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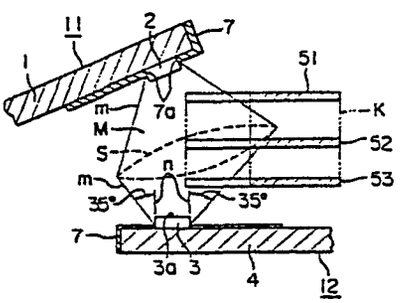
(54) A circuit breaker with arc restricting device.

(57) The present invention relates to a circuit breaker with arc restricting device wherein arc shields (7) made of a material higher in resistivity than the contactor (11, 12) conductors (1, 4) used therein are disposed around contacts (2, 3) on said conductors (1, 4) and wherein a space (M) is set at a predetermined angle on the arc shields (7) in a manner to surround the contacts (2, 3) contains at least a part of an envelope space (K) defined by joining outer edges of a plurality of arc extinguishing plates (51, 52, 53).

FIG. 4(A)



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A CIRCUIT BREAKER WITH ARC RESTRICTING DEVICE

The present invention relates to a circuit breaker with arc restricting device, the interrupting performance of which is enhanced. More particularly, it relates to the relative arrangement between contactors having arc shields and arc extinguishing plates.

Heretofore, sufficient consideration has not been given to the relative arrangement between contactors and arc extinguishing plates, especially the arrangement at the opening of the contactors.

Figure 1, Figure 2 and Figures 3(A) and 3(B) show the opened and closed states of contactors and the configuration of the electric arc between the contactors according to the prior art. In Figure 1, numeral 1 designates a movable conductor made of copper to which a movable contact 2 is fastened. The movable conductor 1 and contact 2 constitute a movable contactor 11. Numeral 3 designates a stationary contact which is fastened to a stationary conductor 4 made of copper. The stationary contact 3 and conductor 4 constitute a stationary contactor 12. Shown at numeral 5 is an arc extinguishing plate for extinguishing an electric arc 6 which occurs when contacts 2 and 3 are separated.

Figure 1 illustrates contactors 11 and 12 in a closed state, wherein electric power is fed from a power supply side to a load side in the order of the components 4 → 3 → 2 → 1.

Now, when the movable conductor 1 causes contact 2 to open due to a trip command which is applied to an operating mechanism portion, not shown, the electric arc 6 develops across the gap between the contacts 2 and 3 as shown, in Figure 2. Further, as the distance between the contacts 2 and 3 increases, the arc 6 moves outwardly away from the contacts 2, 3 and the extremities of the arc (feet) moved onto the conductors 1, 4 as illustrated in Figures 3(A) and 3(B). The movement is due to the following reason:

When the distance between the contacts is short as illustrated in Figure 2, the arc 6 is usually difficult to move. However, as the distance between the contacts increases and accordingly the length of the arc 6 is increased, as shown in Figure 3(A), the arc moves easily even for small forces imposed thereon. In the situation of Figure 3(A), the force on the arc 6 consists of an electromagnetic repulsive force due to the current flowing through the movable conductors 1, 4 and a magnetic attractive force of the arc extinguishing plates 5. These forces cause the arc 6 to move.

When, as shown in Figures 3(A) and 3(B), the arc 6 moves along the electrodes due to the attraction force of the arc extinguishing plates 5, the positive column portion of the arc 6 touches the arc extinguishing plates 5 and is cooled by the latter. Moreover, the arc 6 is stretched by the arc extinguishing plates 5, whereby the cooling is highly promoted. In this way, the extinction of the arc 6 at the current zero point is facilitated. That is, the arc extinguishing performance is attained by utilizing the attraction and cooling of the arc 6 by the arc extinguishing plates 5. In the prior art, circuit breakers of this type,

the feet of the arc 6 freely move on the conductors 1 and 4. It has therefore been impossible to determine the relative arrangement between, particularly, the arc extinguishing plates 5 and the contacts 2, 3 or the conductors 1, 4.

The present invention has for its object to enhance the performance of a circuit breaker by surrounding the contacts thereof with arc shields which are made of a material having a resistivity higher than that of the conductors adjoining said contacts, and by appropriately setting the relative arrangement between the contacts and arc extinguishing plates.

Further features and advantages of the present invention will become apparent from the following description of preferred embodiments with respect to the prior art and making reference to the enclosed drawings, wherein

Figure 1 is a side view for explaining the closed state of a prior-art circuit breaker;

Figure 2 is a side view for explaining the opened state of the prior-art circuit breaker;

Figures 3 (A) and 3(B) illustrate the behaviour of an electric arc, in which Figure 3(A) is a side view and Figure 3(B) is a view seen along the direction HB - HB in Figure 3(A);

Figures 4 (A) and 4(B) illustrate a circuit breaker according to an embodiment of the present invention, in which Figure 4(A) is a vertical sectional view and Figure 4(B) is a plan view of an arc extinguishing plate;

Figure 5 is a perspective view showing an envelope space defined by the arc extinguishing plates;

Figure 6 is a perspective view showing the essential portions of a stationary contactor;

Figure 7 is a perspective view showing a modified embodiment of an arc shield;

Figures 8 (A) and 8(B) illustrate the function of the arc shields, in which Figure 8(A) is a vertical sectional view and Figure 8(B) is a bottom view of a movable contactor and an arc extinguishing plate in Figure 8(A);

Figure 9 is a vertical sectional view showing another embodiment of the present invention; and

Figures 10(A) and 10(B) show still another embodiment, in which Figure 10(A) is a bottom view of a movable contactor and Figure 10(B) is a plan view of a stationary contactor.

In the drawings, the same symbols indicate the same or corresponding parts.

Hereunder, embodiments of the present invention will be described with reference to the drawings.

Referring to Figure 4(A), a pair of electric contactors 11, 12 are provided with arc shields 7, 7 positioned on conductors 1, 4 and formed in a manner so as to conceal the parts of these conductors 1, 4 surrounding contacts 2,3. The arc shields 7 are made of a high resistivity material which is higher in resistivity than that of the conductors 1, 4 which are made of copper. The arc shields 7 may comprise, for example, an organic or inorganic electrically-insulating substance such as ceramics, nichrome, nickel, iron, copper-nickel, copper-manganese, manganin, iron-carbon, iron-nickel, and iron-chromium.

In a position opposite to the force end of the movable contactor 11, there are vertically stacked a plurality of arc extinguishing plates 51, 52 and 53, which define an envelope space K when their outer edges are joined, as illustrated in Figure 5. Symbols m, m in Figure 4(A) indicate a pair of spaces of truncated cones whose bottom surfaces are superposed on each other. The truncated cones have apical surfaces which are closed curved surfaces defined by the inner edges 7a of the arc shields 7 adjoining the respective contacts 2, 3, and conical surfaces which form angles of within 35° with respect to normals n set on the outer surfaces of the adjoining parts of the arc shields 7, 7.

A space M is defined in such a manner that the pair of truncated cones m, m have their bottom surfaces superposed on each other in the state in which both the contactors 11, 12 are fully open. The relationship of arrangement between both the contactors 11, 12 and the arc extinguishing plates 51, 52, 53 is so determined that the space M contains at least a part of the envelope space K of the arc extinguishing plates 51, 52, 53. Accordingly, the space M and the envelope space K have an overlap part D as shown in Figure 4(B). Letter S indicates the remaining section of the space M.

In the above construction, the arc shield 7 functions as follows. As illustrated in Figure 6, the arc shield 7 limits the size of the foot of the arc 6, thereby raising the arc density in the space surrounding the foot of the arc 6. That is, since the arc shield 7 is made of a high resistivity material as described with reference to Figure 4(A), the movement of the foot of the arc 6 along the conductors 1, 4, is limited. As a result, the space proximate to the contact undergoes a pressure rise owing to the high heat of the arc 6. Therefore, unlike the arc in the prior art wherein the foot of the arc's movement is not inhibited, emanating metal particles a which are

emitted from the contact 3 where the foot of the arc 6 exists are confined within a narrow range owing to the effect of the arc shield 7. The density of the metal particles a accordingly increases to raise the arc voltage, so that the current limiting performance is enhanced.

An experiment has revealed that the emanating directions of the metal particles are confined within the internal space of the truncated cone m whose apical surface is the closed curved surface defined by the inner edge 7a of the arc shield 7 and which has the conical surface forming an angle of 35° with respect to the normal n set on the outer surface of the arc shield 7. Even when, as shown in Figure 7, a clearance 8 where the conductor 4 is exposed is existent between the arc shield 7 and the contact 3, a closed curve formed by the inner edge 7a of the arc shield 7 defines the apical surface of the truncated cone m similarly.

Accordingly, the arc 6 is confined within the arc space M which is formed of the overlapping parts of the pair of truncated cones m, m set for the respective contacts 2, 3, as depicted in Figure 8(A). Here, the current of the arc 6 chiefly flows within the arc space M in which the metal particles a are existing (refer to Figure 6).

Owing to the arc shield 7, the emanating directions of the metal particles a are regulated. Moreover, the tendency of metal particles to flow in the regulated directions is greater for circuit breakers having arc shields 7. Accordingly, in order to bend the arc 6 toward the arc extinguishing plates positioned between both contacts so as to prolong the arc, it is necessary to exert a stronger force on the arc 6 than in the prior art or to conversely exploit the intense regulation of the emanating directions of the metal particles of the arc 6 by the arc shields.

In Figures 8(A) and 8(B), the arc space M in which the arc 6 is confined does not overlap the envelope space K of the arc extinguishing plates 5. Accordingly, the driving effect and cooling effect of the arc extinguishing plates 5 on the arc 6 as described before are weakened,so that a stationary current limiting or interrupting effect cannot be demonstrated.

In the present invention, therefore, the arrangement of the contactors 11, 12 and the arc extinguishing plates 51-53 is specified thereby to enhance the performances of the circuit breaker. More specifically, by bringing the arc extinguishing plates 51-53 in Figure 4(A) closer to the contactors 11, 12, the arrangement is so set that the space M contains at least a part of the envelope space K of the arc extinguishing plates 51-53. Thus, the current limiting performance and the interrupting performance are greatly enhanced. The overlapping parts of the arc space M and the envelope space K are defined by the area D shown in Figure 4(B).

When the arc 6 has been developed, that part in the positive column of the arc which has the highest temperature and accordingly includes large quantities of charges is in the space M. Therefore, by arranging the conductors 1, 4, contacts 2, 3, arc shields 7 and arc extinguishing plates 51-53 as described above, the high-temperature and highly-ionized positive column comes into direct contact with the arc extinguishing plates 51-53, and the cooling capability of the arc extinguishing plates 51-53 is utilized most efficiently. Thus, the capability of extinguishing the arc 6 is enhanced.

Figure 9 shows an example in which the opening angle of the movable conductor 1 at the opening of the movable and stationary contactors 11, 12 is made great to enlarge the overlapping area betwen the arc space M and the envelope

space K of the arc extinguishing plates 51-53, whereby the arc extinguishing capability is sharply enhanced. With such relative arrangement, even when struck across the gap between the contactors 11 and 12 having the same separation distance as in the prior art, the arc 6 comes to have a greater effective length as indicated by a broken line A in the figure, because the emanating directions of the arc 6 are regulated. Accordingly, the arc voltage rises, and the current limiting performance improves. In addition, since the arc 6 comes into direct contact with the arc extinguishing plates 51-53, it has an intense driving force exerted thereon by the arc extinguishing plates 51-53 and its length increases more, so that the arc voltage rises still more. Further, since the high-temperature and high-pressure part of the arc 6 is directly cooled by the arc extinguishing plates 51-53, the interrupting performance is enhanced.

Further, in a case where as illustrated in Figures 10(A) and 10(B), arc runways 10, 10 formed of grooves extending towards the arc extinguishing plates 5 are provided in the arc shields 7, 7 so as to expose the conductors 1, 4, the arc 6 rapidly runs along the arc runway 10 and comes into contact with the arc extinguishing plates 5 to be cooled thereby, for small currents wherein the feet of the arc 6 are small. Therefore, the interrupting performance for the small currents is enhanced.

As set forth above, according to the present invention, a circuit breaker which is excellent in the current limiting performance and the interrupting performance is provided.

CLAIM

A circuit breaker with arc restricting device, comprising:
a pair of electric contactors (11, 12) each of which has a conductor (1, 4), and a contact (2, 3) fastened to said conductor (11,12);
arc shields (7) which are formed of a high resistivity material having a resistivity higher than that of said conductors (1,4) and which are respectively disposed on said conductors (1,4) in a manner to surround said contacts (2,3); and
a plurality of arc extinguishing plates (51, 52, 53) which are disposed near said contacts (2,3) and which function to extinguish an electric arc (6) produced by the separation of said contacts (2,3);
said arc shields (7) and said arc extinguishing plates (51, 52,53) constituting the arc limiter, wherein a space (M) defined by a pair of truncated cones (m, m) whose apical surface are closed curved surfaces defined by edges (7a) of said arc shields (7) around the respective contacts (2,3) and which have conical surfaces forming angles of within 35° to normals (n) set on outer surfaces of said arc shields (7), said space (M) between said contacts (2,3) having their bottom parts superposed on each other at the separation of said contacts (2,3), contains at least a part of an envelope space (K) which is defined by joining outer edges of said arc extinguishing plates (51, 52, 53).

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FIG. 1
PRIOR ART

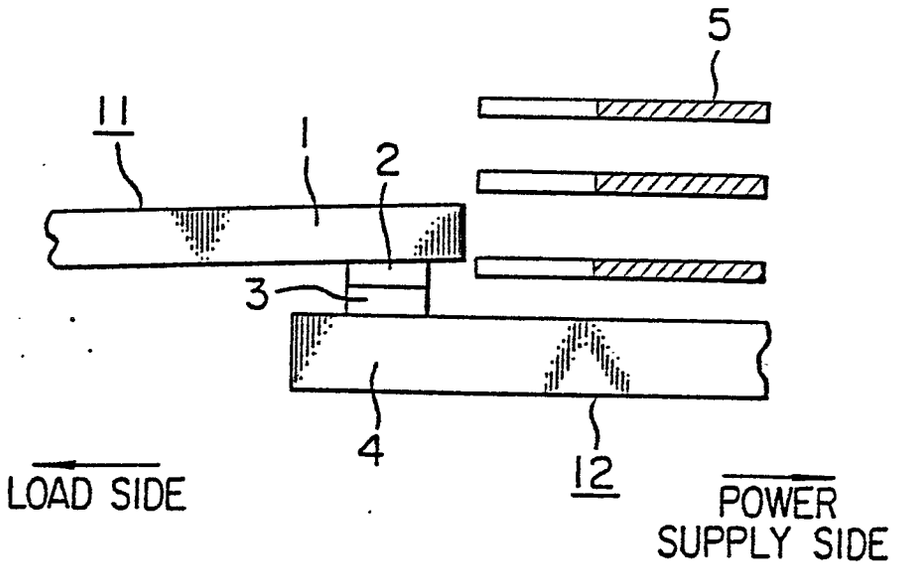


FIG. 2
PRIOR ART

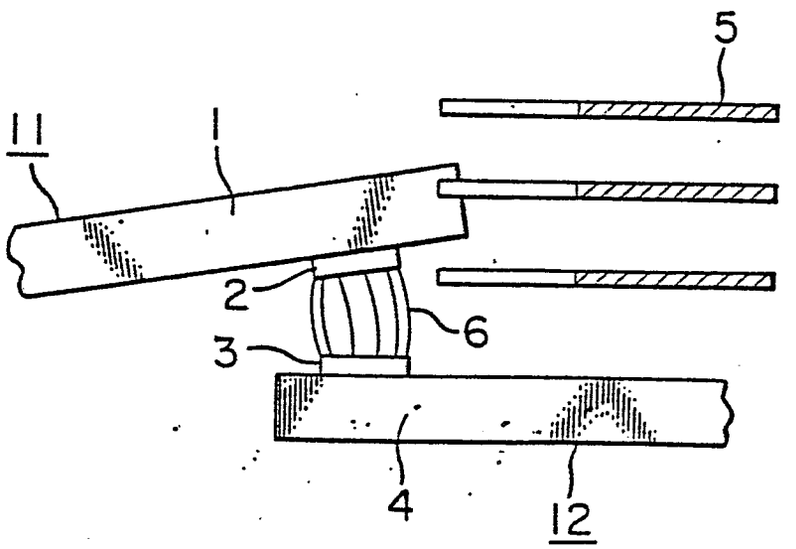


FIG. 3(A)
PRIOR ART

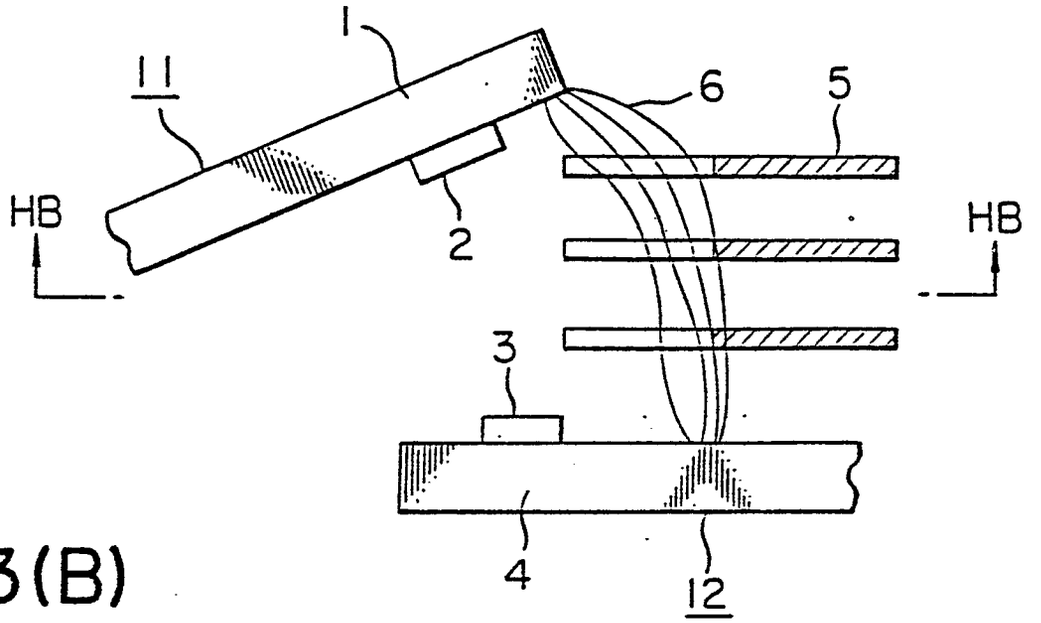


FIG. 3(B)
PRIOR ART

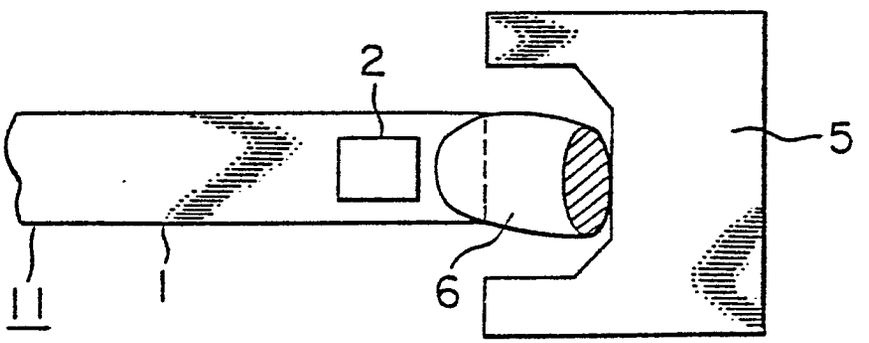


FIG. 4(A)

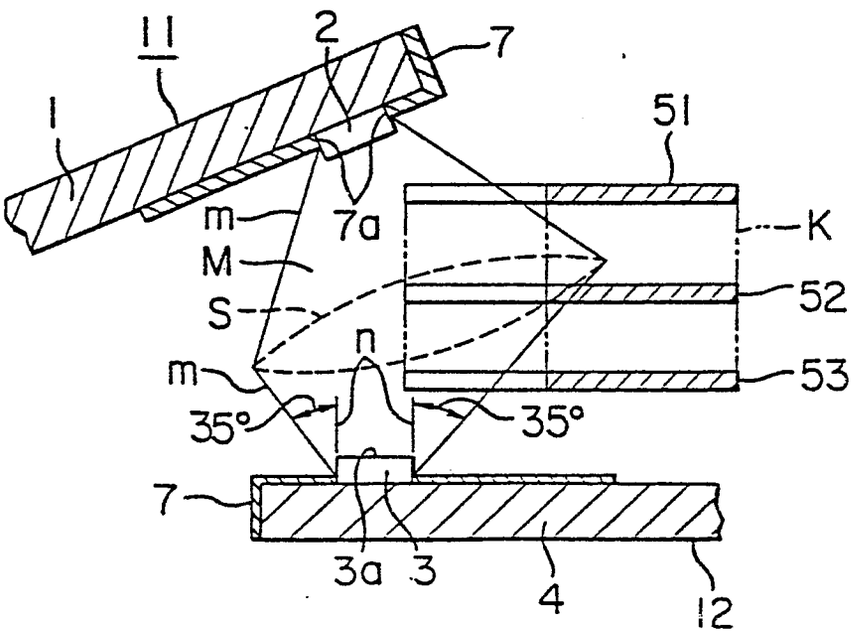


FIG. 4(B)

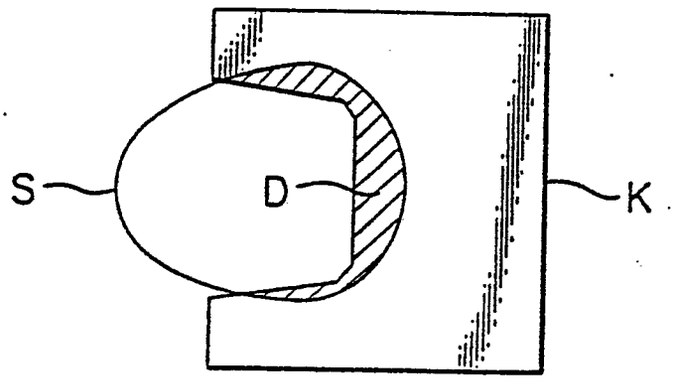


FIG. 5

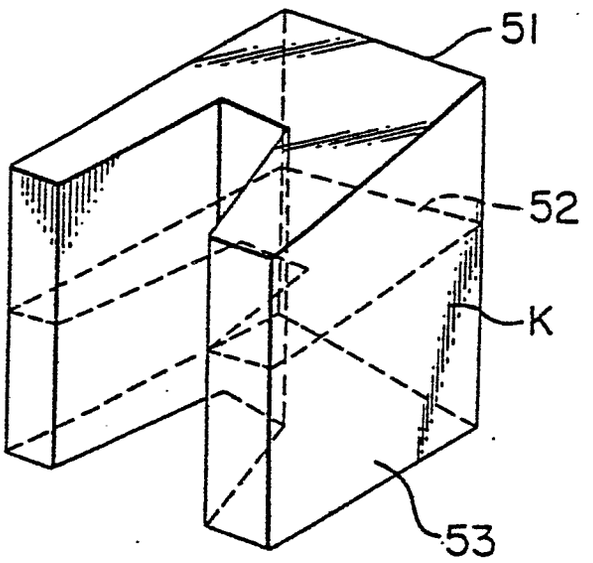


FIG. 6

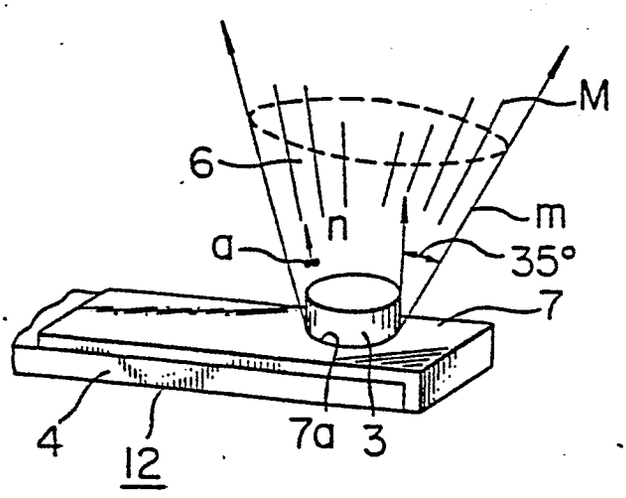


FIG. 7

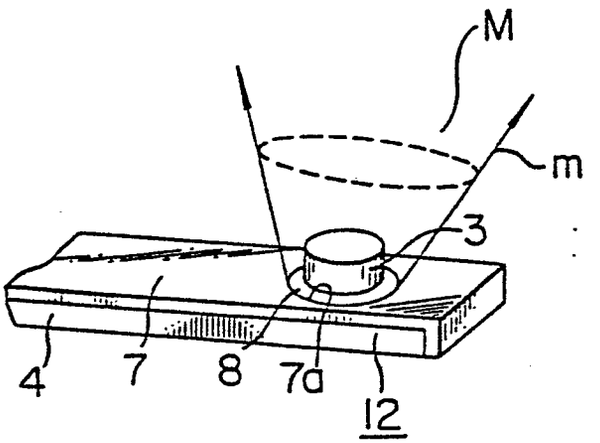


FIG. 8(A)

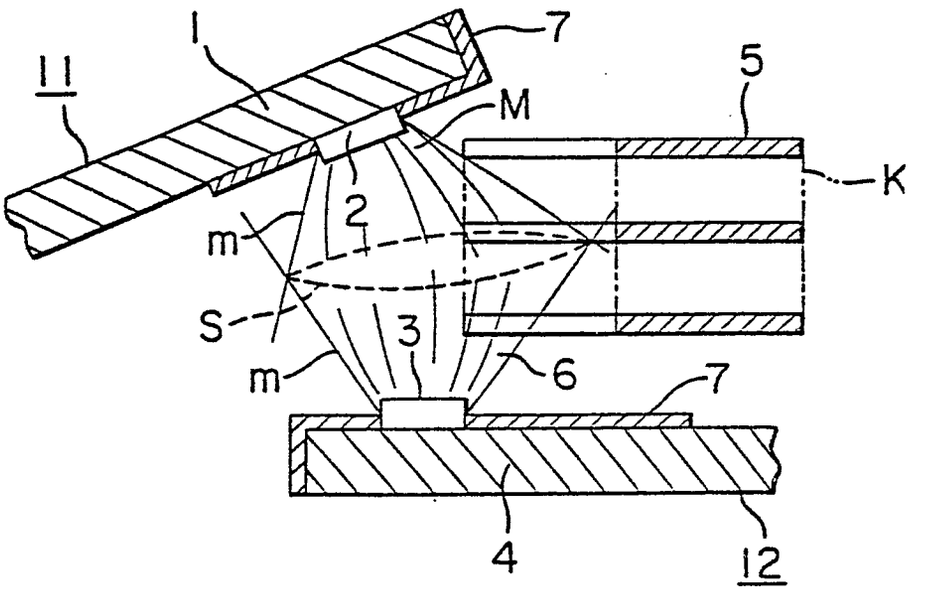


FIG. 8(B)

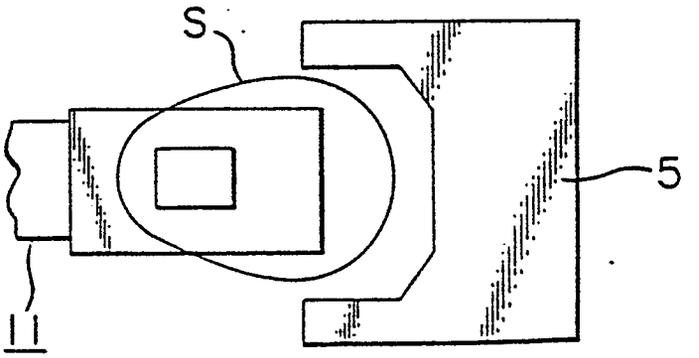


FIG. 9

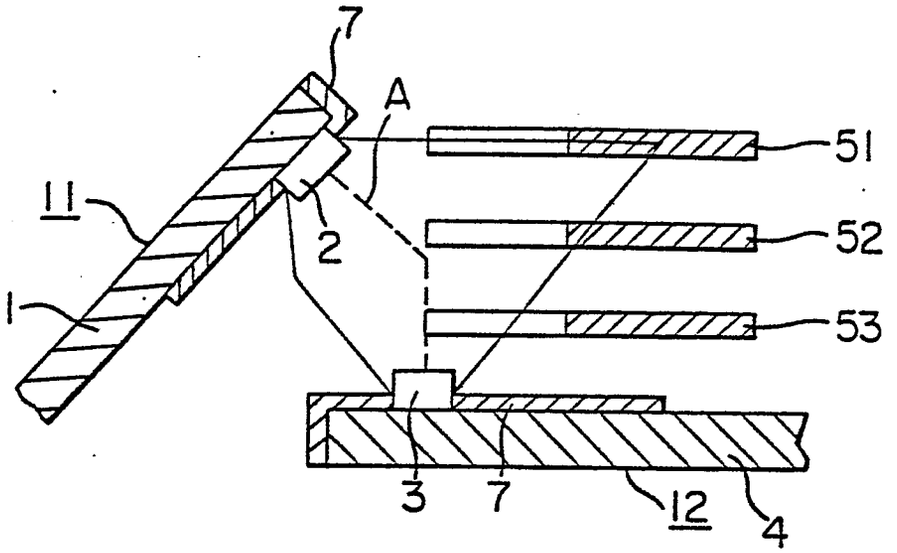


FIG. 10(A)

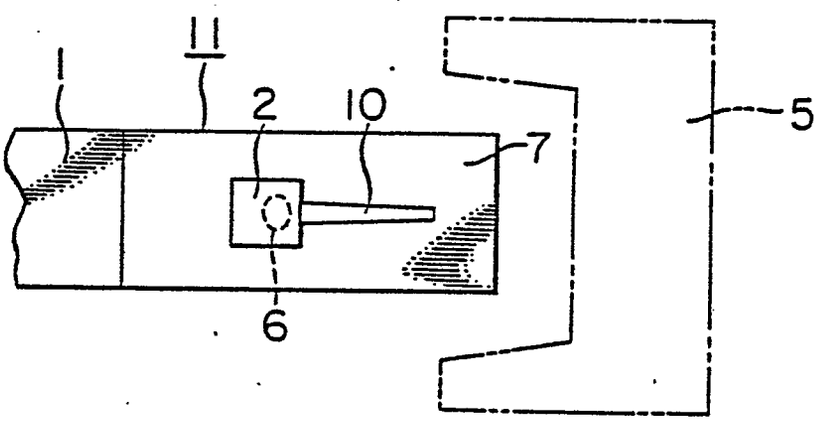
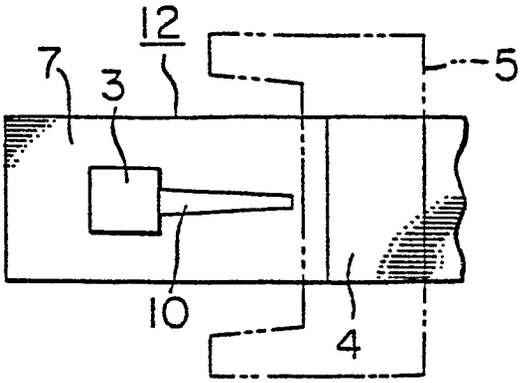


FIG. 10(B)



European Patent Office

EUROPEAN SEARCH REPORT

Application number 0074529

EP 82 10 7758

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
A	DE-A-1 765 051 (DEGUSSA) *Page 3, paragraphs 2-4; page 4; figure 1*	1	H 01 H 9/30 H 01 H 9/34
A	DE-B-1 765 157 (SPRECHER & SCHUH) *Column 3, line 6 to column 4, line 30*	1	
A	US-A-3 310 649 (H.GRERER) *Column 1, lines 29-60*	1	
A	DE-A-1 765 999 (MERLIN & GERIN) *Page 3, paragraphs 5-6; pages 4,5*	1	
A	DE-A-2 513 242 (SIEMENS) *Page 3, paragraphs 2-4*	1	TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
A	DE-B-1 690 463 (ELEKTRO-APPARATE VEB) *Figure 1*	1	H 01 H 9/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	04-01-1983	JANSSENS DE VROOM P.

CATEGORY OF CITED DOCUMENTS

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