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

(11) Publication number: **0 224 296 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **86201961.9**

(51) Int. Cl.⁴: **H01J 9/14**

(22) Date of filing: **10.11.86**

(30) Priority: **11.11.85 NL 8503087**

(43) Date of publication of application:
03.06.87 Bulletin 87/23

(84) Designated Contracting States:
AT DE ES FR GB IT

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(54) Method of drape drawing a shadow mask for a colour display tube, shadow mask manufactured by said method, and colour display tube comprising such a shadow mask.

(57) A shadow mask sheet 1 for a colour display tube consisting of an iron-nickel alloy of the invar type is drape drawn by means of a drawing process. During said drawing process the shadow mask sheet 1 is provided with a skirt 2. By keeping the rim 16 of the skirt 22 clamped in a slip-free manner during the drawing process, the skirt 22 can be plastically deformed simultaneously with the formation of the skirt 22, as a result of which the reproducibility of the shape of the shadow mask sheet 1 is increased.

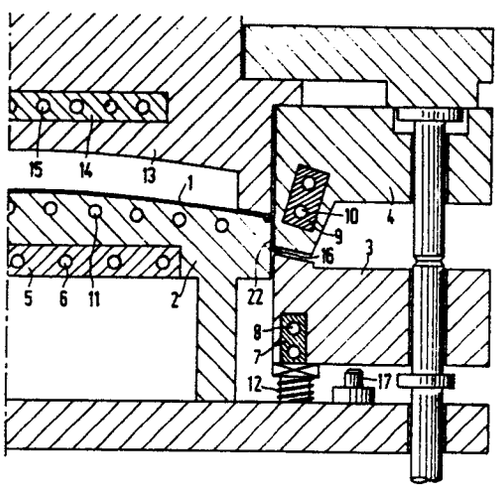

FIG.6

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Method of drape drawing a shadow mask for a colour display tube, shadow mask manufactured by said method, and colour display tube comprising such a shadow mask.

The invention relates to a method of drape drawing, by means of a drawing process, a shadow mask sheet for a colour display tube consisting of an iron-nickel alloy of the invar type, in which a skirt is formed on the shadow mask sheet.

The invention furthermore relates to a shadow mask manufactured by the method according to the invention.

The invention also relates to a colour display tube comprising a shadow mask according to the invention.

Such a method has been proposed in the previously filed Dutch Patent Application 8402958 in which a process is described for drape drawing a shadow mask sheet consisting of an iron-nickel alloy. Prior to the actual drawing process, the shadow mask sheet is subjected to an annealing treatment to produce a complete recrystallisation of the material of the shadow mask sheet without an essential grain growth occurring and to reduce the tensile stress at the 0.2 % proof stress of the material, which tensile stress is too high at room temperature to draw the shadow mask sheet to the desired shape. A further reduction of the tensile stress, however, is necessary to obtain a reproducible process for drape drawing the shadow mask sheet. In order to realise this, the shadow mask sheet during the drawing process is not drape drawn at room temperature but at a higher temperature. During this drape drawing process of the shadow mask sheet, the shadow mask sheet is generally first given the desired shape, in particular an arcuate shape, and the shadow mask sheet is then provided with a skirt. This skirt is formed by bending over the edge of the shadow mask sheet and it may be used for the connection of the shadow mask in a colour display tube. After the skirt has been formed, the drawing process is terminated and the shadow mask is cooled to ambient temperature and the material substantially regains its original, comparatively high 0.2 % proof stress.

It has been found that as a result of this comparatively high 0.2 % proof stress the skirt resiles outwards slightly and as a result of this can adversely influence the shape of the shadow mask sheet. Moreover, it is usual to weld the shadow mask formed to a supporting frame by providing a number of spot welds between said supporting frame and the skirt. An outwardly resiled skirt, however, does not fully engage the supporting frame and thus presents a problem in welding the shadow mask to the supporting frame.

It is the object of the invention to provide a method of drape drawing a shadow mask consisting of an iron-nickel alloy of the invar type, in which a good reproducibility of the shape of the shadow mask sheet is obtained.

For that purpose a method of the kind mentioned in the opening paragraph is characterized according to the invention in that complementarily to the formation of the skirt, said skirt is plastically deformed permanently. It has been found that as a result of the permanent plastic deformation of the skirt, the shape and the position of the skirt are very much controlled. The extent of outward resiling is reduced as a result of which a good reproducibility of the shape of the shadow mask sheet is obtained. An additional advantage of the invention is that the skirt can fully engage a supporting frame and can more easily be welded to said supporting frame.

An embodiment of a method in accordance with the invention is characterized in that the permanent plastic deformation of the skirt takes place at a temperature between 150°C and 250°C. When the plastic deformation is carried out at room temperature, the comparatively high 0.2 % proof stress leads to the material being difficult to work mechanically. The tensile stress at which the shadow mask material reaches the 0.2 % proof stress is reduced when the plastic deformation takes place at a temperature between 150°C and 250°C. As a result of this the mechanical workability is increased and the level of the reproducibility of the drawing process is satisfactory.

A further embodiment of a method in accordance with the invention is characterized in that the plastic deformation of the skirt takes place at least substantially simultaneously with the formation of the skirt, and that a flange is formed on said skirt. The skirt is provided on the shadow mask sheet by means of a drawing operation. The plastic deformation of said skirt involves a complementary operation which takes some time. By keeping the periphery of the shadow mask clamped in a slip-free manner during the drawing process, the formation of the skirt and the plastic deformation thereof can be done simultaneously. This provides a saving in time since according to the invention no complementary operation is necessary any longer for the deformation. Moreover, a complementary heating for the plastic deformation of the skirt of the shadow mask sheet is no longer necessary since the drawing process of the shadow mask sheet can take place already at a temperature between 150°C and 250° C.

Still a further embodiment of a method in accordance with the invention is characterized in that prior to the formation of the flange recesses are provided in the shadow mask sheet, said recesses being formed at least for the greater part in that part of the shadow mask sheet which afterwards constitutes the flange. If the shadow mask is to be connected to a supporting frame, for example by means of spot-welding, it must be possible for the welding apparatus to contact the skirt. The outwardly directed flange could consitute an obstruction therefor. By providing recesses in the flange at the areas where the spot welds have to be provided, the welding apparatus can reach the skirt at these places. Prior to the drawing process, said recesses can be provided in the shadow mask sheet by means of an etching process, for example the same etching process with which mask holes are provided in the shadow mask sheet. However, it is also possible to provide the recesses after the flange has been formed, for example, by cutting away flange material, although this is time-consuming.

An embodiment of the invention will now be described in greater detail with reference to the drawings, in which

Figure 1 shows the tensile stress of an annealed iron-nickel alloy of the invar type as a function of the temperature during the drawing process,

Figures 2 to 8 show the method step by step,

Figure 9 shows a shadow mask manufactured by said method, and

Figure 10 is a sectional view of a shadow mask connected to a supporting frame.

A shadow mask sheet consisting of an iron-nickel alloy of the invar type which comprises 35-37 % by weight of nickel, can be subjected to an annealing treatment preceding the actual drawing process, for example, at a temperature between 700°C and 820°C for a period of time which is sufficient to produce complete recrystallisation of the material of the shadow mask sheet without essential grain growth occurring. As a result of this the tensile stress at which the 0.2 % proof stress is reached is reduced. However, the 0.2 % proof stress reached is still too high to obtain a reproducible process for drape drawing the shadow mask sheet. For that purpose a further reduction of the 0.2 % proof stress has proved necessary. In order to realise this the shadow mask sheet is not drape drawn at room temperature but at a temperature between 150°C and 250°C. Figure 1 shows the variation of the tensile stress at the 0.2 % proof stress as a function of the temperature. In the temperature range from 150°C to 250°C the temperature dependance on the 0.2 % proof stress decreases considerably with increasing temperature. At temperatures above 250°C a comparatively small reduction of the 0.2 % proof stress is still obtained. However, at such high temperatures practical problems start playing a role with regard to the drawing tools which no longer outweigh the advantage of a lower 0.2 % proof stress.

Figure 2 is a diagrammatic sectional view of the device for drape drawing a shadow mask sheet 1. The device for drape drawing the shadow mask sheet 1 comprises a draw die 2 (sometimes termed "mandril"), a pressure ring 3 (sometimes termed "pleat holder") and a draw ring 4. A shadow mask sheet 1 is laid on the draw die 2. The draw ring 4 is then lowered towards the pressure ring 3 so that the shadow mask sheet 1 becomes clamped on opposite sides at its periphery between the draw ring 4 and the pressure ring 3 in a slip-free manner (see Figure 3). The actual drape drawing of the shadow mask sheet 1 takes place by simultaneously lowering the draw ring 4 and the pressure ring 3 as is shown in Figure 4. The shadow mask sheet 1 is then drawn over the draw die 2. During this process the temperature of the shadow mask sheet 1 is adjusted to between 150°C and 250°C. For this purpose the draw die 2 comprises a copper block 5 in which electrical heating elements 6 are embedded. Similarly, the pressure ring 3 comprises copper blocks 7 with heating elemens 8 and the draw ring 4 comprises copper blocks 9 with heating elements 10. The shadow mask sheet 1 can be heated by heating the drawing tools to between 150°C and 250°C. However, the shadow mask sheet 1 may alternatively be heated previously in a furnace at a temperature between 150°C and 250°C. In order to distribute the temperature uniformly over the shadow mask sheet during the drawing process the draw die 2 comprises a number of heat pipes 11 which ensure temperature equalisation at the surface of the draw die 2. After the shadow mask sheet 1 has been drape drawn, it is provided at its periphery with a skirt by bending over peripheral portions of the shadow mask sheet 1. For this purpose the pressure ring 3 is lowered until it bears freely on springs 12 (see Figure 5). The shadow mask sheet 2 is then no longer clamped at its periphery between the pressure ring 3 and the draw ring 4, but is clamped between an ejector 13 and the draw die 2. The ejector 13 also comprises a copper block 14 with heating elements 15 so that the shadow mask sheet 1 contacts the ejector 13 which is also heated to between 150°C and 250°C. The draw ring 4 is then lowered further so that a rim 16 of the skirt 22 becomes clamped between the draw ring 4 and the pressure ring 3 (Figure 6). The pressure ring 3 and the draw ring 4 then compress the springs 12 over a readily defined distance while the rim 16 of

the skirt 22 remains clamped. The skirt 22 is thereby stretched and consequently plastically deformed. The springs 12 are located directly below the faces of the draw ring 4 and pressure ring 3 between which the shadow mask sheet 1 is clamped. The number of springs 12 is chosen so that the pressure force of the draw ring 4 is distributed uniformly between said springs 12. The back pressure provided by the springs 12 when the skirt 22 is formed is equal to the pressure with which the pressure ring 3 and the draw ring 4 are lowered. The rim 16 must be sufficiently wide to ensure permanent good clamping. The springs 12 are then relaxed by raising the ejector 13 (Figure 7). After the forming of the skirt 22 the draw ring 4 is raised and lifts the shadow mask 1 with it. Finally, the shadow mask 1 is ejected from the draw ring 4 by the ejector 13 (Figure 8) and discharged. If the shadow mask 1 is removed rapidly from the draw die 2 the shadow mask 1 may be deformed as a result of this rapid raising because the shadow mask 1 is heated. In order to prevent this the shadow mask 1, while still clamped between the pressure ring 3 and the draw ring 4, can be raised slowly by means of a lever system 17 to a position some distance above the draw die 2. As a result of this the possibility of deformation of the shadow mask 1 is reduced. The lever system 17 may be operated by means of compressed air, for example. After the shadow mask 1 has been raised slowly to said position above the draw die 2, the shadow mask 1 can be rapidly raised further.

It is to be noted that the operating members for the draw ring 4, the pressure ring 3 and the ejector 13 are not shown in the drawings since these do not directly relate to the invention.

In addition to the said possibility of plastically deforming the skirt 22 substantially simultaneously with the formation of the skirt 22, by which plastic deformation a flange 18 is formed, it is also possible to deform the skirt 22 plastically after completion of the drawing process. This may be done at room temperature although in that case the mechanical workability is impeded by the comparatively high 0.2 % proof stress. When said plastic deformation is carried out at a temperature between 150°C and 250°C, the tensile stress at which the 0.2 % proof stress is reached is reduced and the mechanical workability is increased.

The shape given to the skirt 22 by the plastic deformation need not be restricted to an outwardly directed flange 18 as described. When after termination of the drawing process the skirt 22 is plastically deformed, this may be done in various manners. If, however, it is desired for the plastic deformation of the skirt 22 to take place substantially simultaneously with the formation of the skirt 22, according to the embodiment of the invention the form of said plastic deformation is restricted to the outwardly directed flange 18.

A shadow mask 1 manufactured by means of the method according to the invention is shown in Figure 9. As a result of the permanent plastic deformation during the formation of the skirt 22 of the shadow mask 1, the shape of the shadow mask 1 has become readily reproducible. When the preferred form of a method in accordance with the invention is used an outwardly directed flange 18 has moreover been formed on the skirt 22. The width of the flange 18 corresponds to the width of the rim 16 which is still clamped between the draw ring 4 and the pressure ring 3 at the end of the drawing process. As already said, the rim 16 must be sufficiently wide to ensure a good clamping and consequently a readily reproducible shape of the shadow mask 1. On the other hand it is not advisable to make the flange 18 too wide because in that case an amount of excessive material is obtained. The width of the flange 18 should preferably be between 1 and 5 mm.

If it is desired to secure the shadow mask 1 to a supporting frame 19 as is shown in Figure 10, for example by means of spot welding the outwardly directed flange 18 constitutes an obstruction. It is of advantage to make a few recesses 20 in the rim of the shadow mask sheet 1, for example, by etching the recesses during the etching of the mask holes 21. Due to these recesses 20, which are present in the flange 18 after the drawing process, the welding apparatus during welding can reach the skirt 22 of the shadow mask 1 without any obstruction at the area of the recesses 20. The width of the recesses 20 should be adapted to the width of the spot welding apparatus. Excessively wide recesses result during the formation of the skirt 22, in variations in tensile stress in the shadow mask 1 between those places of the skirt 22 which are in the elongation of the recesses 20 and that part of the skirt 22 which is present between the recesses 20. This would detrimentally influence the shape of the shadow mask sheet 1. The width of the recesses 20 should preferably be between 16 and 16 mm. When selecting the depth of the recesses 20 the same two arguments should be considered which played a role in the selection of the width of the recesses 20. A depth of the recess 20 which is at least substantially equal to the flange width is to be preferred.

Claims

1. A method of drape drawing, by means of a drawing process, as shadow mask sheet for a colour display tube consisting of an iron-nickel alloy of the invar type, in which a skirt is formed on the shadow mask sheet, characterized in that complementarily to the formation of the skirt, said skirt is plastically deformed permanently.

2. A method as claimed in Claim 1, characterized in that the permanent plastic deformation of the skirt takes place at a temperature between 150°C and 250°C.

3. A method as claimed in Claim 1 or 2, characterized in that the plastic deformation of the skirt takes place at least substantially simultaneously with the formation of the skirt, and that a flange is formed on said skirt.

4. A method as claimed in Claim 3, characterized in that prior to the formation of the flange recesses are provided in the shadow mask sheet, said recesses being formed at least for the greater part in that part of the shadow mask sheet which afterwards constitutes the flange.

5. A method as claimed in any of the preceding Claims, characterized in that an alloy which contains 35 to 37 % by weight of nickel is chosen for the iron-nickel alloy of the invar type.

6. A shadow mask manufactured by means of the method as claimed in any of the preceding Claims.

7. A colour display tube comprising a shadow mask as claimed in Claim 5.

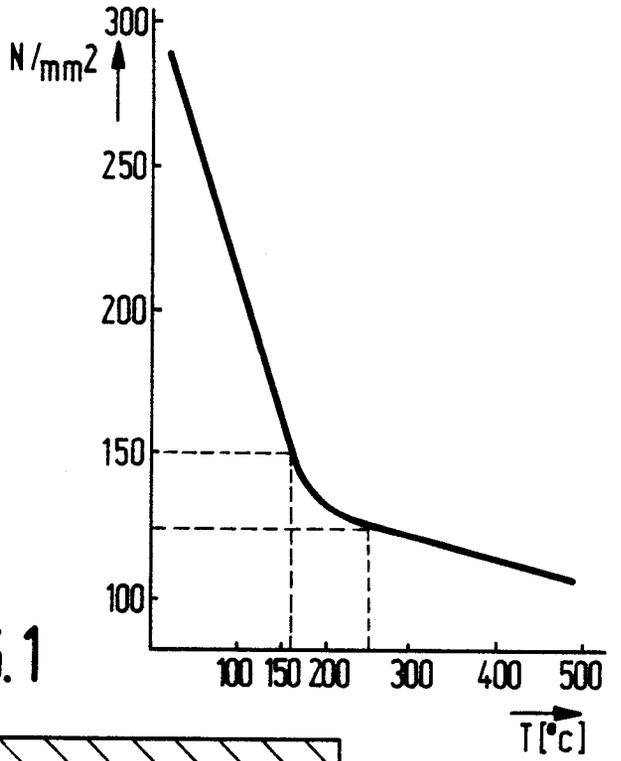
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FIG. 1

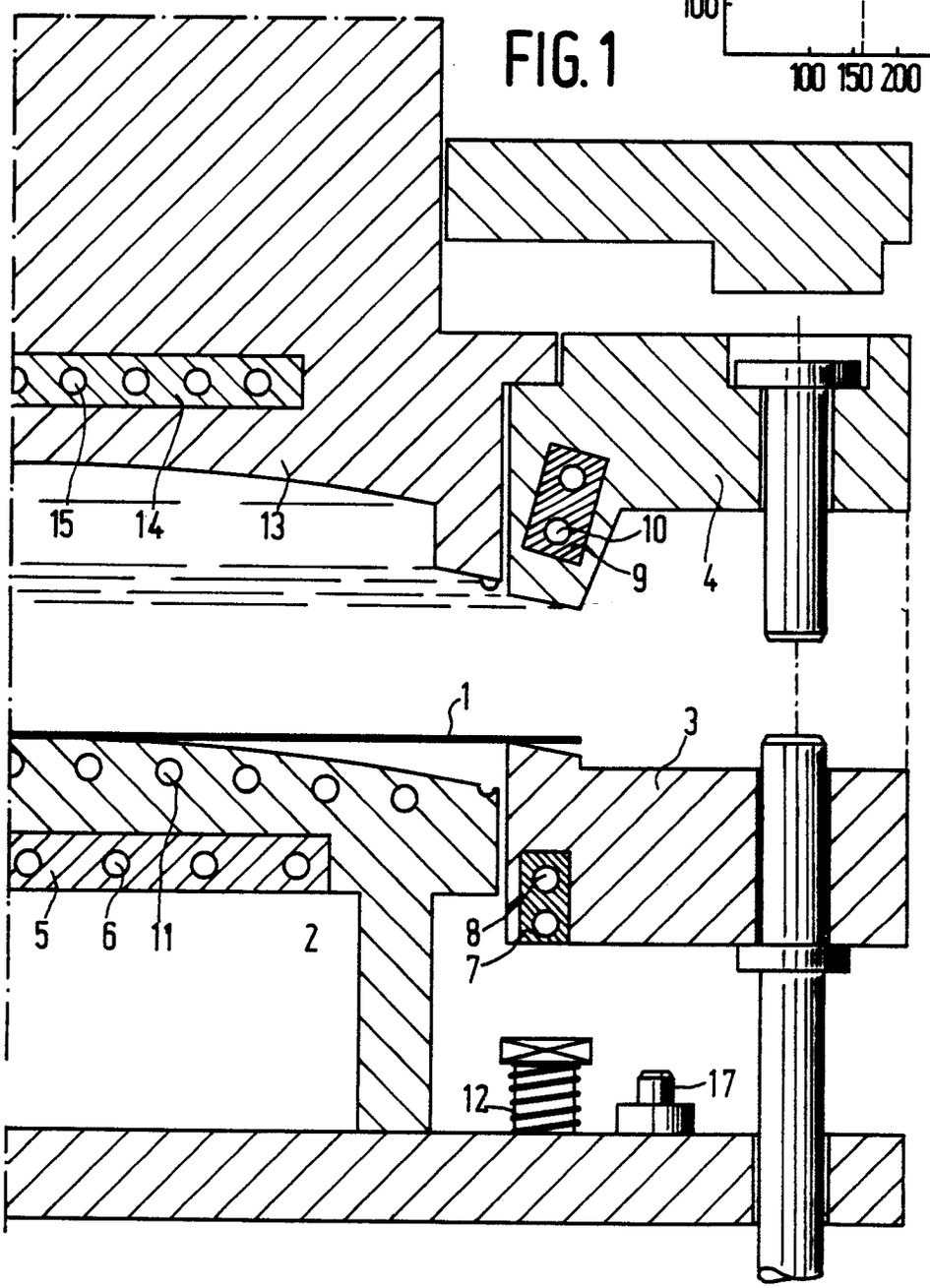
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FIG. 2

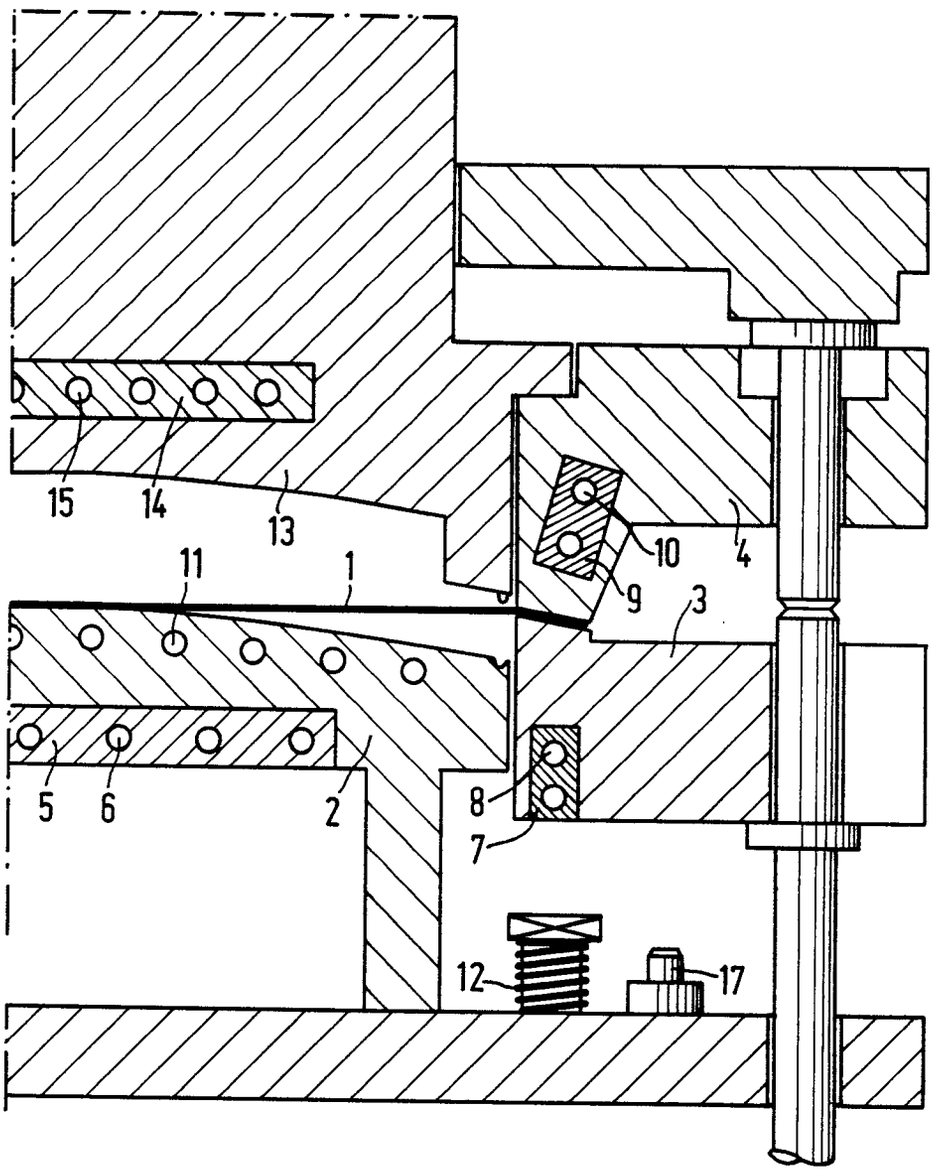

FIG.3

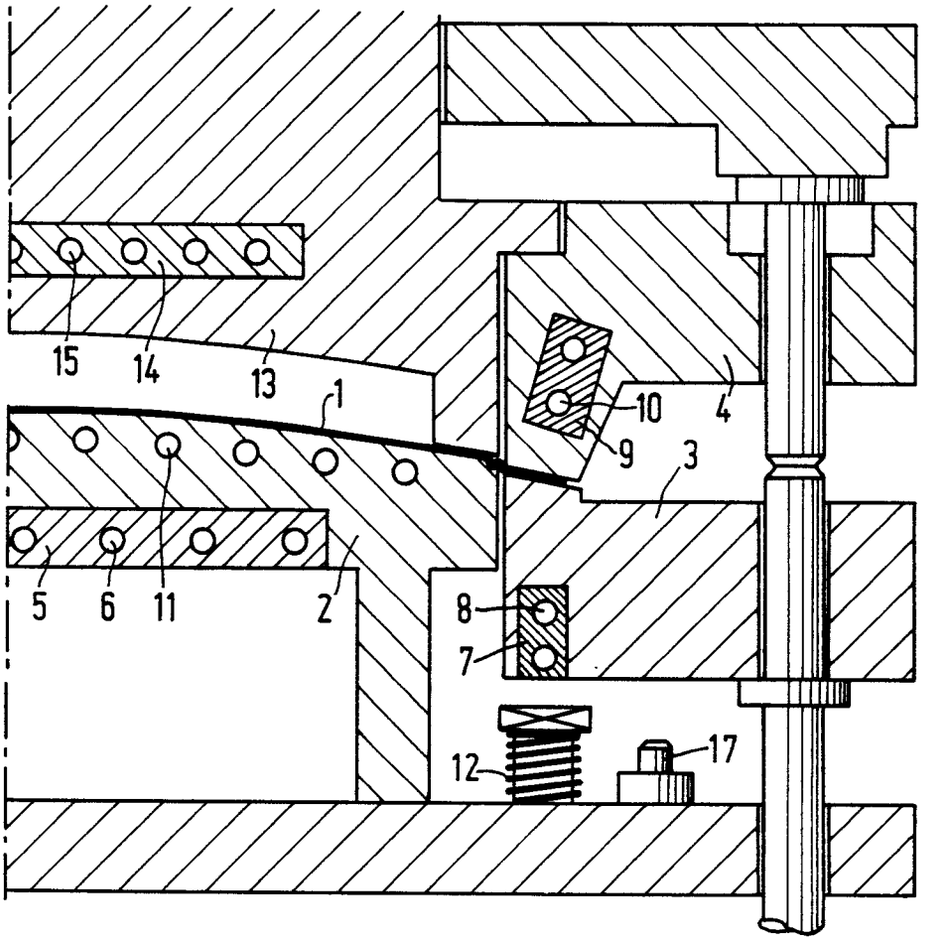

FIG.4

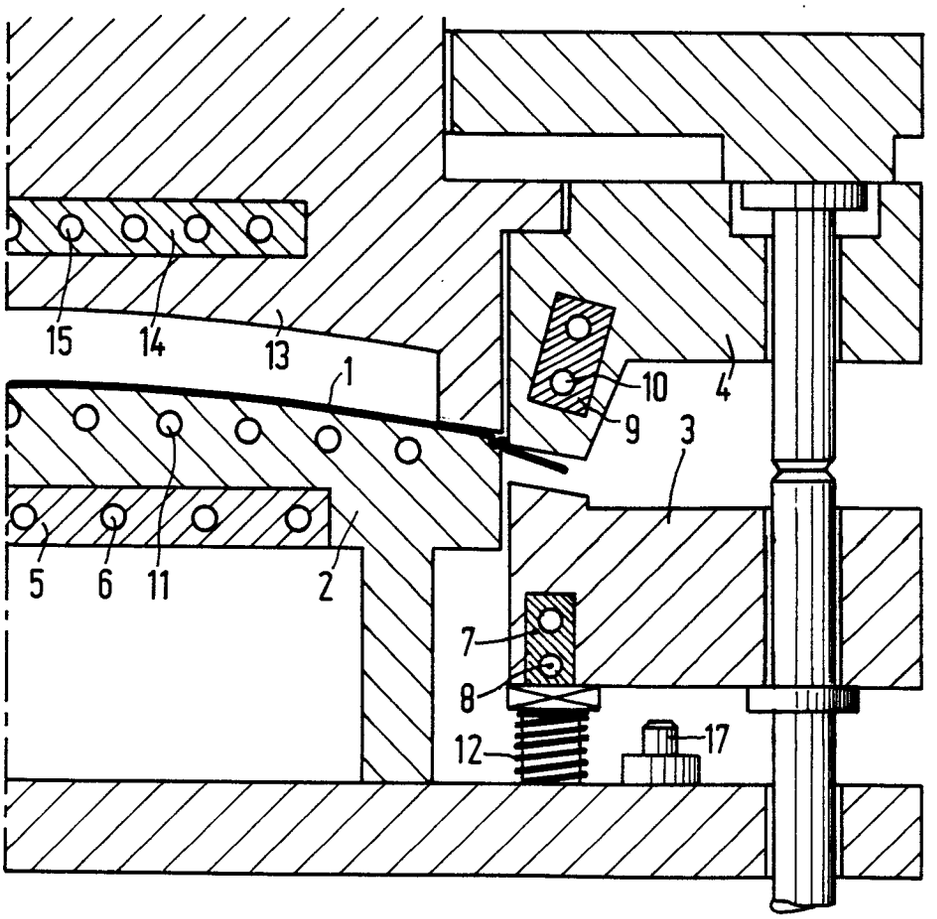

FIG.5

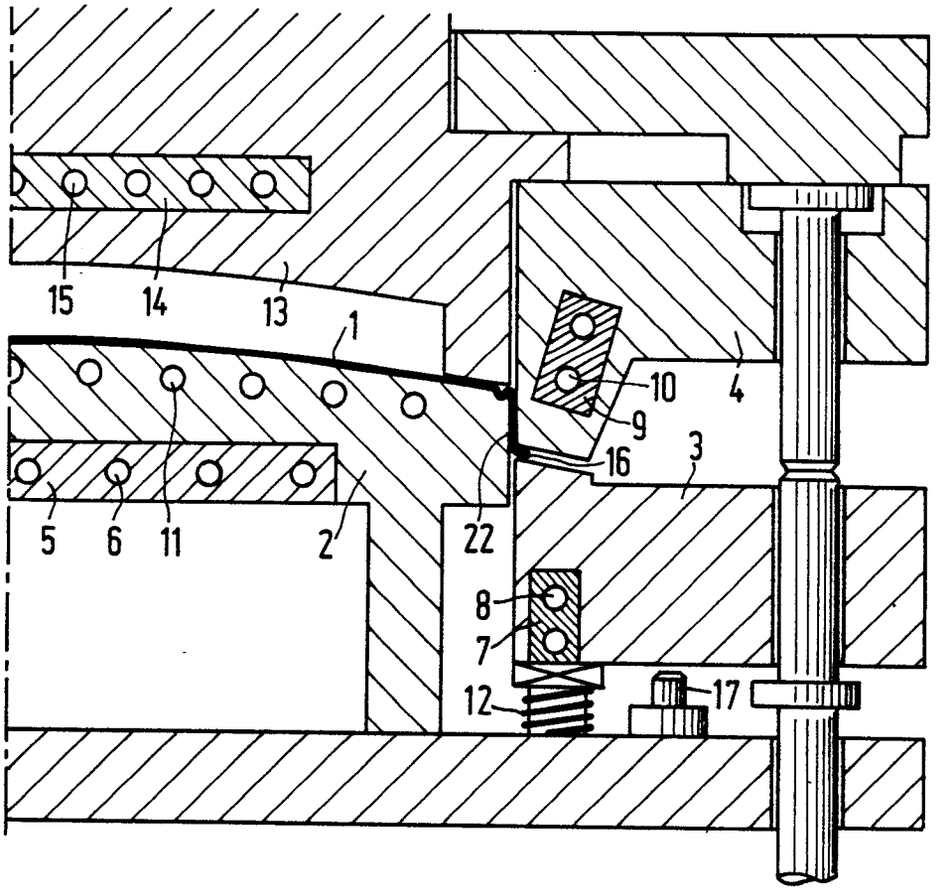
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FIG.6

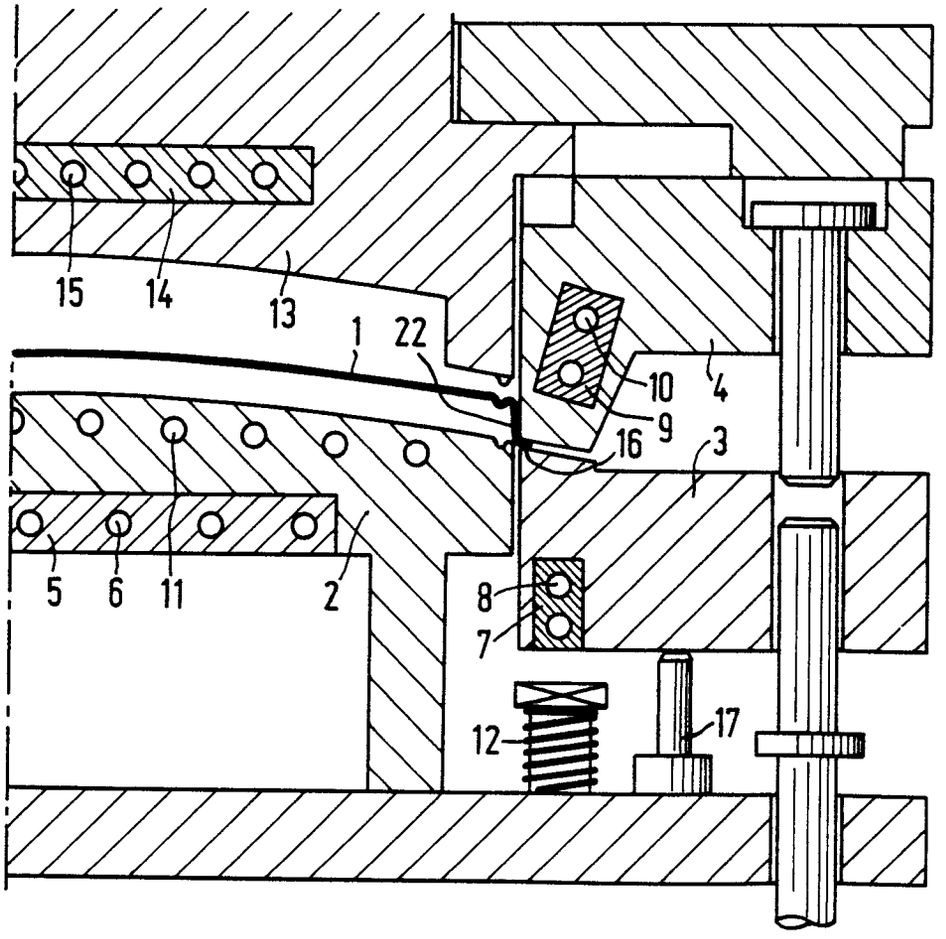
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FIG.7

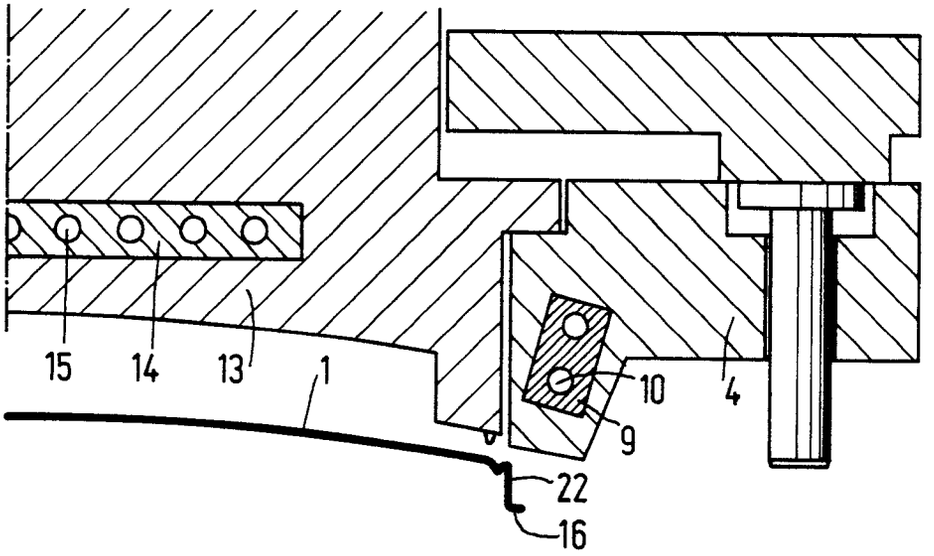

FIG. 8

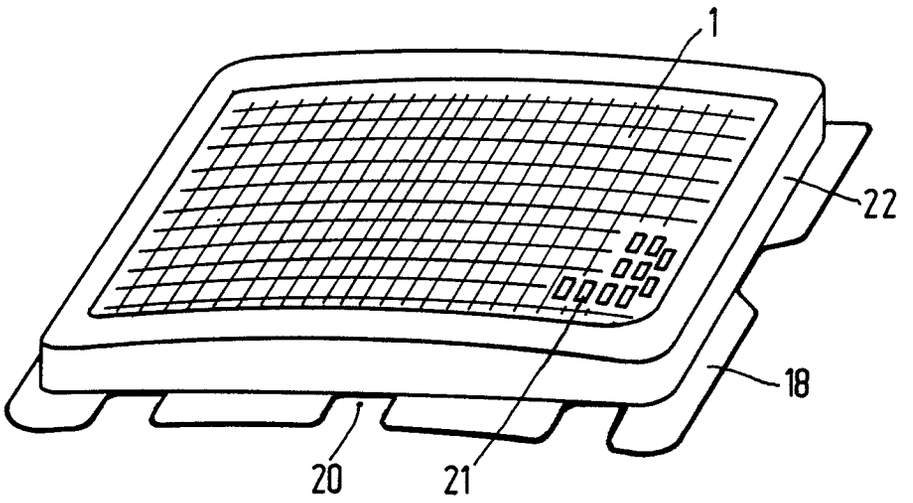

FIG. 9

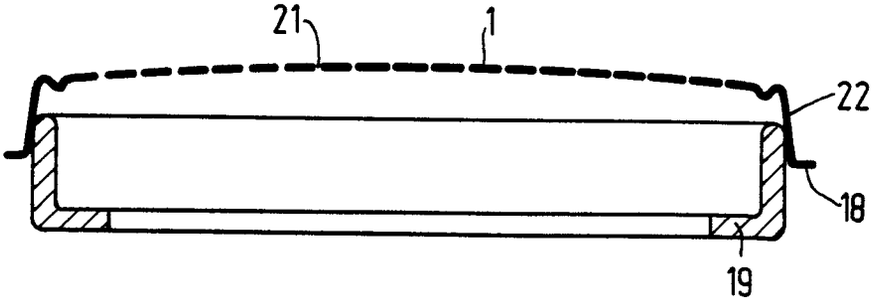

FIG. 10

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 86 20 1961

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.4)
A	FR-A-2 317 759 (PHILIPS) * Page 1, lines 29-36; figure 6 *	1	H 01 J 9/14
A	EP-A-0 124 354 (TOSHIBA) * Page 4, line 23 - page 5, line 4; page 6, lines 9-15; page 9, lines 6-14 *	2,5	
A	FR-A-2 016 879 (WALLACE EXP. MACHINES) * Page 1, lines 28-36; figure 5 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

H 01 J 9/06
H 01 J 29/00
B 21 J 5/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16-02-1987	JANSSON P.E.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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