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CHECKING SYSTEM FOR CONDITION RESPONSIVE APPARATUS

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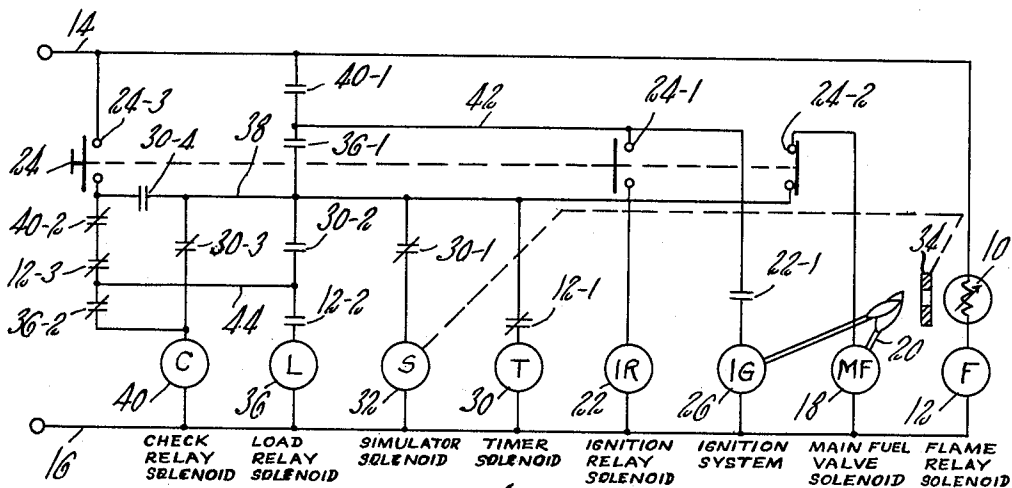
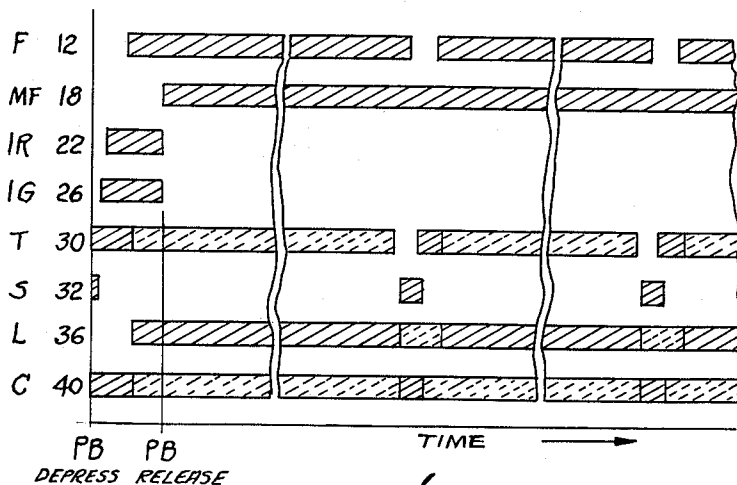


Fig. 1.



RELAY SOLENOID ENERGIZED AND RELAY PICKED UP
RELAY SOLENOID DE-ENERGIZED AND RELAY PICKED UP

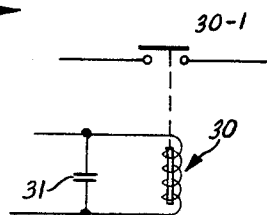


Fig. 1A

1

3,190,341

CHECKING SYSTEM FOR CONDITION RESPONSIVE APPARATUS

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This invention relates to control apparatus and more particularly to condition responsive apparatus of the type particularly useful in supervising fuel burning systems, and to means for insuring reliable operation of the sensory and signal modifying portions of such apparatus.

In condition responsive systems of the type to which the invention relates a load is controlled as a function of a supervised condition, such as flame in the combustion chamber. Such a system is employed for the supervision of the condition of combustion in a furnace chamber with a fuel valve being controlled as a function of the presence or absence of flame in the furnace chamber. Safety considerations dictate that the system must react quickly to the presence or absence of flame so that excessive amounts of unburned fuel will not be introduced into the combustion chamber when no flame is present. Electronic flame sensors have the desirable rapid reaction to the presence or absence of flame for the control of fuel flow, and checking arrangements, for example, of the types disclosed in the copending application, Serial No. 297,639, guard against component malfunctions in such systems, such as, for example, a continuously avalanching sensor of the gas discharge type which falsely indicates the presence of flame, or a runaway transistor in the signal modifying portion of the control system, and operate to place the fuel valve or other controlled load device in safe condition in response to flame failure or component malfunction.

In systems where the sensed condition is continuously present for long intervals of time, and the load must be maintained in continued energized state as long as the system is operating properly, however, as for example, a period of several months in a large continuously operating boiler system, the load control device, typically a relay, may stick in its energized state. In such event even though the sensor checking circuitry operates properly, the load is not de-energized and a potentially explosive condition results.

Accordingly, it is an object of this invention to provide a novel and improved condition supervision system which regularly checks the operability of the system's load control device without change in the condition of the load as long as the load control device properly responds to the checking operation.

Another object of this invention is to provide a novel and improved comprehensive condition supervision and self-checking system.

A further object of the invention is to provide load control checking means suitable for integration with a continuously operating condition responsive system and which over-rides faulty load control and shuts down the supervised system in safe condition upon detected absence of the condition being sensed.

Still another object of this invention is to provide a novel and improved comprehensive combustion super-

2

vision and self-checking system including fuel control checking means which over-rides a faulty fuel valve control and terminates fuel flow to the combustion chamber upon detected absence of flame in the supervised chamber.

Other objects, features and advantages of the invention will be seen as the following description of a preferred embodiment thereof progresses, in conjunction with the drawing, in which:

FIG. 1 is a schematic diagram of a frame sensing system for controlling the flow of fuel to a combustion chamber constructed in accordance with the invention;

FIG. 1a is an auxiliary view illustrating the nature of slow release relay employed in the system of FIG. 1; and

FIG. 2 is a timing diagram indicating the cycle of operation of the system shown in FIG. 1.

With reference to FIG. 1, the control system shown there includes a flame sensor 10 which is connected in series with a flame relay 12 across supply lines 14 and 16 to which electric energy is supplied in conventional manner. Signal modifying circuitry of conventional nature, commonly employed in circuit between the sensor 10 and the relay 12, has been omitted to simplify the drawing. While the condition sensor 10 in the preferred embodiment is a flame sensing device such as a gas discharge type of detector or a lead sulphide cell which provides a used signal in response to the detection of flame to operate the flame relay 12, other types of condition sensors may be employed in the practice of the invention and conditions other than flame may be sensed with apparatus of the invention.

The system load is in the form of a diagrammatically shown main fuel valve 18 which supplies fuel through nozzle 20 to maintain flame in the combustion chamber. Associated with the fuel supply mechanism in the system are an ignition relay 22 connected in series with normally open push button contacts 24-1 and a diagrammatically shown ignition system 26, which may include an ignition transformer and a pilot fuel valve and which is connected in series with relay contacts 22-1. These flame and fuel control components may be of the type that is well known in conventional combustion supervision systems and further details thereof are therefore believed unnecessary.

The system also includes a timing device shown as a slow release relay 30 (shown in schematic form in FIG. 1a), the contacts of which remain in picked up condition for a period of ten seconds after its solenoid circuit is opened. This timer is controlled by normally closed contacts 12-1 operated by the flame relay 12. Timing device 30 controls, through its contacts 30-1, a flame absence simulator which in this embodiment includes a solenoid 32 that is connected in series circuit with those timer contacts. At the end of each timing cycle contacts 30-1 close to energize solenoid 32 and position shutter 34 between the flame and sensor 10 to simulate a flame absence. A load control device in the form of relay 36 is connected in series with normally open contacts 12-2 controlled by the flame relay 12 and normally open contacts 30-2 controlled by the timer 30. The circuit components are connected to a main supply bus 38, the energization of which is controlled by normally open contacts 36-1 of the load control relay 36. This type of self-checking condition supervision control system is dis-

closed in the aforementioned compending application, Serial No. 297,639.

Briefly summarizing the operation of that control, as soon as pilot flame is detected in the combustion chamber, sensor 10 energizes the flame relay 12 which opens contacts 12-1 and initiates a timing cycle. With initiation of a timing cycle load control relay 36 is energized through contacts 12-2 and 30-2 to close the contacts 36-1 and to maintain the bus 38 energized. At the end of the timing cycle the flame absence simulator solenoid is energized and shutter 34 is interposed in front of the sensor 10 to block flame radiation if the sensor 10 and the flame relay 12 are properly operating, relay 12 drops out closing contacts 12-1 to reset the timer by restoring the charge on the capacitor 31 connected across the timer relay solenoid (or to supply heat to an actuator of the type disclosed in the aforementioned application, Serial No. 297,639). As soon as the timer is reset, the simulator solenoid 32 is de-energized and the sensor 10 should again see flame so that the flame relay 12 picks up. When this happens the contacts 12-1 open and a timing cycle is again initiated. Thus a new timing cycle is initiated only after a sequence of flame absence (simulated) and flame reappearance. If this simulated flame absence and reappearance sequence occurs in less than three seconds (the delay of load control relay 36) that relay remains in picked up condition so that the load relay contacts 36-1 do not open and bus 38 is maintained in energized condition. However, should this simulation and reset operation exceed the delay of the load control relay it should drop out, opening contacts 36-1 and shutting down the system in safe condition.

While the other components of the supervision system are regularly cycled, the load control relay remains continuously picked up. A not insubstantial possibility exists that a contact may become stuck so that even on prolonged de-energization of relay 36 its contacts 36-1 do not open. Thus even though the flame sensing circuitry properly operates in response to flame failure or component malfunction, the fuel valve 18 remains energized, permitting continued flow of fuel into the combustion chamber, creating a potentially explosive condition.

The presently disclosed system further includes a checking relay 40 which operates normally open contacts 40-1 connected in series with load control relay contacts 36-1. In order to maintain the bus 38 energized both contacts 36-1 and 40-1 must remain closed. This checking relay has a timing cycle of longer duration than the timing cycle of flame absence simulation timer 30 and at the end of each cycle of timer 30, the system interrupts and reinitiates the timing cycle of the checking device so that its cycle is prevented from being completed. Should the system fail to interrupt and reinitiate the cycle of check timer 40, the electrical connection to bus 38 will automatically be broken at the end of the check cycle and the entire system will be de-energized in safe condition.

The circuitry also includes a supplementary holding circuit set of contacts 30-3 used on start-up and, as a safeguard to prevent the start-up of the system whenever any one of the relays 12, 36 or 40 is in picked up condition, three sets of normally closed contacts connected in series with the check relay 40: flame relay contacts 12-3, load relay contacts 36-2 and check relay contacts 40-2.

The operating cycle of this system may best be understood with reference to the timing diagram of FIG. 2 in which the delays between energization of a relay solenoid and actuation of contacts as a result thereof have been somewhat exaggerated in order to better indicate the sequence of operation. When the push button 24 is depressed, contacts 24-1 and 24-3 are closed, and if the system relays are properly in de-energized condition, check relay 40 is energized through contacts 40-2, 12-3 and 36-2, and bus 38 is energized through the further contacts 30-3 so that simulator solenoid 32 and the timer

relay 30 are also energized. The simulator solenoid 32 is de-energized as soon as the timer 30 opens its normally closed contacts 30-1 and shutter 34 drops out so that the sensor 10 may see flame as soon as it is established in the combustion chamber.

With the pick up of timer 30 an auxiliary circuit path to bus 38 is completed through timer contacts 30-4, and with the pick up of check relay 40, contacts 40-1 close energizing bus 42 and the ignition control circuitry. As push button contacts 24-1 are closed, the relay 22 is energized to close contacts 22-1, enabling the ignition circuitry 26. While ignition is being established, push button 24 holds contacts 24-2 open so that the main fuel valve 18 is not energized. Energy continues to be supplied to the check relay through timer contacts 30-2, line 44 and load relay contacts 36-2 in order that the timing cycle of the check relay may be synchronized with the energization of the load relay 36. That is, the fifteen second timing cycle of the check relay is not started until the load relay is energized.

It will be noted that should there be a malfunction due to improper operation of one or more of the major relays, ignition is inhibited as that circuit is controlled by check relay 40 and its energization is a function of the de-energization of flame relay 12, load relay 36 and the check relay 40 itself. Thus, whenever one of those relays sticks combustion cannot be established in the combustion chamber, and a malfunction which might result in a subsequent undetected unsafe condition at a later time thus can be detected and corrected.

Upon establishment and detection of pilot flame in the combustion chamber by sensor 10 a signal is generated to pick up flame relay 12, opening contacts 12-1 to de-energize timer 30 and initiate a flame relay checking cycle. At the same time contacts 12-2 are closed permitting energization of load control relay 36 and the closing of contacts 36-1 complete a holding circuit with contacts 40-1 across contacts 24-3 so that the push button may be released. Upon such release contacts 24-1 open de-energizing the ignition circuitry and contacts 24-2 close energizing the main fuel valve 18 so that the flame in the combustion chamber is maintained. If the push button should be released before load control relay 36 is picked up, whether due to absence of flame or other cause, the circuit to bus 38 will be immediately opened and the fuel valve 18 or other load cannot be energized. With the energization of load control relay 36, contacts 36-2 open and de-energize the solenoid of check relay 40 so that its timing cycle is initiated. (This state of a de-energized solenoid with the relay remaining in picked up condition is indicated in FIG. 2 by dashed lines.)

This check cycle has a duration in excess of the cycle of timer 30 and in a preferred embodiment is fifteen seconds. With proper operation of the system these two timing cycles are initiated at substantially the same time but on termination of the cycle of timer 30, the load control relay circuit is opened (contacts 30-3), and the check relay timing cycle is interrupted and reset with the closing of contacts 30-3. At the same time simulator solenoid 32 is energized and moves shutter 34 between the sensor 10 and the flame so that flame relay 12 drops out if the sensor and signal modifying circuitry is operating properly. This drop out resets timer 30 by re-energizing its solenoid. In response to this resetting operation, contacts 30-1 open to de-energize shutter solenoid 32 so that the flame absence simulating condition is removed. As soon as the flame sensor 10 detects flame again, relay 12 is energized and opens contacts 12-1 to initiate another timing cycle. The timing cycle of the check relay 40 is restarted, and the circuit of load relay 36 is then again energized to hold its contacts in picked up condition.

Should the flame relay 12 ever drop out due to flame failure or defective components, contacts 12-2 open and the load control relay 36 opens contacts 36-1 within three seconds, de-energizing bus 38. If the load control relay

should stick, holding contacts 36-1 closed, the timer 30 is held energized upon flame failure (through contacts 12-1), and contacts 30-3 are held open so that the check cycle is not interrupted and thus relay 40 times out. At the end of that cycle contacts 40-1 open, immediately de-energizing bus 38 and shutting down the system.

Thus the invention provides a control circuit which provides an over-riding control on the load control device while also providing additional checks in a simplified manner both for initiation of the condition to be sensed and also checking the entire operability of the circuit. While a preferred embodiment of the invention has been shown and described, various modifications thereof will be obvious to those skilled in the art. Therefore, it is not intended that the invention be limited to the disclosed embodiment or to details thereof and departures may be made therefrom within the spirit and scope of the invention as defined in the claims.

What is claimed is:

1. A combustion control system comprising a flame sensor adapted to sense the presence of flame in a supervised combustion chamber,

a flame relay controlled by said flame sensor to indicate the presence or absence of flame in the supervised combustion chamber,

a load control device responsive to said flame relay for controlling the flow of fuel to said combustion chamber,

simulator means for allowing said flame relay to be de-energized independently of the presence of flame in said combustion chamber,

a first timer operative to provide a first timing cycle, flame relay responsive means for causing said first timer to initiate a timing cycle upon detection of flame in said combustion chamber by said flame sensor, means responsive to said first timer to actuate said simulator means at the end of said first timing cycle, means responsive to the de-energization of said flame relay to de-energize said load control device and to reset said first timer,

a second timer operative to provide a second timing cycle of longer duration than said first timing cycle, said second timer being operatively connected to terminate the flow of fuel to said combustion chamber at the end of its cycle,

means for causing said second timer to initiate its timing cycle upon energization of said load control device,

and means responsive to the end of each cycle of said first timer to interrupt the cycle of and reset said second timer.

2. The system as claimed in claim 1 wherein said first and second timers include delayed release relays.

3. A combustion control system comprising a flame sensor adapted to sense the presence of flame in a supervised combustion chamber,

means controlled by said flame sensor for indicating the presence or absence of flame in the supervised combustion chamber,

means for controlling the flow of fuel to said combustion chambers as a function of the indicated presence or absence of flame in said combustion chamber,

a first timer operative to provide a first timing cycle, flame sensor responsive means for causing said first timer to initiate a timing cycle upon detection of flame in said combustion chamber by said flame sensor,

means to allow said indicator means to indicate an absence of flame at the end of said first timing cycle, means responsive to an indicated absence of flame in said combustion chamber to reset said first timer,

a second timer operative to provide a second timing cycle of longer duration than said first timing cycle, said second timer being operatively connected to ter-

minate the flow of fuel to said combustion chamber at the end of its cycle,

means for causing said second timer to initiate its timing cycle in response to the energization of said first timer,

and means responsive to the end of each cycle of said first timer to interrupt the cycle of and reset said second timer.

4. A combustion control system comprising a flame sensor adapted to sense the presence of flame in a supervised combustion chamber,

a flame relay controlled by said flame sensor having a first state indicating the presence of flame in the supervised combustion chamber, and a second state indicating the absence of flame in said chamber,

a timer having a timing cycle of predetermined duration,

said timer being in a first state during each timing cycle and in a second state at the end of each timing cycle,

simulator means responsive to said timer being in its second state for allowing said flame relay to be placed in its second state independently of the presence of flame in said combustion chamber,

a load control device responsive to said flame relay having a first state permitting the flow of fuel to said combustion chamber and a second state blocking said flow of fuel,

ignition means for establishing flame in said combustion chamber,

and means for enabling the energization of said ignition means only when said flame relay, timer and load control device are all in their respective second states.

5. A combustion control system comprising a flame sensor adapted to sense the presence of flame in a supervised combustion chamber,

a flame relay controlled by said flame sensor to indicate the presence or absence of flame in the supervised combustion chamber,

a checking timer having a timing cycle of predetermined duration,

simulator means for allowing said flame relay to be de-energized independently of the presence of flame in said combustion chamber,

a load control device responsive to said flame relay for controlling the flow of fuel to said combustion chamber,

ignition means for establishing flame in said combustion chamber,

a second timer operative to provide a timing cycle of shorter duration than the cycle of said checking timer,

flame relay responsive means for causing said second timer to initiate a timing cycle upon detection of flame in said combustion chamber by said flame sensor,

means responsive to said second timer to actuate said simulator means at the end of its timing cycle,

means responsive to the de-energization of said flame relay to de-energize said load control device and to reset said second timer,

and means responsive to the resetting of said second timer to deactuate said simulator means and permit re-energization of said flame relay.

6. A combustion control system comprising a flame sensor adapted to sense the presence of flame in a supervised combustion chamber,

a flame relay controlled by said flame sensor having a first state indicating the presence of flame in the supervised combustion chamber, and a second state indicating the absence of flame in said chamber,

a checking timer having a timing cycle of predetermined duration,

said first relay having a first state in which it is in during each timing cycle and a second state in which it is in at the end of each timing cycle,

simulator means responsive to said first relay being in said second state for allowing said flame relay to be de-energized independently of the presence of flame in said combustion chamber,
 a load control device responsive to said flame relay having a first state permitting the flow of fuel to said combustion chamber and a second state blocking said flow of fuel,
 ignition means for establishing flame in said combustion chamber,
 means for enabling the energization of said ignition means only when said flame relay, timer and load control device are all in their respective second states,
 a second timer operative to provide a timing cycle of shorter duration than the cycle of said checking timer,
 flame relay responsive means for causing said second timer to initiate a timing cycle upon detection of flame in said combustion chamber by said flame sensor,
 means responsive to said second timer at the end of its timing cycle to actuate said simulator means,
 means responsive to the de-energization of said flame relay to de-energize said load control device and to reset said second timer,
 means responsive to the resetting of said second timer to deactuate said simulator means and permit re-energization of said flame relay,
 and means responsive to the completion of the timing cycle of checking timer to over-ride said load control device and terminate flow of fuel to said combustion chamber.

7. A combustion control system comprising a flame sensor adapted to sense the presence of flame in a supervised combustion chamber,
 a flame relay controlled by said flame sensor to indicate the presence or absence of flame in the supervised combustion chamber,
 a checking timer having a timing cycle of predetermined duration,
 ignition means for establishing flame in said combustion chamber,
 means responsive to said checking timer for controlling the energization of said ignition means,
 a load control device responsive to said flame relay for controlling the flow of fuel to said combustion chamber,
 simulator means for allowing said flame relay to be de-energized independently of the presence of flame in said combustion chamber,
 a second timer operative to provide a timing cycle of shorter duration than the cycle of said checking timer,
 flame relay responsive means for causing said second timer to initiate a timing cycle upon detection of flame in said combustion chamber by said flame sensor,
 means responsive to the end of the timing cycle of said second timer to actuate said simulator means and to interrupt the timing cycle of and reset said checking timer,
 means responsive to the de-energization of said flame relay to de-energize said load control device and to reset said second timer,
 means responsive to the resetting of said second timer to deactuate said simulator means and permit re-energization of said flame relay,
 and means responsive to the completion of the timing cycle of checking timer to over-ride said load control device and terminate flow of fuel to said combustion chamber.

8. A condition supervision system comprising a condition sensor adapted to sense the presence of a condition to be supervised,
 means controlled by said condition sensor for indicat-

ing the presence or absence of the supervised condition,
 control means operative as a function of the indicated presence or absence of the supervised condition,
 a first timer operative to provide a first timing cycle, condition sensor responsive means for causing said first timer to initiate a timing cycle upon detection of the supervised condition by said condition sensor, means to allow said control means to indicate a condition absence of flame at the end of each timing cycle of said first timer,
 means responsive to an indicated condition absence to reset said first timer,
 a second timer operative to provide a second timing cycle of longer duration than said first timing cycle, said second timer being operatively connected to operate said control means at the end of its cycle,
 means for causing said second timer to initiate its timing cycle in response to the energization of said first timer,
 and means responsive to the end of each cycle of said first timer to interrupt the cycle of and reset said second timer.

9. A condition supervision system comprising a condition sensor adapted to sense the presence of a condition to be supervised,
 a condition indicating means controlled by said condition sensor having a first state indicating the presence of the supervised condition, and a second state indicating the absence of the supervised condition,
 a timer having a timing cycle of predetermined duration, said timer having a first state during each timing cycle and a second state at the end of each timing cycle,
 simulator means responsive to said timer being in its second state for allowing said condition indicating means so placed in its second state independently of the presence of the supervised condition,
 a load control device responsive to said condition indicating means having first and second states,
 condition initiating means,
 and means for enabling the energization of said condition initiating means only when said condition indicating means, timer and load control device are all in their respective second states.

10. A combustion control system comprising a flame sensor adapted to sense the presence of flame in a supervised combustion chamber,
 a flame relay controlled by said flame sensor to indicate the presence or absence of flame in the supervised combustion chamber,
 a first slow release relay having a timing cycle of predetermined duration,
 said first relay having a first state in which it is in during each timing cycle and a second state in which it is in at the end of each timing cycle,
 simulator means responsive to said first relay being in said second state for allowing said flame relay to be de-energized independently of the presence of flame in said combustion chamber,
 a load control device responsive to said flame relay having a first state permitting the flow of fuel to said combustion chamber and a second state blocking said flow of fuel,
 ignition means for establishing flame in said combustion chamber,
 means for enabling the energization of said ignition means only when said flame relay, first slow release relay and load control device are all in their respective second states,
 a second slow release relay having a timing cycle of shorter duration than the cycle of said first relay,
 flame relay responsive means for causing said second relay to initiate a timing cycle upon detection of

flame in said combustion chamber by said flame
 sensor,
 means responsive to said second relay at the end of
 its timing cycle to actuate said simulator means,
 and to interrupt the timing cycle of and reset said
 first relay, 5
 means responsive to the de-energization of said flame
 relay to de-energize said load control device and
 to reset said second relay,
 means responsive to the resetting of said second relay 10
 to deactuate said simulator means and permit re-
 energization of said flame relay,
 and means responsive to the completion of the timing

cycle of first relay to over-ride said load control
 device and terminate flow of fuel to said combustion
 chamber.

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