreased, and the lowering speed of the piston is increased. Accordingly, the moving contact motion becomes more rapid. The suitable position for interruption varies with the interrupting current, because the generated gas pressure varies with the current, accordingly the degree of accelerating the moving contact motion is changed. This is the reason why more than one oil-jet opening are provided along the route for the moving contact **44** as shown in FIG. 4, so as to be capable of interrupting all currents in an intended range.

FIG. 5 shows the characteristic curves with the braking device. The curves are indicated in time (X-axis) and transferring distance (Y-axis) S_0 means the starting time when the moving contact begins to part the stationary contacts and S_0–S_{10} means the distance from the stationary contact to final static position of the moving contact at the end of its whole movement. The characteristic for no current operation or small current interrupting is indicated by curve C_1, and curve C_2 is for the case of large current interruption. S_1 is a position at which the braking action begins and corresponds to distance (from S_0) to the upper internal surface *a* (FIG. 4 of jet opening 45_2. S_2 is a position at which the braking action finishes, and corresponds to distance (from S_0) to the lower internal surface *b* (FIG. 4) of jet opening 45_2. From the drawing it is understood that curve C_1 is nearly a straight line, with a gentle slope for the final motion of the contact **44** receiving shock-absorbing action. Curve C_2 indicates that the moving contact reaches S_1 in less time of t_a than in case of C_1 and takes longer time t_b to move up to S_2. If the suitable position for the interrupting current is in neighborhood of opening 45_2, moving velocity of the contact **44** is suddenly decreased. Therefore, when passing the position, the chance of encountering zero-current is surely increased. The distance to S_1 beginning the braking action becomes longer with the interrupting current increases and vice versa.

According to this invention, the following advantages are attained:

When the moving contact is passing the neighborhood of the most suitable position for arc extinguishing, a kind of braking action is given to the motion of the contact, thereby lengthening the time duration required to pass the position, and the number of chances to encounter the zero-current in the position is increased. Thus, the interruption is surely achieved while moving contact is within the quenching chamber. Furthermore, any extension of the chamber is unnecessary to get the sure interruption.

What we claim is:

1. An oil circuit breaker comprising: an arc-extinguishing chamber; stationary contacts arranged in said chamber; at least one movable contact adapted to depart, at the time of interruption, from said stationary contacts to travel through said chamber and to finally to go out thereof; and a braking device including means adapted to perform braking action on said movable contact when said contact passes the position moist suitable for arc extinguishing, so as to make it easier for the zero-current time to be encountered, and further including means for releasing said braking action on said movable contact when it has passed the neighborhood of said most suitable position at the time of interruption.