(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 358 149 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **89116296.8**

(51) Int. Cl.5: **H01H 47/00**

(22) Date of filing: **04.09.89**

(30) Priority: **05.09.88 JP 220355/88**

(43) Date of publication of application:
14.03.90 Bulletin 90/11

(84) Designated Contracting States:
DE FR GB

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(54) Load drive circuits.

(57) This invention is concerned with a load drive circuit using circuits of normal make contacts or normal brake contacts.

This load drive circuit comprises a plurality of main contacts pairs (R3a, R4a), main relays (R3, R4) the number of which is the same as that of the main contacts pairs, first auxiliary contacts pairs (R3b, R4b) the number of which is the same as that of the main contacts pairs, second auxiliary contacts pairs (R2a2, R2a3) the number of which is the same as that of the main contacts pairs, a first relay (R1), a second relay (R2), a third auxiliary contact (R2b), a fourth auxiliary contact (R1a2), a fifth auxiliary contact (R1b), and a starting switch (S). The plurality of main contacts pairs are connected in a main circuit for energizing a load (4) so that the load (4) can be started to operate by the logical product of all the main contacts pairs (R3a, R4a). The main relays (R3, R4) are used to open and close the main contacts. The first auxiliary contacts are opened when the main contacts are closed, and closed when they are opened. The first relay is connected in series with the third auxiliary contact, the plurality of first auxiliary contacts pairs and the starting switch across a power supply (5). The second relay is connected in series with the fourth auxiliary contact and the starting switch across the power supply (5). The main relays are respectively connected in series with the second auxiliary contacts pairs across the power supply (5). Any one of the main relays is connected in series with the fifth auxiliary contact. The self-holding contacts pairs (R1a1, R2a1) are respectively connected in parallel with the third and fourth auxiliary contacts pairs (R2b, R1a2). The third auxiliary contact is closed when the self-holding contact (R2a1) connected to the second relay and the second auxiliary contacts are opened, and opened when they are closed. The fifth auxiliary contact is closed when the self-holding contact (R1a1) connected to the first relay and the fourth auxiliary contact are opened, and opened when they are closed.

Thus, when the contacts of any one of the contacts pairs through which electric power is supplied to the load (4) are not opened due to some situations, the supply of power cannot be prevented from being resumed after the load drive circuit is once stopped from operation.

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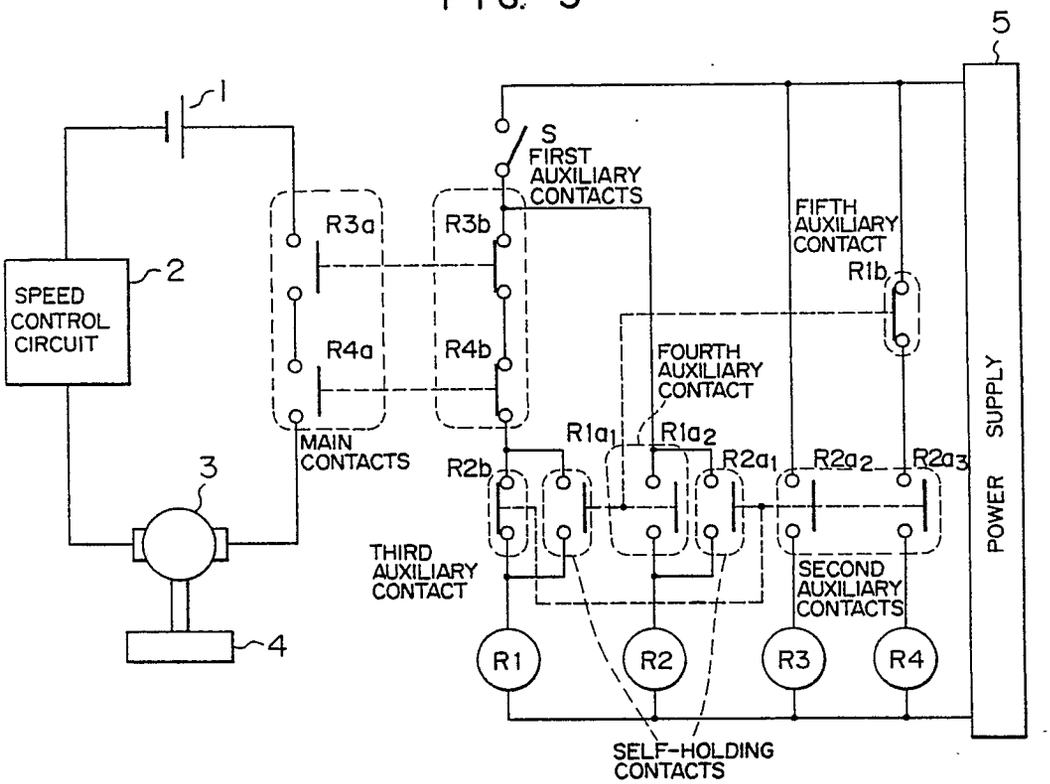
FIG. 3


5
1
S
FIRST
AUXILIARY
CONTACTS
FIFTH
AUXILIARY
CONTACT
R1b
R3a
R3b
2
SPEED
CONTROL
CIRCUIT
R4a
R4b
FOURTH
AUXILIARY
CONTACT
R1a1
R1a2
R2a1
R2a2
R2a3
POWER SUPPLY
MAIN
CONTACTS
3
R2b
THIRD
AUXILIARY
CONTACT
SECOND
AUXILIARY
CONTACTS
4
R1
R2
R3
R4
SELF-HOLDING
CONTACTS

LOAD DRIVE CIRCUITS

BACKGROUND OF THE INVENTION

This invention relates to load drive circuits, and particularly to one in which when the contacts of at least the main circuit through which electric power is supplied to a load are not opened due to some situations, the power is once stopped from being supplied to the load, and then the supply of power is prevented from being resumed.

When a large current is flowed through the contacts to a load, the contacts may be fused to stick and not be operated.

The conventional load drive circuit capable of preventing the contacts from being fused to stick and thus to misoperate is a circuit comprising a relay having make-before-brake contacts which mechanically operate in such a manner as shown in Fig. 1.

Referring to Fig. 1, there are shown a D C power supply 1 for a D C motor, a speed control circuit 2, the D C motor 3, a load 4, relays R1, R2, contacts R1a1, R1a2, R1b to be opened and closed by the relay R1, and contacts R2a1, R2a2, R2b to be opened and closed by the relay R2. In addition, there are shown a power supply 5 for driving these relays, and a starting switch S. In Fig. 1, the broken lines indicate that these contacts are mechanically interlocked.

The operation of the conventional load drive circuit of Fig. 1 will be described below.

When the starting switch S is closed to make the power be supplied to the D C motor 3, the relays R1, R2 are energized by the power supply through the contacts R1b, R2b to operate the contacts R1a1, R1a2, R1b, R2a1, R2a2, R2b. As a result, the contacts R1a2, R2a2 are closed to allow the D C motor 3 to be driven.

For better understanding the sequence of the operation processes, Fig. 2 shows the diagram of operation of the conventional load drive circuit of Fig. 1. In Fig. 2, the circled letter indicates the corresponding relay and the noncircled letter the corresponding contacts. The make operation of relays and contacts is represented by ×, and the brake operation thereof by -. Referring to Fig. 2, when the operation is completed at point A, the operation can be again started from point A′. From Fig. 2, it will be understood that in order for the relays R1, R2 to hold themselves, the contacts R1a1 and R2a1 must be closed before the contacts R1b and R2b are opened. To make this timing, these contacts must be constructed to be special contacts such as make-before-brake contacts.

The prior art using the make-before-brake contacts is described in the operation manual of "Safe Operation of Industrial Robots" (Sicherer Betrieb von Industrierobotern).

SUMMARY OF THE INVENTION

It is an object of this invention to provide a load drive circuit having normal make contacts or brake contacts in place of special conacts such as the make-before-brake contacts and in which when the contacts through which power is supplied to a load are not opened due to some situations, the supply of power is once stopped and then prevented from being resumed.

It is another object of this invention to provide a load drive circuit capable of simply detecting the abnormal operation of the contacts under the condition that the load drive operation is once stopped and then prevented from being resumed.

The above objects can be achieved by the constructions of (A) to (H) under the conditions of (1) to (4) as follows.

(1) The drive circuit within the main circuit takes the logical product of at least two or more make contacts.

(2) Two or more contacts do not simultaneously make abnormal operation, or only one pair of contacts makes abnormal operation.

(3) The make contact and the brake contact are exclusive.

(4) The make contacts themselves are not affected by each other or the brake contacts themselves similarly not affected by each other.

Under the conditions,

(A) The load drive circuit is formed of a plurality of pairs of main contacts, main relays of which the number is the same as that of the pairs of main contacts, first auxiliary contacts of which the pair number is the same as that of the main contacts, second auxiliary contacts of which the pair number is the same as that of the main contacts, a first relay, a second relay, third and fourth auxiliary contacts and a starting switch.

(B) A plurality of pairs of main contacts are connected in the main circuit of energizing a load so that the load cannot be started to operate until these main contacts are all closed.

(C) The main relay makes the main contacts open and close. The first auxiliary contacts are opened when the main contacts are closed, and closed when they are opened.

(D) The first relay is connected across the power supply in series with the third auxiliary contact, a plurality of pairs of first auxiliary contacts

and the starting switch.

(E) The second relay is connected across the power supply in series with the fourth auxiliary contact and the starting switch. The main relays are connected across the power supply in series with the second auxiliary contacts. One of the main relays is connected in series with the fifth auxiliary contact.

(F) The self-holding contacts are respectively connected in parallel with the third and fourth auxiliary contacts.

(G) The third auxiliary contact is closed when the self-holding contacts connected to the second relay and the second auxiliary contacts are opened, and opened when they are closed.

(H) The fifth auxiliary contact is closed when the self-holding contacts connected to the first relay and the fourth auxiliary contact are opened, and are opened when they are closed.

According to this invention, under the above constructions, (a) to (h), the contacts of any one pair are not opened due to some situations, the supply of power to the load cannot be resumed by the operation of the starting switch as in the following cases of (a) to (f).

(a) When in the main circuit the contacts of any one of a plurality of pairs of main contacts through which power is supplied to the load are not opened due to some situations, the first auxiliary contacts interlocked with this defective main contacts cannot be closed even after the stop of the load. Thus, since the first relay cannot be energized by operating the starting switch, the supply of power cannot be resumed.

(b) When the contacts of any one of a plurality of pairs of first auxiliary contacts are not opened due to some situations, the main contacts interlocked with the defective first auxiliary contacts cannot be closed, and hence the supply of power cannot be resumed by operating the starting switch.

(c) When the contacts of any one of the second auxiliary contacts pair and the self-holding contacts pair connected to the second relay are not opened due to some situations, the third auxiliary contact interlocked with the defective one of the second auxiliary contacts pair and the self-holding contacts pair connected to the second relay cannot be closed even after the stop of power to the load. Therefore, since the first relay cannot be energized by operating the starting switch, the supply of power cannot be resumed.

(d) When the contacts of any one of the fourth auxiliary contact and the self-holding contacts pair connected to the first relay are not opened due to some situations, the fifth auxiliary contact interlocked with the defective one of the fourth auxiliary contact and the self-holding contacts pair connected to the first relay cannot be opened even after the stop of power to the load. Thus, the main relay connected in series with the fifth auxiliary contact cannot be energized, and hence the supply of power cannot be resumed.

(e) When the third auxiliary contact is not opened due to some situations, the second auxiliary contacts interlocked with the defective third auxiliary contact cannot be opened. Therefore, since the main relay cannot be energized, the supply of power cannot be resumed.

(f) When the fifth auxiliary contact is not opened due to some situations, the fourth auxiliary contact interlocked with the defective fifth auxiliary contact cannot be opened. Thus, since the second relay cannot be energized, the supply of power cannot be resumed.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the present invention will now be described in conjunction with the accompanying drawings, in which:

Fig. 1 is a circuit diagram of a conventional load drive circuit;

Fig. 2 is a diagram of normal operation of the circuit of Fig. 1;

Fig. 3 is a circuit diagram of a load drive circuit according to this invention;

Fig. 4 is a diagram of normal operation of the circuit of Fig. 3; and

Figs. 5A to 5F are diagrams of abnormal operation of the circuits of Fig. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of this invention will be described with reference to Fig. 3.

Fig. 3 shows one embodiment of this invention. Referring to Fig. 3, there are shown the D C power supply 1 for D C motor, the speed control circuit 2, the D C motor 3, the load 4, the first relay R1, the second relay R2, main relays R3, R4, main contacts R3a, R4a operated by the main relays R3, R4, first auxiliary contacts R3b, R4b mechanically interlocked with the main contacts R3a, R4a, second auxiliary contacts R2a2, R2a3 to be operated by the second relay R2, third contact R2b mechanically interlocked with the second auxiliary contacts R2a2, R2a3, fourth auxiliary contact R1a2 to be operated by the first relay R1, fifth auxiliary contact R1b interlocked with the fourth auxiliary contact R1a2, and self-holding contacts R1a1, R2a1 to be operated by the first relay R1 and the second relay R2 and mechanically interlocked with the fifth auxiliary contact R1b and the third auxiliary

contact R2b, respectively. Also, shown at 5 is the power supply for these relays, and at S is the starting switch.

The operation of the first embodiment of a load drive circuit of this invention shown in Fig. 3 will be described below.

In the normal operation, when the starting switch S is closed, the first relay R1 is energized through the first auxiliary contacts R3b, 54b and the third auxiliary contact R2b, and then the second relay R2 is energized through the closed fourth auxiliary contact R1a2. Moreover, the main relay R3 is operated through the closed second auxiliary contact R2a2. Since the first auxiliary contact R3b is opened by the main relay R3, the first relay R1 is in the nonenergized condition. Thus, since the fifth auxiliary contact R1b is closed, the main relay R4 is energized.

As a result, the main contacts R3a, R4a are both closed, and thus the D C motor 3 is driven. In the normal operation, even if the starting switch S is opened to once stop the supply of power to the load, and even if the operation is advanced to point B, the operation is returned to point B′, and the starting switch S is again opened, thereby achieving the same normal operation as above.

For better understanding of the sequence of the operation processes, Fig. 4 shows a diagram useful for explaining the operation of a load drive circuit of this invention of Fig. 3. In Fig. 4, similarly as in Fig. 2, the circled characters represent the corresponding relays and the noncircled characters the corresponding contacts. Moreover, the make operation of the relay and contacts is represented by mark ×, and the brake operation thereof by mark -.

In the abnormal operation, or when the contacts of any pair are not opened due to some situations, in either of the following cases (a) to (f) the supply of power cannot be resumed even by operating again the starting switch S after the D C motor 3 is stopped.

(a) When in the main circuit the contacts of any one of a plurality of main contacts R3a, R4a through which power is supplied to the load 4 are not opened due to some situations, the first auxiliary contacts R3b, R4b interlocked with this defective main contacts cannot be closed even after the stop of power to the load. Thus, since the first relay R1 cannot be energized by operating the starting switch S, the supply of power cannot be resumed. For example, the operation in the case when the main contact R3a is not opened is illustrated in Fig. 5A.

(b) When the contacts of any one of a plurality of first auxiliary contacts R3b, R4b are not opened due to some situations, the main contacts R3a, R4a interlocaked with the defective first auxiliary contacts R3b, R4b cannot be closed, and hence the supply of power cannot be resumed by operating the starting switch S. For example, the operation in the case when the first auxiliary contact R3b is not opened is illustrated in Fig. 5B.

(c) When the contacts of any one pair of the second auxiliary contacts pairs R2a2, R2a3 and the self-holding contacts pair R2a1 connected to the second relay R2 are not opened due to some situations, the third auxiliary contact R2b interlocked with the defective pair of the second auxiliary contacts pairs and the self-holding contacts pair connected to the second relay cannot be closed even after the stop of power to the load. Therefore, since the first relay R1 cannot be energized by operating the starting switch S, the supply of power cannot be resumed. For example, the operation in the case when the second auxiliary contact R2a2 is not opened is illustrated in Fig. 5C.

(d) When the contacts of any one pair of the fourth auxiliary contact R1a2 and the self-holding contacts pair connected to the first relay R1 are not opened due to some situations, the fifth auxiliary contact R1b interlocked with the defective pair of the fourth auxiliary contact contact R1a2 and the self-holding contact R1a1 connected to the first relay R1 cannot be opened even after the stop of power to the load. Thus, the main relay R4 connected in series with the fifth auxiliary contact R1b cannot be energized by operating the starting switch S, and hence the supply of power cannot be resumed. For example, the operation in the case when the fourth auxiliary contact R1a2 is not opened is illustrated in Fig. 5D.

(e) When the third auxiliary contact R2b is not opened due to some situations, the second auxiliary contacts R2a2, R2a3 interlocked with the defective third auxiliary contact R2b cannot be opened. Therefore, since the main relays R3, R4 cannot be energized, the supply of power cannot be resumed. For example, the operation in the case when the third auxiliary contact R2b is not opened is illustrated in Fig. 5E.

(f) When the fifth auxiliary contact R1b is not opened due to some situations, the fourth auxiliary contact R1a2 interlocked with the defective fifth auxiliary contact R1b cannot be opened. Thus, since the second relay R2 cannot be energized, the supply of power cannot be resumed. For example, the operation in the case when the fifth auxiliary contact R1b is not opened is illustrated in Fig. 5F.

According to the invention, it is possible to simply prevent the contacts of any contact pair from being fused to stick thus leading to misoperation and to certainly detect the fused and sticked contacts.

Moreover, it is possible to use the normal on-

off contacts in place of special contacts such as the make-before-brake contacts.

Claims

1. A load drive circuit comprising first and second relays (R1, R2), a plurality of main contacts pairs (R3a, R4a), main relays (R3, R4) the number of which is the same as that of said main contacts pairs, first auxiliary contacts pairs (R3b, R4b) the number of which is the same as that of said main contacts pairs, second auxiliary contacts pairs (R2a2, R2a3) and self-holding contacts pairs (R1a1, R2a1) the number of which is the same as that of said main contacts pairs, third auxiliary contact (R2b), fourth auxiliary contact (R1a2), fifth auxiliary contact (R1b), a starting switch (S), and a power supply (5), said plurality of main contacts pairs (R3a, R4a) being connected in a main circuit for energizing a load (4) so that said load (4) can be started to operate by the logical product of all said main contacts pairs (R3a, R4a), said main relays (R3, R4) being used to open and close said main contacts, said first auxiliary contacts being closed when said main contacts are opened, and opened when said main contacts are closed, said starting switch and said first relay being connected in series with said plurality of first auxiliary contacts pairs and said third auxiliary contact across said power supply, said second relay being connected in series with said fourth auxiliary contact and said starting switch across said power supply, said second auxiliary contacts pairs being respectively connected in series with said main relays across said power supply, one of said second auxiliary contacts pairs being connected in series with said fifth auxiliary contact, said self-holding contacts pairs being respectively connected in parallel with said third and fourth auxiliary contacts pairs, said third auxiliary contact being closed when said second auxiliary contacts and the self-holding contacts connected to said second relay are opened, and opened when they are closed, said fifth auxiliary contact being closed when the self-holding contacts connected to said first relay and said fourth auxiliary contact is opened, and opened when they are closed.

2. A load drive circuit according to claim 1, wherein two or more contacts pairs of said main contacts pairs (R3a, R4a), said first auxiliary contacts pairs (R3b, R4b), said second auxiliary contacts pairs (R2a2, R2a3), said third auxiliary contact (R2b), said fourth auxiliary contact (R1a2), said fifth auxiliary contact (R1b), and said self-holding contacts pairs (R1a1, R2a1) are not abnormally operated at the same time.

3. A load drive circuit according to claim 1, wherein the make contacts pairs and the brake contacts pairs of said main contacts pairs (R3a, R4a), said first auxiliary contacts pairs (R3b, R4b), said second auxiliary contacts pairs (R2a2, R2a3), said third auxiliary contact R2b, said fourth auxiliary contact (R1a2), said fifth auxiliary contact R1b, and said self-holding contacts pairs (R1a1, R2a1) are exclusive.

4. A load drive circuit according to claim 1, wherein the make contacts pairs themselves or the brake contacts pairs themselves of said main contacts pairs (R3a, R4a), said first auxiliary contacts pairs (R3b, R4b), said second auxiliary contacts pairs (R2a2, R2a3), said third auxiliary contact (R2b), said fourth auxiliary contact R1a2, said fifth auxiliary contact (R1b), and said self-holding contacts pairs (R1a1, R2a1) are not affected by each other.

5. A load drive circuit according to claim 1, wherein said main contacts pairs (R3a, R4a), said first auxiliary contacts pairs (R3b, R4b), said second auxiliary contacts pairs (R2a2, R2a3), said third auxiliary contact (R2b), said fourth auxiliary contact (R1a2), said fifth auxiliary contact (R1b), and said self-holding contacts pairs (R1a1, R2a1) are all formed of normal make contacts or normal brake contacts.

FIG. 1

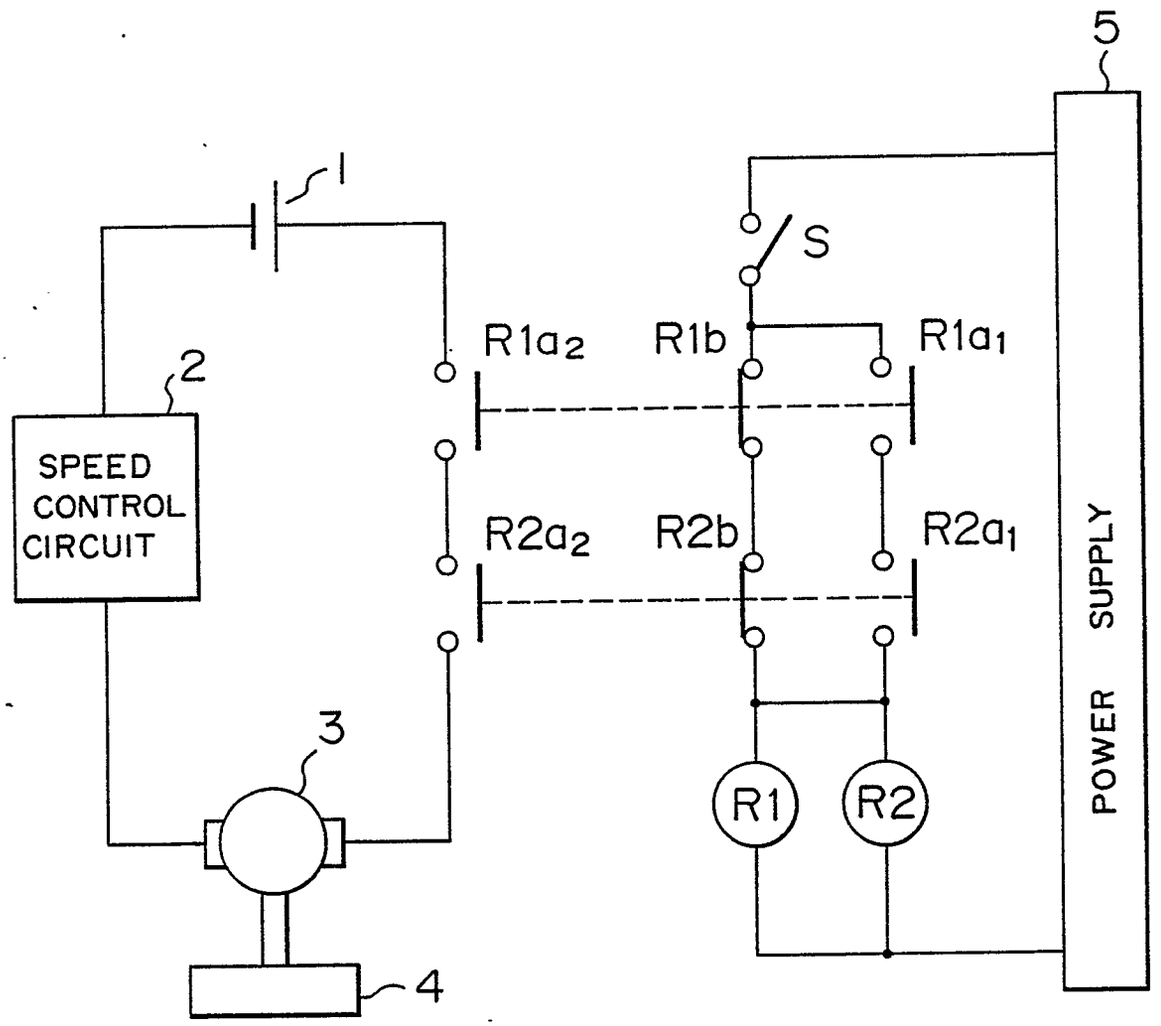

5
1
S
R1a2
R1b
R1a1
2
SPEED
CONTROL
CIRCUIT
R2a2
R2b
R2a1
3
R1
R2
POWER SUPPLY
4

FIG. 2

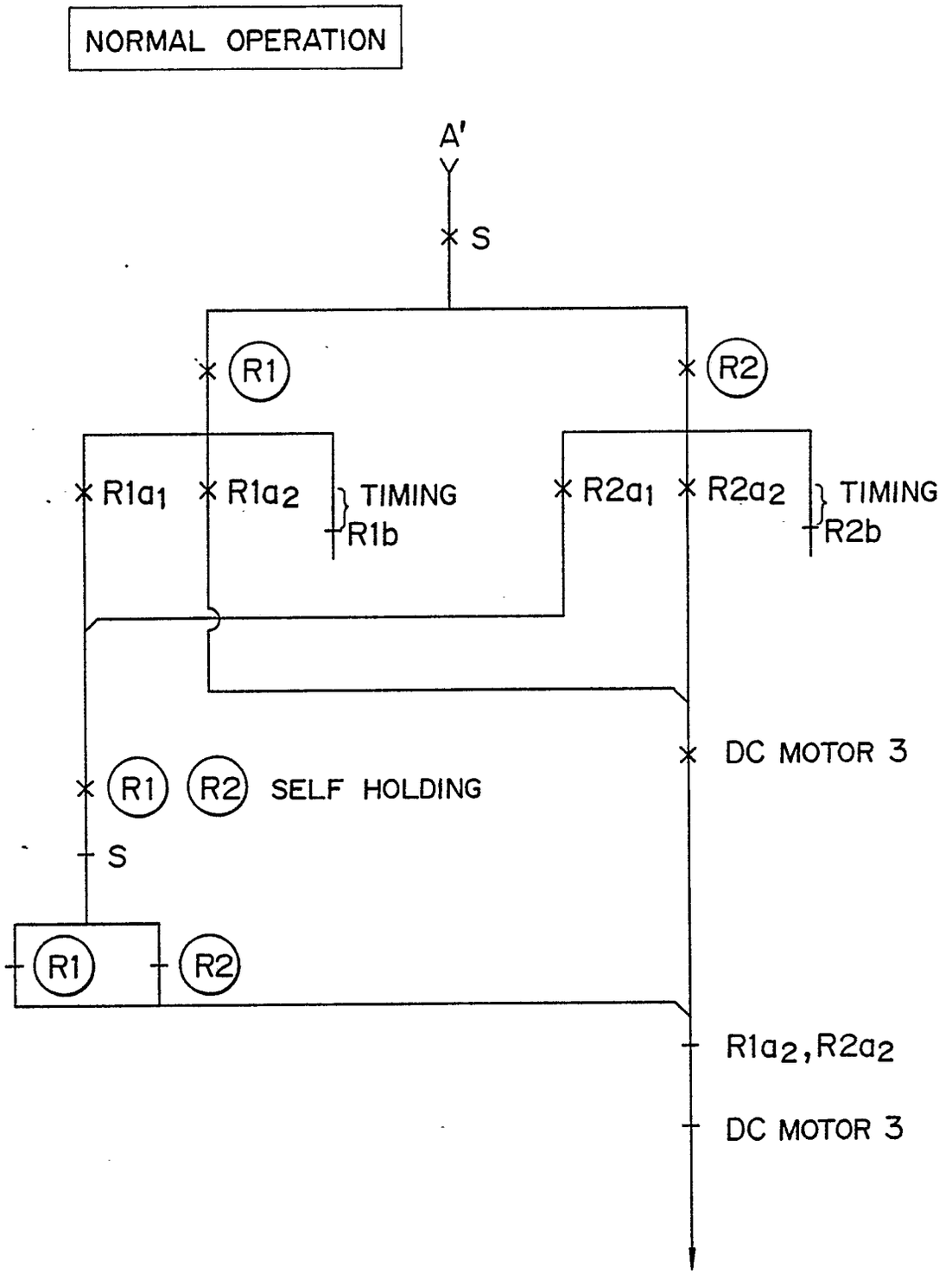

NORMAL OPERATION
A'
S
R1
R2
R1a1
R1a2
TIMING
R1b
R2a1
R2a2
TIMING
R2b
DC MOTOR 3
R1
R2
SELF HOLDING
S
R1
R2
R1a2,R2a2
DC MOTOR 3

FIG. 3

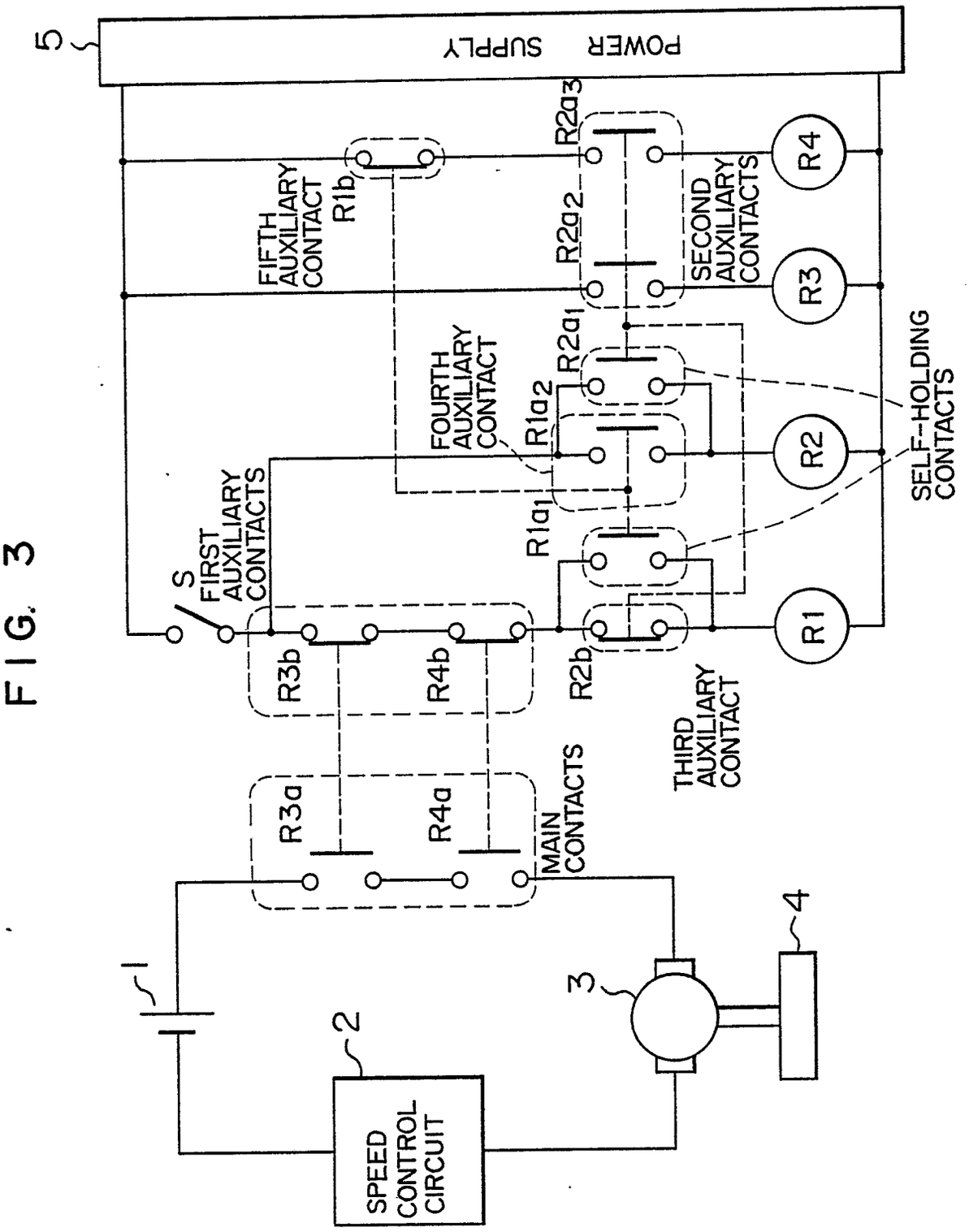

5
POWER SUPPLY
FIFTH AUXILIARY CONTACT
R1b
R2a3
R2a2
SECOND AUXILIARY CONTACTS
R4
R3
FOURTH AUXILIARY CONTACT
R1a2
R2a1
R2
SELF-HOLDING CONTACTS
R1a1
S
FIRST AUXILIARY CONTACTS
R1
R3b
R4b
R2b
THIRD AUXILIARY CONTACT
R3a
R4a
MAIN CONTACTS
1
2
SPEED CONTROL CIRCUIT
3
4

FIG. 4

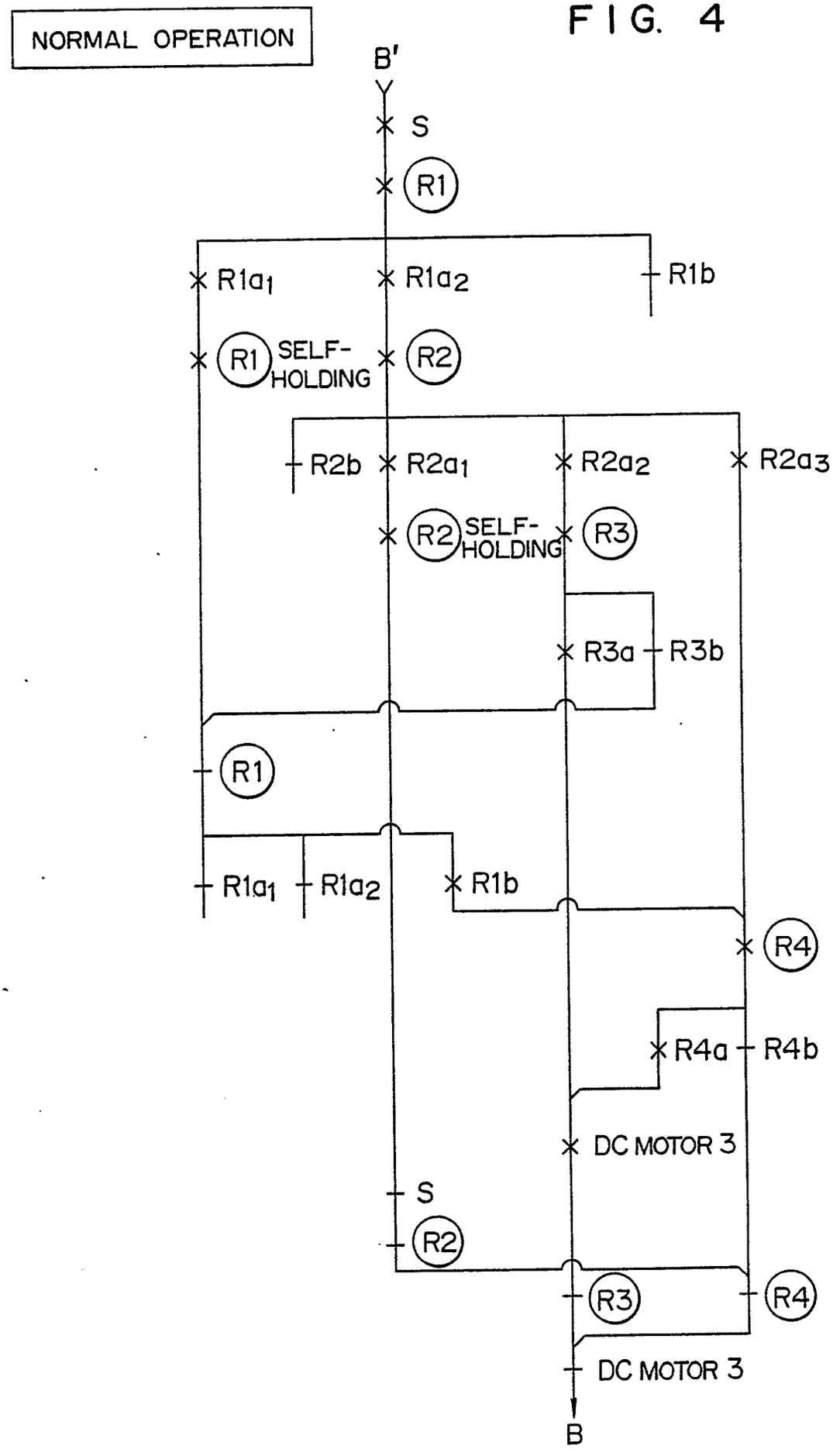

NORMAL OPERATION
B'
S
R1
R1a1
R1a2
R1b
R1
SELF-HOLDING
R2
R2b
R2a1
R2a2
R2a3
R2
SELF-HOLDING
R3
R3a
R3b
R1
R1a1
R1a2
R1b
R4
R4a
R4b
DC MOTOR 3
S
R2
R3
R4
DC MOTOR 3
B

FIG. 5A

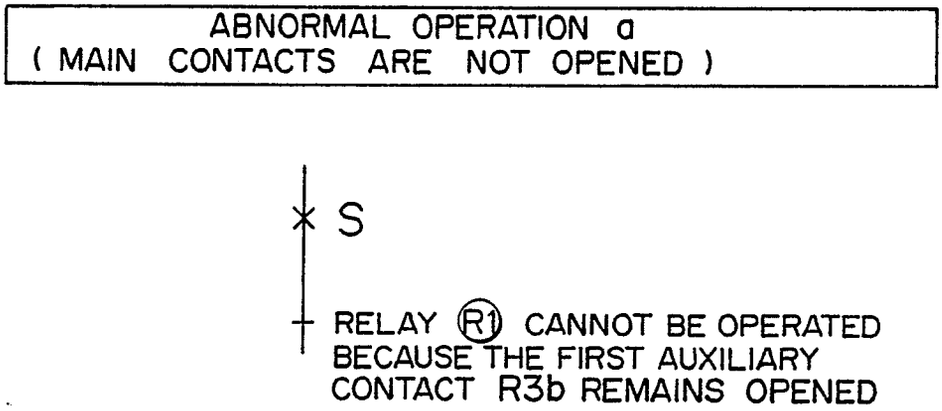

ABNORMAL OPERATION a
(MAIN CONTACTS ARE NOT OPENED)
S
RELAY R1 CANNOT BE OPERATED
BECAUSE THE FIRST AUXILIARY
CONTACT R3b REMAINS OPENED

FIG. 5B

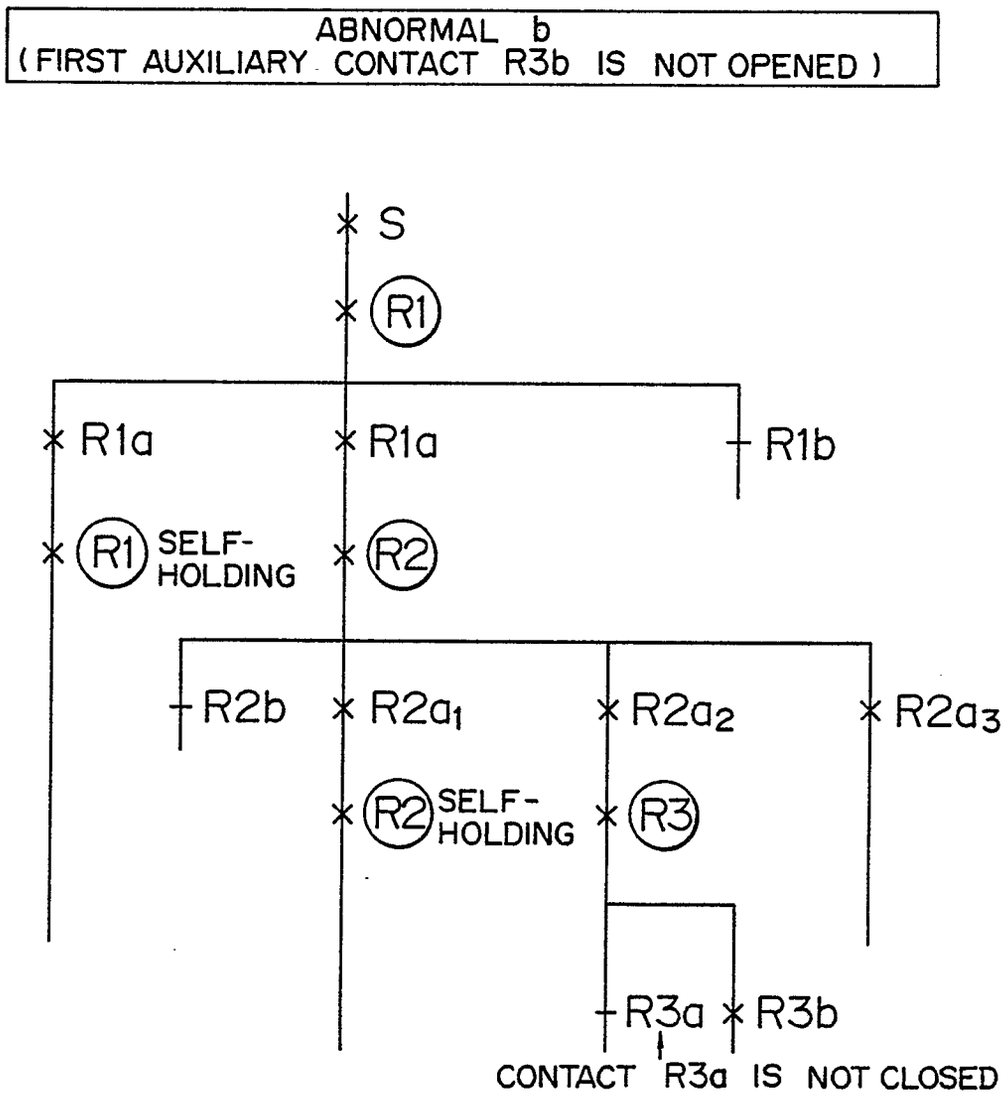

ABNORMAL b
(FIRST AUXILIARY CONTACT R3b IS NOT OPENED)
S
R1
R1a
R1a
R1b
R1 SELF-HOLDING
R2
R2b
R2a1
R2a2
R2a3
R2 SELF-HOLDING
R3
R3a
R3b
CONTACT R3a IS NOT CLOSED

FIG. 5C

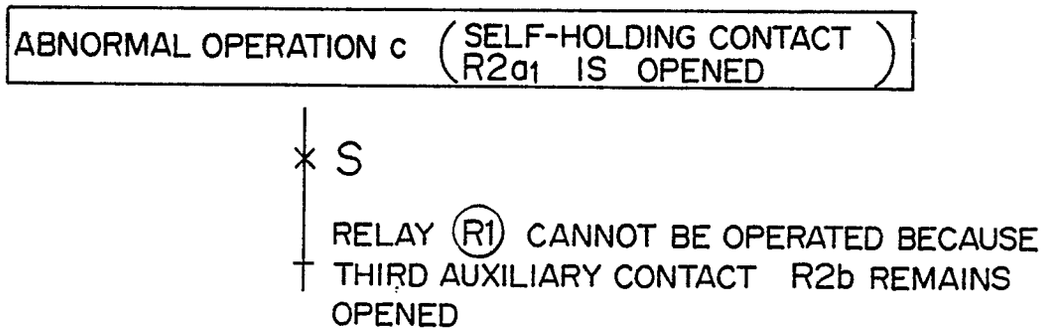

ABNORMAL OPERATION c (SELF-HOLDING CONTACT R2a1 IS OPENED)
S
RELAY (R1) CANNOT BE OPERATED BECAUSE THIRD AUXILIARY CONTACT R2b REMAINS OPENED

FIG. 5D

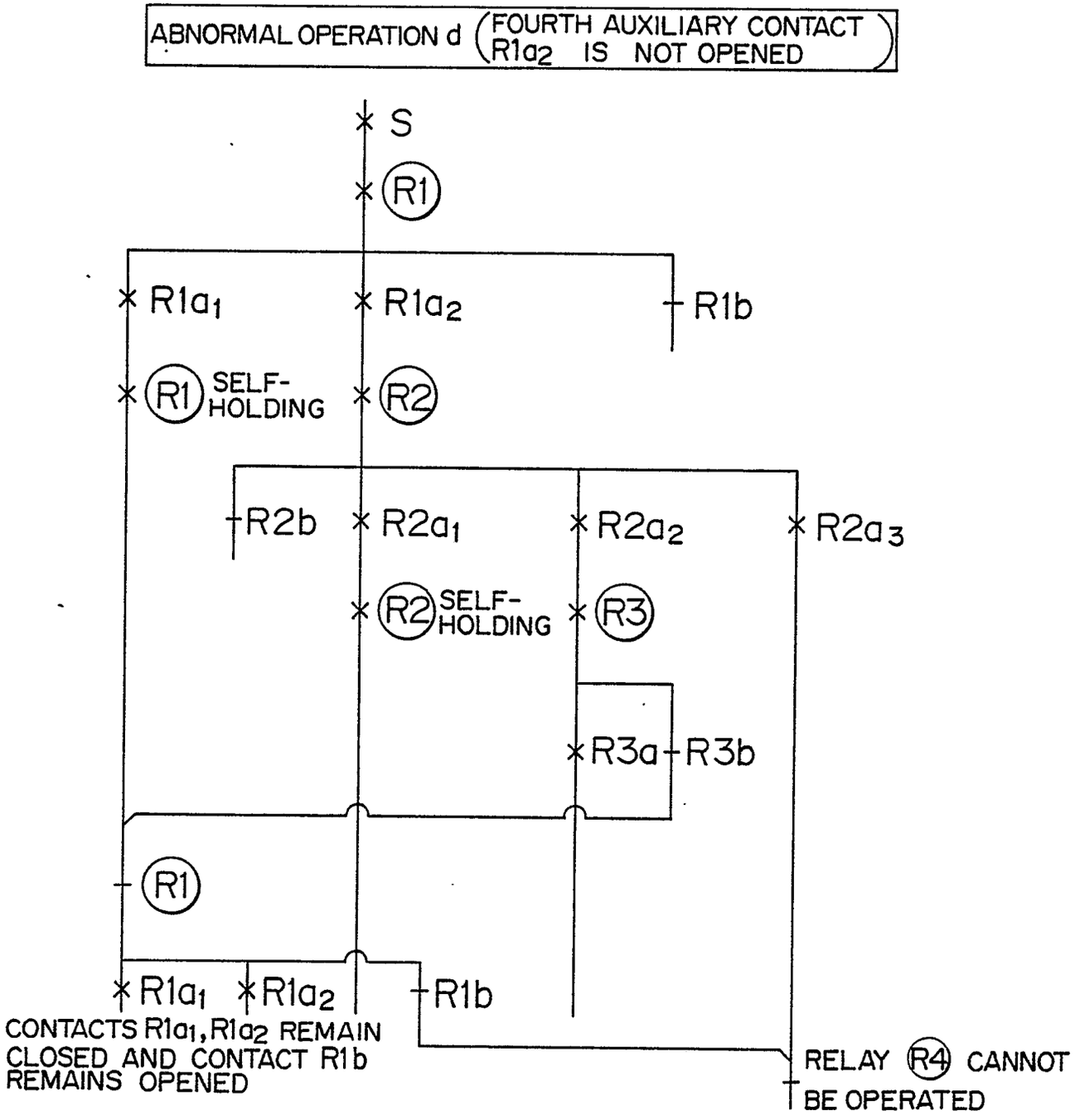

ABNORMAL OPERATION d (FOURTH AUXILIARY CONTACT R1a2 IS NOT OPENED)
S
R1
R1a1
R1a2
R1b
R1 SELF-HOLDING
R2
R2b
R2a1
R2a2
R2a3
R2 SELF-HOLDING
R3
R3a
R3b
R1
R1a1
R1a2
R1b
CONTACTS R1a1, R1a2 REMAIN CLOSED AND CONTACT R1b REMAINS OPENED
RELAY (R4) CANNOT BE OPERATED

FIG. 5E

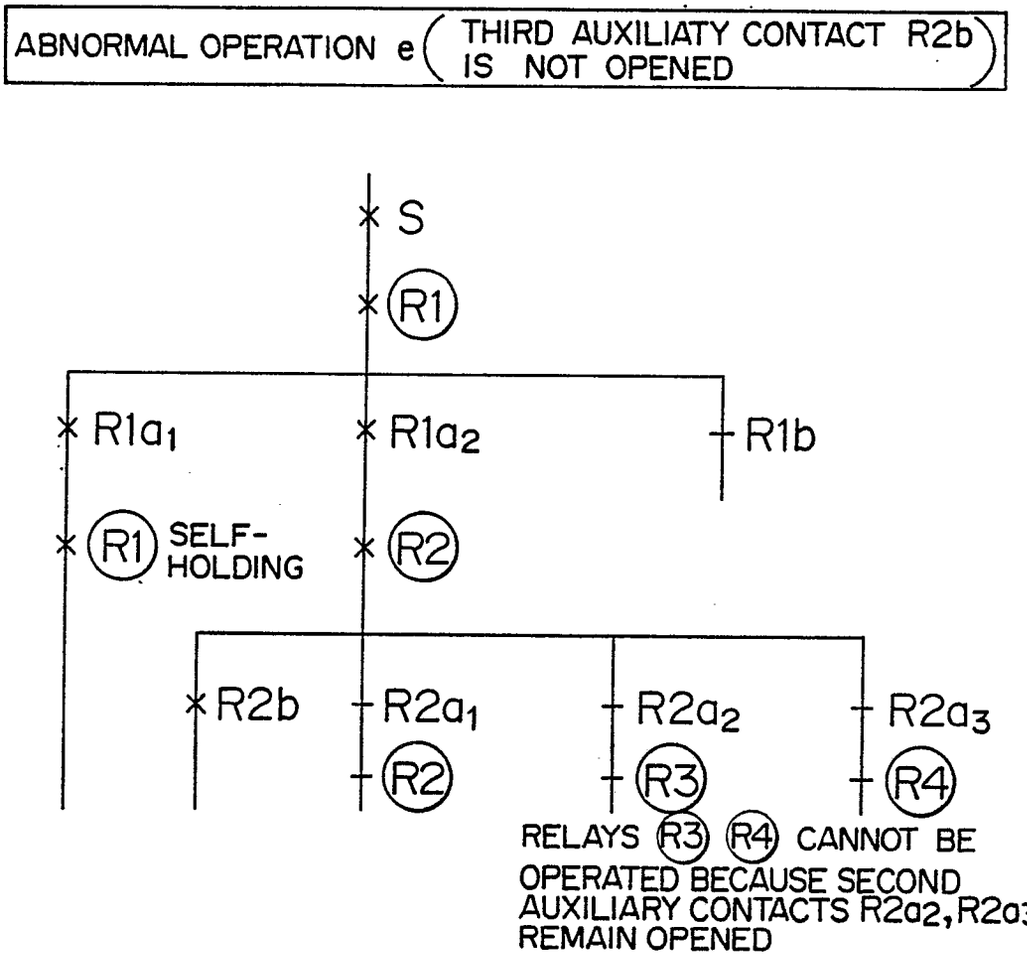
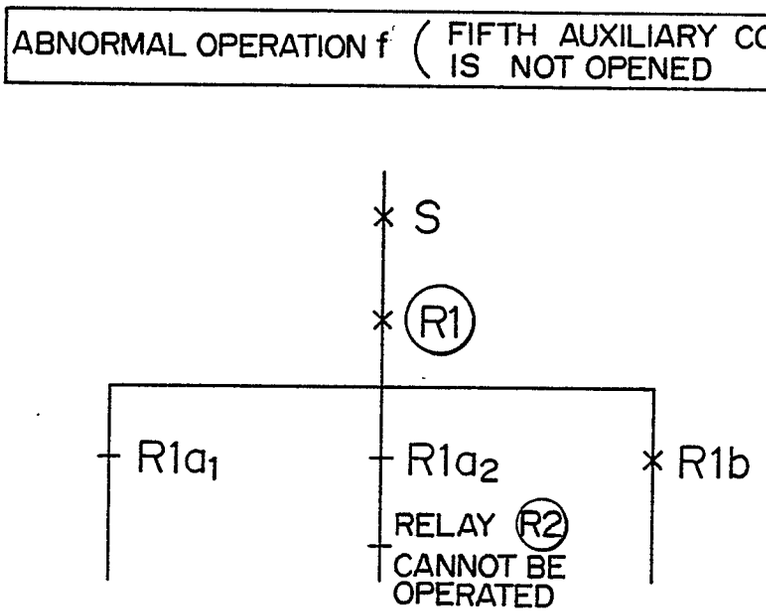

ABNORMAL OPERATION e (THIRD AUXILIATY CONTACT R2b IS NOT OPENED)
S
R1
R1a1
R1a2
R1b
R1 SELF-HOLDING
R2
R2b
R2a1
R2a2
R2a3
R2
R3
R4
RELAYS R3 R4 CANNOT BE OPERATED BECAUSE SECOND AUXILIARY CONTACTS R2a2, R2a3 REMAIN OPENED

FIG. 5F


ABNORMAL OPERATION f (FIFTH AUXILIARY CONTACT R1b IS NOT OPENED)
S
R1
R1a1
R1a2
R1b
RELAY R2 CANNOT BE OPERATED