Aug. 24, 1954

C. H. JONES ET AL

CIRCUIT INTERRUPTER

Filed Dec. 6, 1949

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Fig.1.

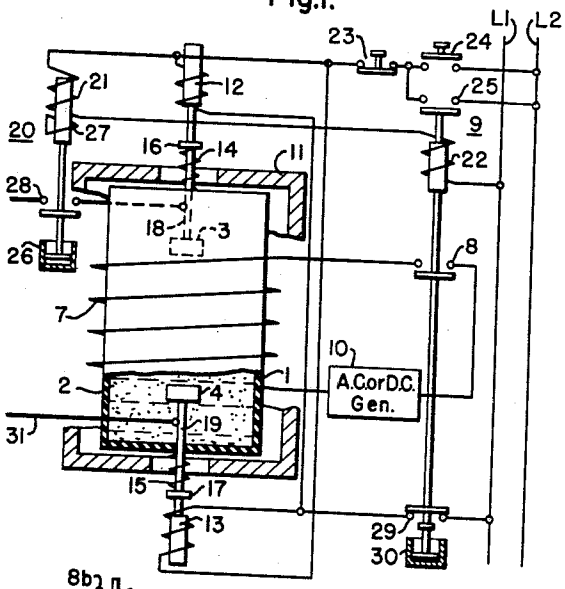


Fig.2.

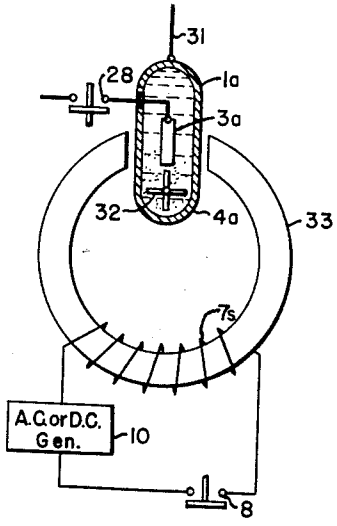


Fig.3.

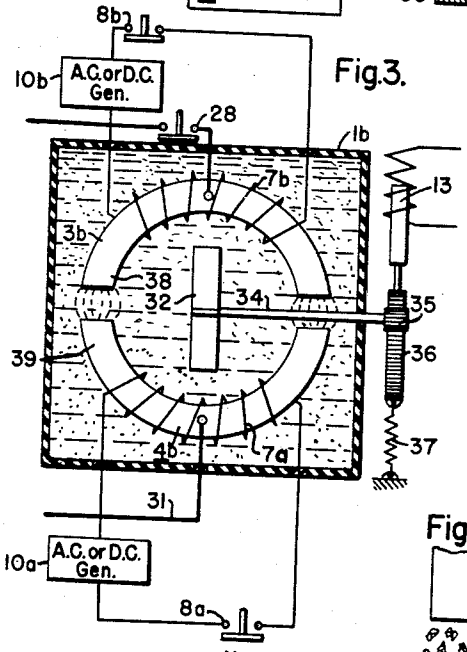


Fig.4.

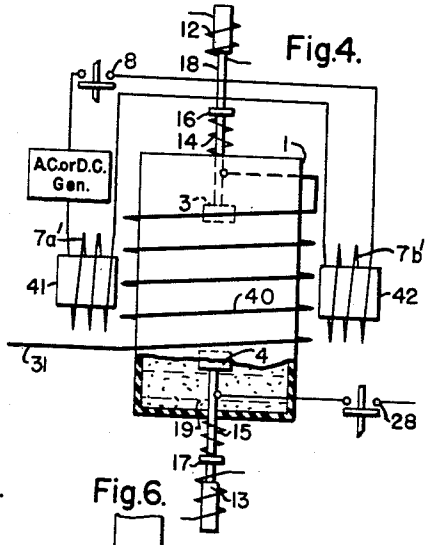


Fig.5.



Fig.6.



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Patented Aug. 24, 1954

2,687,500

UNITED STATES PATENT OFFICE

2,687,500

CIRCUIT INTERRUPTER

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Application December 6, 1949, Serial No. 131,412

9 Claims. (Cl. 317—135)

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This invention relates to circuit interrupters in general, and, more particularly, to a novel device for interrupting the current flow therethrough.

A general object of our invention is to provide an improved circuit interrupter which will more effectively open and close the circuit than has been attained heretofore.

A more specific object is to provide an improved circuit interrupter utilizing a mixture of a non-rigid, non-conducting medium, and particles of magnetic material distributed therein in the region between terminals in the circuit of the interrupter, and to employ a magnetic field to align the magnetic particles into conductive magnetic chains extending between the terminals forming conductive paths for the current flow therebetween.

Another object is to provide a new circuit interrupting arrangement by agitating a medium containing magnetic particles aligned to conduct a current so as to disperse the magnetic particles following removal of an aligning magnetic field.

Another object is to provide an improved circuit interrupter utilizing a dielectric liquid in which is dispersed particles of magnetic material, and to employ a magnetic field to align the magnetic particles into conductive magnetic chains extending between the electrodes forming conductive paths for the current flow therebetween.

A further object is to provide an improved circuit interrupter of the type set forth in the immediately preceding paragraph in which improved agitating means are provided to disperse the magnetic particles following removal of the magnetic field.

Another object is to provide an improved circuit interrupter employing magnetic particles disposed in a non-rigid, non-conducting medium with a magnetic field for aligning the magnetic particles into conductive chains extending between the electrodes, and to utilize therewith disconnect means for interrupting any residual current through the interrupter following removal of the magnetic field.

Still another object is to provide an improved circuit interrupter of the alternating-current type in which improved magnetic means are employed to more effectively bring about circuit interruption at a current zero.

Circuit interrupters of the prior art have depended upon various agencies for effecting circuit interruption. In some of them, reliance has been placed upon speed in separating the movable contacts. In others, reliance has been placed

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upon blow-out coils, which necessarily introduced complications, and in still other interrupters the arc has been broken into a series of shorter serially related arcs which were rotated upon cool surfaces to bring about their interruption.

It is obvious that circuit breakers built to carry hundreds or thousands of amperes continuously must have heavy contacts and so require strong springs to get the contacts separated rapidly enough. The maximum practical speed used is about 2½ feet a second. Sometimes it was deemed necessary to have a plurality of breaks in series so as to increase the effective contact separation speed of the breaker taken as a whole. However, in such cases, the maximum speed was only about 20 feet per second.

In other interrupters disclosed by the prior art, compressed gas has been used at pressures ranging from 100 to 300 pounds per square inch for opening the contacts and blowing a blast of gas at the drawn arc to effect the extinction thereof. In such cases, the breakers used 15 to 25 cubic feet of air each time the circuit was opened.

In the circuit interrupter of our invention, no heavy springs are employed and no compressed gas for moving the contacts is employed because in our invention the contacts do not move completely together in the closed circuit position of the interrupter.

Further objects and advantages will readily become apparent upon reading the following specification taken in conjunction with the drawing, in which:

Figure 1 illustrates somewhat diagrammatically a circuit interrupter embodying our invention and shown in the open circuit position;

Fig. 2 illustrates another form of circuit interrupter embodying our invention and shown in the open circuit position;

Fig. 3 illustrates still a further embodiment of our invention, the interrupter being shown in the open circuit position;

Fig. 4 illustrates a circuit interrupter embodying our invention and utilizing an improved magnetic control scheme to effectively bring about circuit interruption at a current zero on the alternating-current wave.

Fig. 5 diagrammatically illustrates a pair of electrodes with the circuit being open because of an absence of a magnetic field; and

Fig. 6 is a view similar to that of Fig. 5 but illustrating the conditions existing following an application of the magnetic field.

Referring to the drawing, and more particularly to Figure 1 thereof, the reference numeral

1 designates an insulating tank or container in which is disposed a suitable mixture 2 of a non-conducting medium such as oil and a magnetic powder. The mixture 2 fills the space between the electrodes 3, 4.

In our invention, any finely divided magnetizable conducting powder may be used in the dielectric medium. The powder may be iron, nickel, silicon iron, magnetite, etc. The dielectric medium may be oil, wood flour, finely divided rubberized particles, alkyl phosphates, chlorinated diphenyl, dibutyl sebacate, or other non-rigid, non-conducting materials in which the magnetic conducting particles may be dispersed.

It is only necessary that the non-conducting material be movable as by being fluid or finely divided, that is, the particles of which are comparable with the size of the magnetic particles. Also the particles should be somewhat freely movable so that there will not be too much resistance to motion of the magnetic particles in the resultant mass.

Referring to Fig. 5 for an understanding of the principles applicable to our invention, it will be noted that when no magnetic field is applied, the magnetic particles 5 are distributed in random position in the space between the electrodes 3, 4. However, upon an application of a magnetic field applied to the space between the electrodes 3, 4, as shown in Fig. 6, the magnetic particles 5 align themselves into chains 6 forming conductive paths between the electrodes 3, 4. The magnetic field may result from an A. C. or D. C. source, and may be in any direction. Preferably, however, a D. C. field is used with a direction of the D. C. field taken parallel to a straight line connecting the electrodes 3, 4.

It is apparent upon an inspection of Fig. 6 that the existence of the several conductive chains 6 leads to a condition in which current flow is easily obtained between the spaced electrodes 3, 4.

Referring again to Fig. 1, it will be observed that we have provided means for establishing a magnetic field including an energizing winding 7 in series with the front contacts 8 of a contactor 9. An A. C. or D. C. source 10 is interposed in the circuit including the energizing winding 7 so that when the front contacts 8 of the contactor 9 close, a magnetic field will be set up within the container 1, an iron shell 11 being provided to intensify the magnetic field. The formation of such a magnetic field will cause the magnetic particles 5 to be attracted and to form chains along the lines of magnetic flux and thus drawn into close physical contact. The flux density will determine the massiveness of the chains and thus the conductivity of the mixture.

To insure a dispersal of the magnetic particles 5 within the oil or other non-conducting medium following removal of the magnetic field, we provide a mechanical agitator, in this instance comprising motion of the electrodes 3, 4. They are moved inwardly by solenoids 12, 13 and outwardly following deenergization of the solenoids 12, 13 by compression springs 14, 15. The compression springs 14, 15 seat at one end on the tank 1, and at the other end on washers 16, 17 movable with the electrode rods 18, 19. Thus, energization of the solenoids 12, 13 will move the electrodes toward each other a short distance compressing the springs 14, 15. Deenergization of the solenoids 12, 13 will permit the compression springs 14, 15 to force the electrodes 3, 4 outwardly mechanically agitating the mix 2 and thereby dispersing the particles 5 within the oil. Such agitating motion of the electrodes 3, 4 within the tank 1 breaks the adherence between the particles 5, constituting the chains 6, and causes the mixture to be rendered non-conductive.

To effectively prevent the passage of any residual current in the open circuit position of the interrupter, as shown in Fig. 1, we provide an external disconnect switch 20. The operation of the disconnect switch 20 is synchronized with the operation of the interrupter by having the energizing coil 21 of the disconnect switch 20 in series with the coil 22 of the contactor 9. Preferably, a normally closed push-button 23 is provided in series with the winding 21 which is energized from the line L2. Also, a normally open push button 24 is included in the circuit to the winding 21 which is bypassed by front contacts 25 of the contactor 9.

The disconnect switch 20 has a delayed closing furnished by the dashpot 26, so that on closing the interrupter the chains 6 will have had time to form before an impressing of line potential to the electrodes 3, 4. This eliminates the possibility of sparking within the mix 2 which otherwise might occur. The disconnect switch 20 also has a delayed opening provided by the closed turn 27. Consequently, the disconnect switch 20 will drop out on the opening operation of the interrupter after the opening of the contactor 9. This insures opening the circuit within the mix 2 following removal of the magnetic field and by the mechanical agitation process, and not at the disconnect switch contacts 28. The latter, of course, are not suitable for breaking currents of appreciable magnitude, but are capable of interrupting any small residual current remaining following the main interruption process.

The operation of the interrupter is as follows. During the closing operation, one manually presses the closing button 24. This energizes the coils 21, 22 of the disconnect switch 20 and contactor 9 respectively across the control lines L1, L2. Also, the solenoids 12, 13 are energized at the same time through the back contacts 29 of the contactor 9.

Since the contactor 9 is slow closing by virtue of the dashpot 30, the solenoids are energized and the electrodes 3, 4 move toward each other compressing the springs 14, 15 before the contacts 8 close energizing the magnetic field. Consequently, when the contacts 8 do close energizing the magnetic field the compression springs 14, 15 are already compressed at this time, and the electrodes 3, 4 are in their inward position.

The energization of the magnetic field by the closing of contacts 8 "freezes" the mix 2, preventing retraction of the electrodes 3, 4 even though the solenoids 12, 13 are deenergized by opening of the contacts 29. The wiping contacts 29 open after contacts 8 have closed. A short time after closing of the contacts 8 energizing the magnetic field, the disconnect contacts 28 close applying line potential to the interrupter. The circuit is then closed through the interrupter, with the electrode solenoids 12, 13 deenergized, and compression springs 14, 15 compressed.

The electrical circuit through the interrupter itself includes the external disconnect switch 20 (the contacts 28 of which are now closed), electrode 3, conductive chains 6, to electrode 4 and hence to external circuit connection 31.

To open the interrupter, it is merely necessary to push the opening button 23, which is normally closed. The opening of the normally closed push button 23 will break the electrical circuit through the windings 21, 22 to deenergize the contactor 9 and cause an opening of the circuit through the field winding 7 to remove the magnetic field. The mix 2 will "unfreeze" and permit the springs 14, 15 to force the electrodes 3, 4 apart, thereby agitating the mix to disperse the magnetic particles 5 in the oil to break the conductive chains 6.

The closed turn 27 is provided in the disconnect switch 20 to delay opening of the contacts 28 until after the chains 6 have been broken by the agitating separating movement of the electrodes 3, 4.

Referring to Fig. 2, it will be apparent that certain features are similar to those previously disclosed in Fig. 1. The container 1a may, as before, be agitated, but in this instance by an agitator or paddle wheel 32. The electrode 3a is disposed within the container 1a and the container 1a itself may constitute the other electrode 4a which may be connected to the external circuit 31.

In this embodiment, an iron yoke member 33 is employed, being surrounded by an energizing winding 7s, having the same function as the coil 7 of Fig. 1. The winding 7s is energized by a source 10 and contacts 8 of a contactor 9, the latter not being shown. The method of operation is the same as that previously described, and hence it will not be repeated. The operation of the paddle wheel 32 may be the same as that clearly shown in Fig. 3, which shows another embodiment of our invention, and which will now be described.

The paddle wheel 32 of Fig. 3 is on a shaft 34 having a pinion gear 35 at the external end thereof. The shaft 34 does not obstruct the interelectrode space. A rack 36 is biased downwardly by a tension spring 37 and is moved upwardly in opposition to the tension spring 37 by a solenoid 13. The circuit for the solenoid 13 may be the same as in Fig. 1. The disconnect switch 28 is in series with the electrode 3b, which in this instance is constituted by a yoke member 38 of magnetic material, such as iron and disposed within the enclosure 1b. The other electrode 4b is preferably constituted by a similarly shaped member 39. Windings 7a, 7b are employed having the same function as the winding 7 of Fig. 1, and being energized from suitable sources 10a, 10b. The normally open contacts 8a, 8b in series respectively with the windings 7a, 7b are preferably simultaneously operated by any suitable means so that upon the formation of a magnetic field between the ends of the yoke members 38, 39, conductive chains 6 may be formed therebetween to complete the circuit. The control scheme may be that as indicated heretofore in connection with Fig. 1.

In Fig. 4 we have shown a container 1 similar in type to that of Fig. 1 with a similar means for agitation. In this embodiment of our invention, however, we provide two cooperating magnetic fields, each disposed at right angles to the other. One magnetic field, herein called the control field, is transverse of the container 1 and is set up by two field windings 7a', 7b' electrically in series and controlled by the contacts 8 as in Fig. 1. The other magnetic field is axially of the container 1, and is set up by the series coil 40. Alternating current flows through the main circuit 31. Preferably iron cores 41, 42 are provided for the windings 7a', 7b' to lower the reluctance of the magnetic circuit.

The device functions as follows. As long as the control field is present, a conducting state exists within the container 1. The two fields merely add vectorially and current passes between the electrodes 3, 4. When it is desired to interrupt the current flow through the interrupter, the control field is cut off by pressing the open button 23, as heretofore explained in connection with Fig. 1. The control field goes to zero, but if the instantaneous value of the current through the series winding 40 is high, there will still exist a relatively high value of magnetic field within the container 1 to cause the continuance of the existence of the conductive chains 6. When the instantaneous value of the series circuit current goes to zero, the auxiliary magnetic field set up by the series winding 40 will also go to zero, the mix will "unfreeze" and at the zero point on the alternating-current wave the particles will be dispersed by the agitating movement of the electrodes 3, 4.

Thus, in Fig. 4 we have disclosed a magnetic control arrangement in which interruption of the circuit takes place effectively at a current zero on the alternating-current wave.

From the foregoing description of several embodiments of our invention, it will be apparent that we have provided an improved magnetic fluid-type of circuit interrupter in which the circuit is effectively opened and closed. When the magnetic field is present, as in Fig. 6, conductive paths 6 are caused to form between the electrodes 3, 4 by the adherence of the particles 5 to each other and to the electrodes 3, 4. Upon the removal of the magnetic field, the agitation process may be depended upon to break the chains 6 and render the mixture 2 non-conducting by dispersing the magnetic particles 5 within the oil, thereby breaking the chains 6.

The dielectric medium need not be oil, but may be any suitable non-rigid, non-conducting medium. Clearly other devices for agitating the mix may be employed. Those described were merely for purposes of illustration. The disconnect means insures breakage of any residual current passing through the device.

Although we have shown and described specific structures, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made therein by those skilled in the art without departing from the spirit and scope of the appended claims.

We claim as our invention:

1. A circuit interrupter including a container containing a magnetizable powder disposed in a dielectric liquid, a pair of electrodes associated with the container in contact with the dielectric liquid between which current may flow and be interrupted, means for establishing a magnetic field within the dielectric liquid to establish a conductive condition therein between the electrodes, means for removing the magnetic field to establish a non-conductive state in the region between the electrodes, disconnect means serially connected with the electrodes, means for closing the disconnect means during the closing operation only after establishment of the magnetic field within the dielectric liquid, and means for opening said disconnect means only after removal of the magnetic field within the dielectric liquid to establish a non-conductive state therein.

2. A circuit interrupter including a container

containing an iron powder disposed in oil, a pair of electrodes associated with the container in contact with the oil between which current may flow and be interrupted, means for establishing a magnetic field within the oil, an agitator for dispersing the magnetic powder within the oil disposed in the container following removal of the magnetic field to break the conductive chains of magnetic powder extending between the two electrodes, disconnect means serially connected with the electrodes, means for closing said disconnect means during the closing operation only after establishment of the magnetic field, and means for opening said disconnect means during the opening operation only after removal of the magnetic field.

3. A circuit interrupter including a container containing a magnetizable powder disposed in a dielectric liquid, a pair of electrodes associated with the container in contact with the dielectric liquid between which current may flow and be interrupted, means for establishing a magnetic field within the dielectric liquid, a mechanical agitator utilizing motion of at least one electrode for dispersing the magnetizable powder within the dielectric liquid disposed in the container following removal of the magnetic field to break the conductive chains of magnetic powder extending between the two electrodes, disconnect means serially connected with the electrodes, means for closing said disconnect means during the closing operation only after establishment of the magnetic field, and means for opening said disconnect means during the opening operation only after removal of the magnetic field to establish an open circuit condition.

4. A circuit interrupter including finely divided magnetic particles dispersed in a non-rigid non-conducting medium, a pair of electrodes disposed in said medium, means for establishing a magnetic field in the medium to form conductive magnetic chains of the magnetic particles between the electrodes to establish current flow therebetween, spring means biasing at least one electrode, means for causing motion of the electrode and for energizing the spring means prior to the establishment of said magnetic field, and the deenergization of the magnetic field permitting the spring means to cause motion of the electrode to result in agitation of the particles, thereby dispersing them within the medium to break the conductive chains of magnetic particles extending between the two electrodes.

5. An alternating current circuit interrupter including a mix of finely divided conducting magnetic particles dispersed in a non-rigid, non-conducting medium, a pair of spaced electrodes having the mix therebetween, means other than the controlled main circuit for establishing a magnetic control field in the mix at will to bring about current flow through the interrupter by a formation of conducting chains of the particles, means for discontinuing said magnetic control field at will, and a series coil in which flows at least a portion of the series current disposed in such proximity to the mix to set up an auxiliary magnetic field therein responsive to the series current, whereby upon removal of the control field the auxiliary magnetic field will tend to maintain the mix in a conducting state until near a current zero on the alternating current wave.

6. An alternating current circuit interrupter including a mix of finely divided conducting magnetic particles dispersed in a non-rigid, non-conducting medium, a pair of spaced electrodes having the mix therebetween, means other than the controlled main circuit for establishing a magnetic control field in the mix at will to bring about current flow through the interrupter by a formation of conducting chains of the particles, means for discontinuing said magnetic control field at will, a series coil in which flows at least a portion of the series current disposed in such proximity to the mix to set up an auxiliary magnetic field therein responsive to the series current, whereby upon removal of the control field the auxiliary magnetic field will tend to maintain the mix in a conducting state until near a current zero on the alternating current wave, and the control and auxiliary magnetic fields being oriented at a substantial angle with respect to each other so that the fields will not cancel each other to permit cessation of current flow other than near a current zero on the alternating current wave.

7. An alternating current circuit interrupter including a mix of finely divided conducting magnetic particles dispersed in a non-rigid, non-conducting medium, a pair of spaced electrodes having the mix therebetween, means biasing one electrode to move, means other than the controlled main circuit for establishing a magnetic control field in the mix at will to bring about current flow through the interrupter by a formation of conducting chains of particles within the mix, means for discontinuing said magnetic control field at will, means for causing motion of said one electrode and for tensioning said biasing means prior to the establishment of said magnetic control field, a series coil in which flows at least a portion of the series current disposed in such proximity to the mix to set up an auxiliary magnetic field therein responsive to the series current, whereby upon removal of the control field the auxiliary magnetic field will tend to maintain the mix in a conducting state until near a current zero on the alternating current wave at which time the biasing means will cause said one electrode to move and in so doing will disperse the magnetic conducting particles to effect the non-conducting state.

8. An alternating current circuit interrupter including a mix of finely divided conducting magnetic particles dispersed in a non-rigid, non-conducting medium, a pair of spaced electrodes having the mix therebetween, means biasing one electrode to move, means other than the controlled main circuit for establishing a magnetic control field in the mix at will to bring about current flow through the interrupter by a formation of conducting chains of particles within the mix, means for discontinuing said magnetic control field at will, means for causing motion of said one electrode and for tensioning said biasing means prior to the establishment of said magnetic control field, a series coil in which flows at least a portion of the series current disposed in such proximity to the mix to set up an auxiliary magnetic field therein responsive to the series current, whereby upon removal of the control field the auxiliary magnetic field will tend to maintain the mix in a conducting state until near a current zero on the alternating current wave at which time the biasing means will cause said one electrode to move and in so doing will disperse the magnetic conducting particles to effect the non-conducting state, and the control and auxiliary magnetic fields being oriented at a substantial angle with respect to each other so that the fields will not cancel each other to permit

cessation of current flow other than near a current zero on the alternating current wave.

9. An alternating current circuit interrupter including a mix of finely divided conducting magnetic particles dispersed in a non-rigid, non-conducting medium, a pair of spaced electrodes having the mix therebetween, means other than the controlled main circuit for establishing a magnetic control field in the mix at will to bring about current flow through the interrupter by a formation of conducting chains of the particles within the mix, means for discontinuing said magnetic control field at will, agitator means, means tensioning said agitator means prior to the formation of conducting chains within the mix, the formation of the chains within the mix maintaining the tensioning of the agitator means and rendering the same motionless, means for establishing an alternating magnetic field only when the interrupter is closed, which is auxiliary to the magnetic control field and is substantially in phase with the alternating current flowing through the interrupter, whereby upon removal of the control field the auxiliary field will maintain the conducting chains within the mix until near a current zero, at which time the agitator means will be released and move under the effect of the tensioning means to effect dispersal of the particles.

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