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(54) **Keypad assembly.**

(57) A keypad assembly comprises an elastomeric membrane (4) with integral keys (3) which extend through apertures (2) in a housing (1). In the non-actuated (OFF) position the keys are substantially flush or slightly proud of the top surface (1a) of the housing, but when the keys are depressed they descend beneath the top surface (1a). The apertures (2) or the keys (3) (or both) have chamfered walls, the angle of chamfer being at least 4° and preferably 7°-10°. This prevents the keys from jarring or sticking against the walls of the apertures, enabling them to return to the non-actuated position without difficulty.

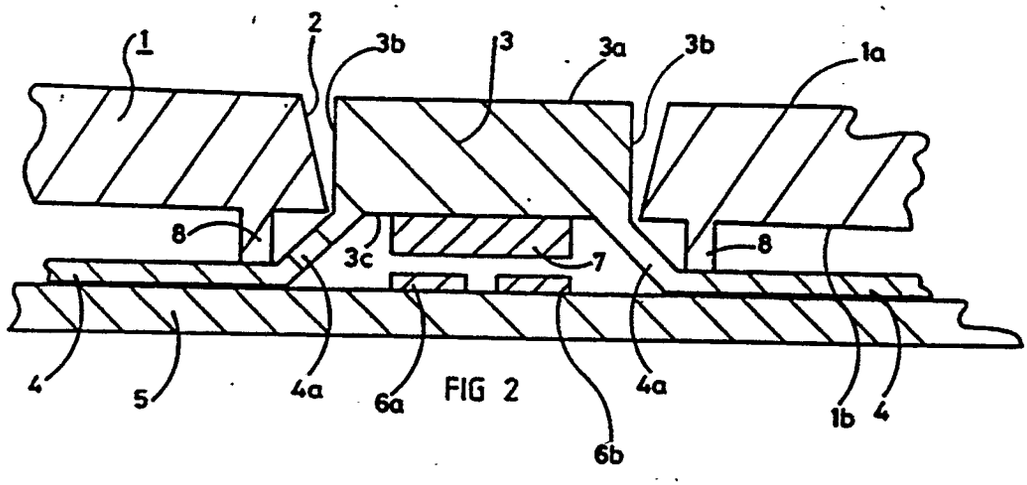

FIG 2

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KEYPAD ASSEMBLY

This invention relates to a keypad assembly, particularly but not exclusively, comprising an elastomeric membrane keypad.

Known elastomeric keypads comprise a unitary sheet of elastomeric material, e.g. silicon rubber, from which the keys are formed by integral protrusions. The keys may be of any suitable shape (as viewed by the user) and are commonly rectangular, circular or square. A membrane keypad of this kind is disclosed, for example, in US Patent No. US-A-4,636,593. Conventionally each of the keys extends into a respective aperture in a housing member and the keys can be depressed to actuate an electrical or electronic function depending upon the particular apparatus in conjunction with which the keypad is being used. Such a keypad has many applications and may, for example, be used in an electronic calculator or with portable communications apparatus such as a radio telephone.

A problem with prior art elastomeric membrane keypads is that if the keys can be depressed below the top (front) surface of the apertured housing member, there is a tendency for the keys to jar or stick in the actuated or "ON" position within the aperture. The reason this happens is that due to the compressibility of the elastomer it is frequently the case that a key will not remain level when it is depressed. Consequently, a top corner, edge or side of the key may bear against the wall of the aperture in the housing member and the high frictional properties characteristic of the elastomer can cause the key to stick so that it does not properly return to the non-actuated or "OFF" position. This problem is even more acute when the keys have sharp (90 degree) top edges or corners, as is commonly the case.

One solution to this problem is to provide apertures which are substantially larger than the keys, but this has the disadvantage that the keypad is less well sealed from the environment so that foreign bodies can easily enter into the keypad assembly and adversely affect the operation, and also the visual appearance of the keypad assembly is impaired since a relatively wide gap will be visible around the key.

According to a first aspect of the present invention there is provided a keypad assembly comprising a housing having on a generally flat portion thereof apertures which extend between top and bottom major surfaces of said flat portion, and a plurality of retractable keys each extending into a respective one of said apertures, wherein the keys are formed as protrusions in a unitary sheet of elastomeric material, which keys can be depressed from a first non-actuated position to a second actuated position at which second position the top surface of the key is below the top surface of said flat portion of the housing, said keys being capable of tilting during movement to the actuated position, wherein the walls of the aperture or the side faces of the keys or both are chamfered such that when the key is tilted to a maximum extent the side faces of the key and the respective adjacent walls of the aperture are substantially parallel or diverge towards the top surfaces thereof.

A keypad in accordance with this first aspect of the invention has the advantage that the chamfered walls of the apertures or the keys (or both) are arranged to maintain the side face of the key spaced apart from the aperture walls even when the key suffers maximum tilt so that the key is not hindered in returning to its non-actuated or "OFF" position after it has been depressed. In fact, the Applicants have found that the incidence of keys sticking can be virtually eliminated. Furthermore, the chamfer means that the walls of the aperture can be spaced very closely to the key at least around the base of the key. This has the twin effect of providing a good environmental seal and also enhancing the visual appearance of the keypad.

According to a further aspect of the invention there is provided a keypad assembly comprising a housing having on a generally flat portion thereof apertures which extend between top and bottom major surfaces of said flat portion, and a plurality of retractable keys each extending into a respective one of said apertures, wherein the keys are formed as protrusions in a unitary sheet of elastomeric material, which keys can be depressed from a first non-actuated position to a second actuated position at which second position the top surface of the key is below the top surface of said flat portion of the housing, the apertures having chamfered walls which converge towards the bottom surface of said flat portion, the chamfer of said walls extending to a level below the top surface of the key when the key is in the second position.

A keypad in accordance with this aspect of the invention has the advantage that the chamfered walls of the apertures (which taper towards the bottom) offer a sloping surface to help guide the key back to its non-actuated or "OFF" position even if it should bear against the aperture walls.

In a preferred embodiment, the Applicants have found that optimum relief from key sticking is obtained when the angle of chamfer is at least 4° and preferably in the range from 7-10° (inclusive) from the vertical. Excellent results are obtained with an angle of substantially 8°.

Embodiments of the invention will now be de-

scribed, by way of example, with reference to the accompanying drawing, in which:-

Figure 1 is a front elevation of a keypad assembly in accordance with the invention,

Figure 2 is a cross-section through one of the keys of the keypad assembly in Figure 1 in accordance with a first embodiment showing the key in the non-actuated position,

Figure 3 is a cross-section of the part of the keyboard assembly in Figure 2 showing the key in a tilted, actuated position,

Figure 4 is a geometric diagram to illustrate the preferred minimum chamfer angle,

Figure 5 is a cross-section showing part of a modified version of keypad assembly in accordance with the first embodiment,

Figure 6 is a cross-section through one of the keys of the keypad assembly in Figure 1 in accordance with a further embodiment of the invention, showing the key in the non-actuated position, and

Figure 7 is a cross-section of the part of the keypad assembly in Figure 6 showing the key in the tilted, actuated position.

It is noted here that in the various Figures the same reference signs have been used to designate corresponding parts.

Referring to Figure 1, there is shown a keypad assembly comprising a generally flat cover member 1 forming part of the overall keypad housing. The cover 1 may be a flat plate-like cover and fixed to an open rectangular box beneath, or may itself have integral side walls extending into the plane of the page and adapted to be fastened to a flat back plate or to another open rectangular box-like member to complete the housing. Present in the cover 1 is an array of apertures 2 which, as can be seen from Figure 2, extend the full way through the cover 1 from the top surface 1a to the bottom surface 1b thereof. Extending into each aperture 2 is a respective key 3 which can be depressed by a user. As shown, the keys 3 are generally lozenge-shaped and have substantially vertical sides 3b (see Figure 2). However, the keys may have any suitable shape and may be, for example, rectangular, circular, or square.

Turning to Figure 2, it can be seen that the apertures 2 into which the keys 3 extend are chamfered, the narrowest portion of the aperture being at the bottom surface 1b of cover 1. In the preferred embodiment, the angle of the chamfer is approximately 8° from the vertical, although any angle of 4° or more may be used, but best results are obtained if the angle of chamfer is in the range from 7° to 10° inclusive.

The keys 3 are formed as protruding portions of a sheet or membrane 4 of spongy, compressible material, i.e. an elastomer such as silicon rubber. The rubber membrane 4 is suitably 1mm thick. The keys 3 are joined to the main body of the membrane 4 by inclined portions 4a around the periphery of the key 3. All the keys are similarly formed as protruding portions of the same membrane which thus constitutes a unitary keypad. The membrane 4 is present on a circuit board 5 on which may be mounted various electrical and/or electronic circuit components (not shown) in known manner, which the various keys are intended to activate as follows. On the circuit board 5 beneath each key 3 is present a pair of electrical contacts 6a,6b. A single corresponding electrical contact 7 (which may be formed of compressible material) is present on the underside 3c of the key 3 so that when the key is depressed to its actuated or "ON" position the contact 7 bridges the contacts 6a and 6b on the circuit board 5 and so completes the electrical circuit of the appropriate circuit (not shown) to be activated.

The cover 1 is provided with integral projection 8 which depends from the underside of the cover 1 and presses the membrane 4 against the circuit board 5 around the periphery of the aperture 2 to enhance the tactile response of the key 3.

In the present embodiment the thickness of the cover 1 may be 2.5mm and similarly the thickness (or height) of the keys 3 is 2.5mm. As shown, the top surface 3a of the key is substantially flush with the top surface 1a of the cover 1 when the key is in its non-actuated or "OFF" position. Alternatively, however, the keys 3 may be proud of the cover 1 when they are in the "OFF" position. The vertical gap between the bottom surface 1b of cover 1 and the membrane 4 may be 1.5mm and, as already mentioned, the thickness of the membrane 4 is 1mm. The nominal length of the key 3 may be 15mm and the corresponding nominal dimension of the aperture at the bottom surface 1b of the cover 1 may be 15.7mm, yielding a nominal gap of 0.35mm between the key and the base of the aperture along the length of the keys. The nominal width of the key may be 7.5mm and the corresponding nominal dimension of the aperture at the bottom surface 1b may be 8.2mm, yielding a nominal gap of 0.35mm between the key and the base of the aperture along the width of the keys. There is thus a nominal gap of only 0.35mm around the whole periphery of the keys 3. This provides good environmental sealing to prevent contamination and foreign bodies entering into the keypad assembly. As already noted, the chamfer angle of the aperture walls is suitably 8°. This, in combination with the small (0.35mm) gap around the base of the key, provides a very pleasing visual appearance as illustrated in Figure 1, presenting a narrow moat-like feature around each key. More importantly, the sloping walls of the aperture 2

provide the important advantage that if the key 3 is depressed in a manner so that the top surface 3a does not descend in a level or uniform manner then the aperture walls 2 enable the key 3 to return to the non-actuated position without sticking or jarring since the top corner or edge of the key 3 is not confronted by a vertical wall. To further enhance this effect the top edges or corners of the keys 3 may be bevelled or rounded.

The thicknesses of the contacts 6a,6b and 7 are not critical, but assuming the combined thickness is approximately 0.5mm, then the maximum travel permitted to key 3 between the "ON" and "OFF" positions will be approximately 1mm. In other words, when the key 3 is fully depressed the top surface thereof (when it is level) will be 1mm below the top surface 1a of the cover 1.

Figure 3 shows the situation when the key 3 is depressed unevenly or off-centre to its actuated position and so is tilted. It can be seen that the contact 7 on the underside of the key 3 bridges the two contacts 6a and 6b on the printed circuit board 5. As shown, the contact 7 is compressible and is distorted by the pressure applied to the key when the key is depressed in this manner. In practice, the key itself is compressible and so will also suffer some distortion, but for the sake of clarity this is not shown in the Figure. Indeed, the contact 7 itself need not be compressible, since the deformation necessary to accommodate the electrical connection in the tilted actuated position shown may be suffered by the elastomeric key alone. In Figure 2 the key 3 is shown with the maximum tilt angle, that is to say, the shortest side of the key 3 is tilted so that the top edge has substantially not moved from the non-actuated position while the depressed edge has travelled to the fully actuated position. Referring to Figure 4, it can be seen that the tilt angle x is the angle whose sine is given by the quotient of the lengths of the sides B and A of the triangle illustrated therein, i.e. B/A, where B is the distance which the key travels between the non-actuated position and the actuated position, namely 1mm, and A is the minimum dimension of the bottom surface of the key 3, namely 7.5mm, i.e. the width dimension. Therefore, x is the angle whose sine is 1/7.5 = 0.133. The maximum angle x by which the keys 3 can be tilted is therefore approximately 7.5°. In order for the side face 3b of the key 3 not to bear against the walls of the aperture 2 the aperture walls have a chamfer angle which is substantially equal to or greater than the maximum tilt angle of 7.5°. Hence a chamfer angle of approximately 8° is ideal.

For the avoidance of doubt, it is emphasised here that it is not the intention for the key to be tilted when it is actuated. Preferably, pressure would be applied centrally or evenly to the key so that it would descend evenly, i.e. in a level attitude, to the actuated position. The arrangement of the present invention caters for the fact that if the key is pressed off-centre it may not suffer maximum tilt but an intermediate value, in the present embodiment 0-8°.

In the embodiment just described, the chamfered walls extend at the same angle the full thickness of the cover 1 from the top surface 1a to the bottom surface 1b.

Figure 5 shows a portion of an alternative cover member 1 around the aperture 2. In this case the lowermost wall portion 1c of the aperture 2 is vertical, the major intermediate portion 1d is chamfered at an angle of at least 4°, preferably approximately 8°, and a small top portion 1e is more severely chamfered. The chamfer angle of the top portion 1e may be, for example, 45° which gives a pleasing visual effect to the moat feature surrounding the keys. Indeed, to this same end, the wall portion 1e need not be flat but may instead be convex or concave. Figure 3 shows in a broken line the position of the key 3 in its fully depressed position and it can be seen that the chamfered portion 1e of the wall 2 extends below the top surface of the key 3 in this position and therefore this arrangement is also effective in preventing the problem of sticking keys.

Figures 6 and 7 illustrate an alternative embodiment in which the keys 3 (rather than the aperture walls) have chamfered side faces 3b. Figure 7 shows the key 3 in the actuated, but tilted position, similar to Figure 3 of the previous embodiment. Similar reasoning leads to a maximum tilt angle of approximately 7.5° based on the same dimensions recited above for the various features of the assembly. It follows that the preferred chamfer angle for the side faces is again approximately 8°.

In view of the foregoing description it will be evident to a person skilled in the art that various modifications can be made within the scope of the invention as defined in the following claims. For example, both the aperture walls and the side faces may be chamfered in which case the combined chamfer angle would suitably be approximately 8° for the reasons explained above. Furthermore, the chamfered walls of the apertures or side faces of the keys need not be strictly planar, but may have a concave or convex configuration.

Claims

1. A keypad assembly comprising a housing having on a generally flat portion thereof apertures which extend between top and bottom major surfaces of said flat portion, and a plurality of retractable keys

each extending into a respective one of said apertures, wherein the keys are formed as protrusions in a unitary sheet of elastomeric material, which keys can be depressed from a first non-actuated position to a second actuated position at which second position the top surface of the key is below the top surface of said flat portion of the housing, said keys being capable of tilting during movement to the actuated position, wherein the walls of the aperture or the side faces of the keys or both are chamfered such that when the key is tilted to a maximum extent the side faces of the key and the respective adjacent walls of the aperture are substantially parallel or diverge towards the top surfaces thereof.

2. A keypad assembly comprising a housing having on a generally flat portion thereof apertures which extend between top and bottom major surfaces of said flat portion, and a plurality of retractable keys each extending into a respective one of said apertures, wherein the keys are formed as protrusions in a unitary sheet of elastomeric material, which keys can be depressed from a first non-actuated position to a second actuated position at which second position the top surface of the key is below the top surface of said flat portion of the housing, the apertures having chamfered walls which converge towards the bottom surface of said flat portion, the chamfer of said walls extending to a level below the top surface of the key when the key is in the second position.

3. A keypad assembly as claimed in any of the preceding claims wherein the top surface of each key is substantially coplanar with the top surface of the flat portion of the housing when the key is in the non-actuated position.

4. A keypad assembly as claimed in any of the preceding claims wherein the shape of the aperture at the bottom surface of the flat portion of the housing corresponds to the shape of the key at the bottom surface thereof.

5. A keypad assembly as claimed in any of the preceding claims wherein the angle of chamfer is at least equal to the angle whose sine is the quotient of the value of the distance between the non-actuated position and the actuated position of the keys on the one one hand and the minimum dimension of the bottom surface of the keys on the other hand.

6. A keypad assembly as claimed in claim 5 wherein the angle of chamfer is at least 4° from the vertical.

7. A keypad assembly as claimed in claim 6 wherein the angle of chamfer is in the range of 7° to 10° inclusive from the vertical.

8. A keypad assembly as claimed in claim 7 wherein the angle of chamfer is substantially 8° from the vertical.

9. A keypad assembly as claimed in any of the preceding claims and further comprising a circuit board having pairs of electrical contact means present thereon, the bottom surface of each key being provided with electrically conductive means arranged to connect electrically with a respective pair of said contact means when the key is actuated.

10. A keypad assembly as claimed in claim 9 when dependant from claim 3 wherein the flat portion of the housing comprises protrusions depending from the bottom surface thereof around the periphery of the apertures, which protrusions press the elastomeric sheet against the circuit board.

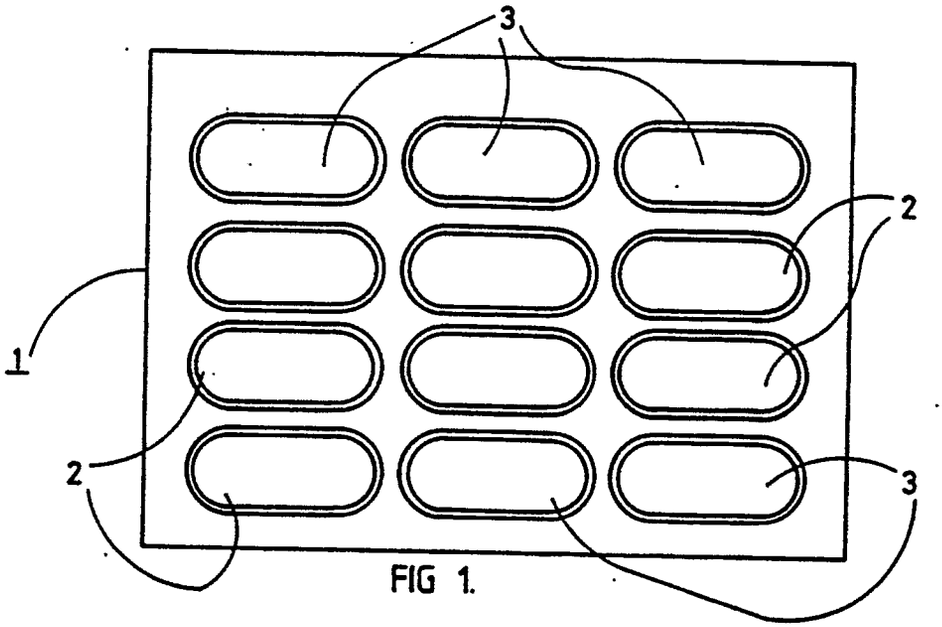

FIG 1.

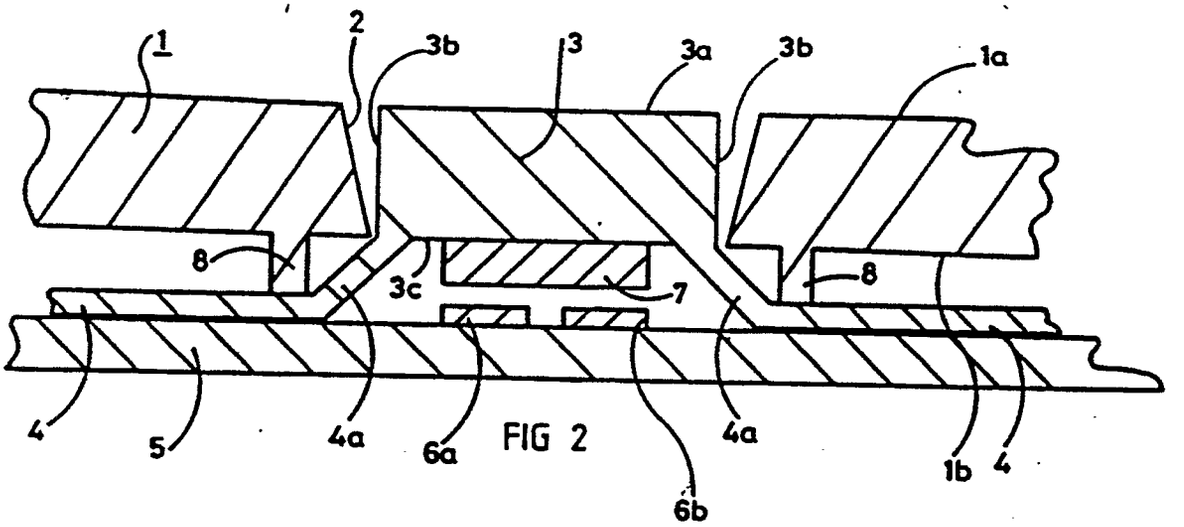

FIG 2

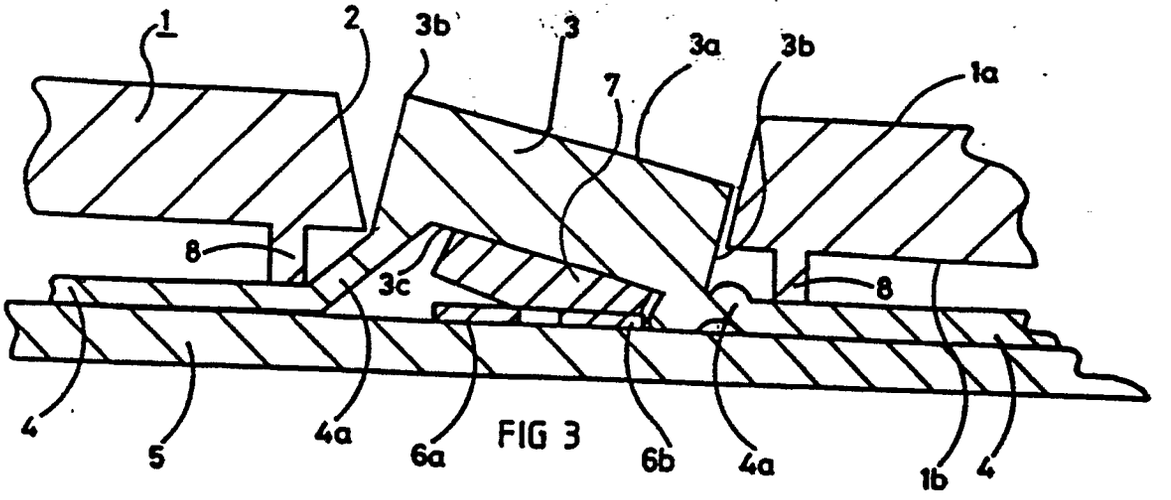

FIG 3

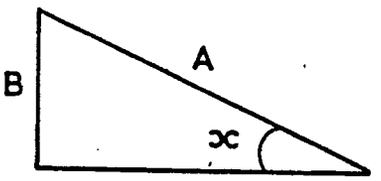

FIG 4

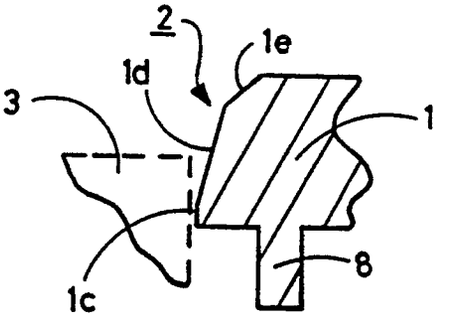

FIG 5

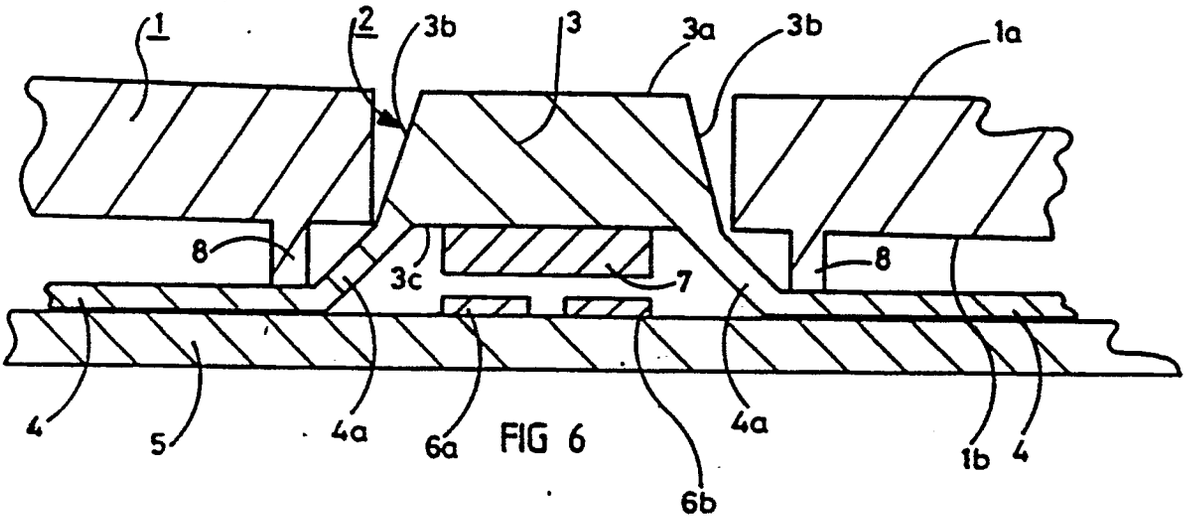

FIG 6

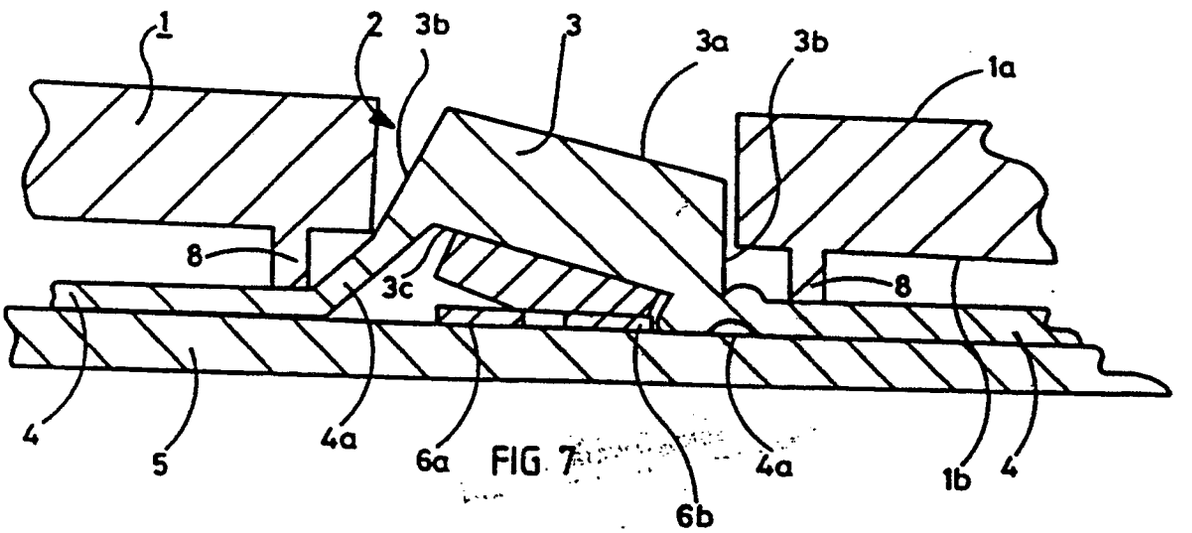

FIG 7