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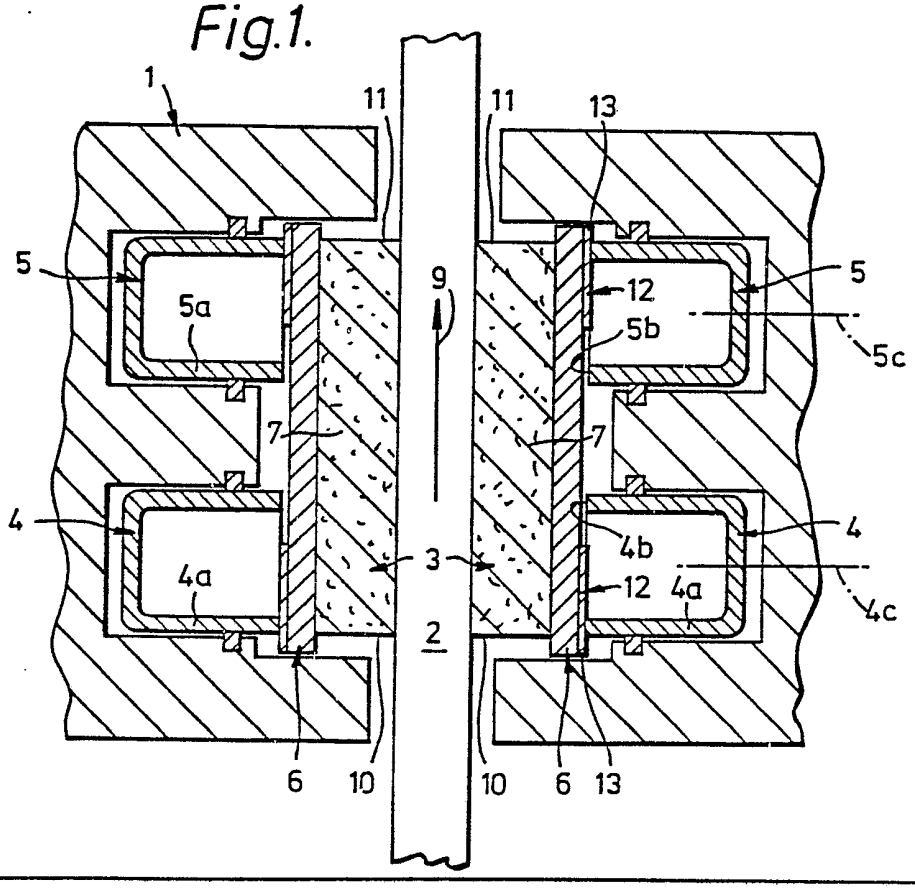
(54) Disc-brake assembly

(57) A disc brake assembly has a brake pad 3 comprising a friction slab 7 and a backing plate 6 pressed against the side of a rotating brake disc 2 by two hydraulic pistons 4*a*, 5*a*. The slab 7 has leading and trailing edges 10, 11 with respect to the direction 9 of rotation of the disc and pressure from the pistons 4*a*, 5*a* is applied to the slab 7 through pressure regions 12 having centres of pressure which are displaced from the geometrical centres 4*c*, 5*c* of the respective pistons to be nearer to the leading and trailing edges 10, 11 than are the geometrical centres of those pistons to alleviate squeal. The aforementioned displacement is provided by layers of material 13 against which part only of the piston end faces 4*b* and 5*b* react.

In alternative arrangements the displacement of the centre of pressure is provided by recesses or rebates formed on the rear face of the backing plate 6; by curvature of the backing plate to present a concave surface to the end faces of the pistons; by profiling the end faces of the pistons or by providing an intermediate profiled member between the pistons and the brake pad.

Fig.1.



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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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Fig.1.

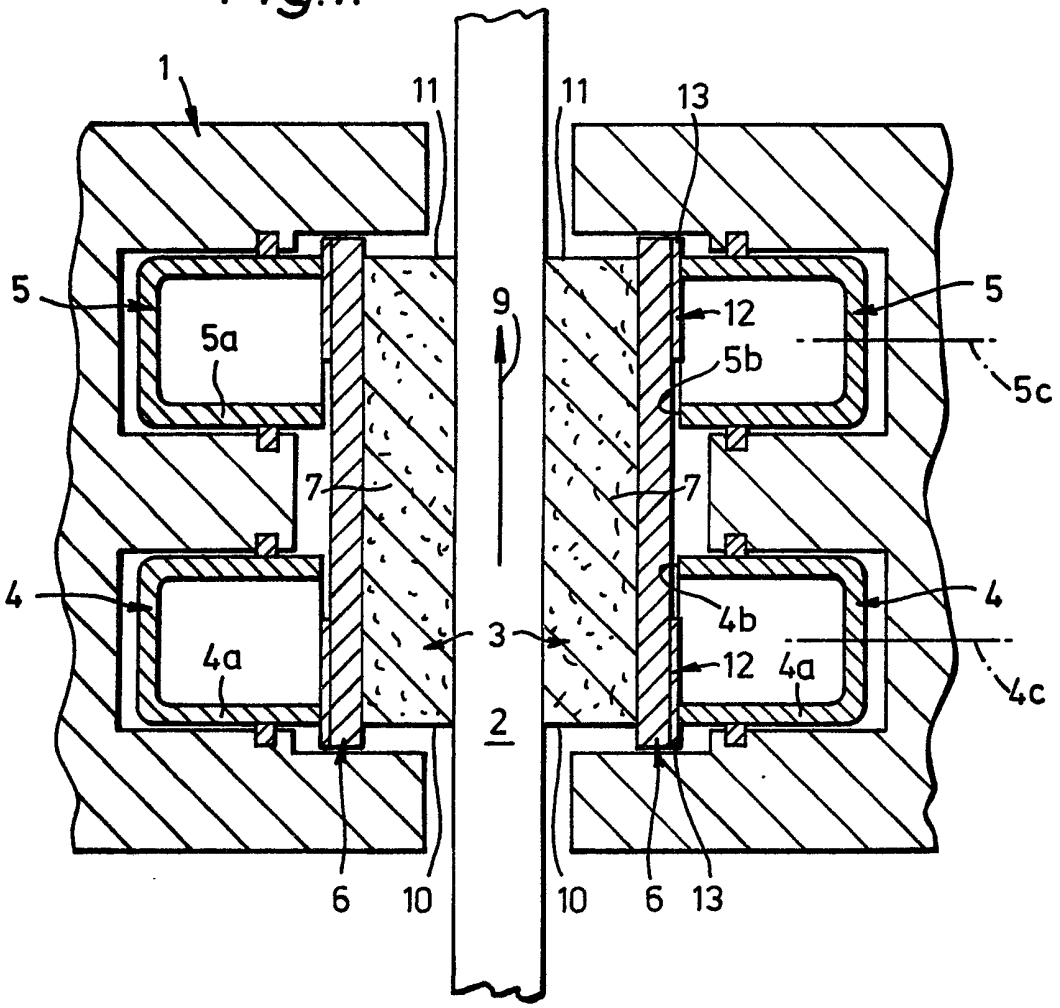

Fig.2.

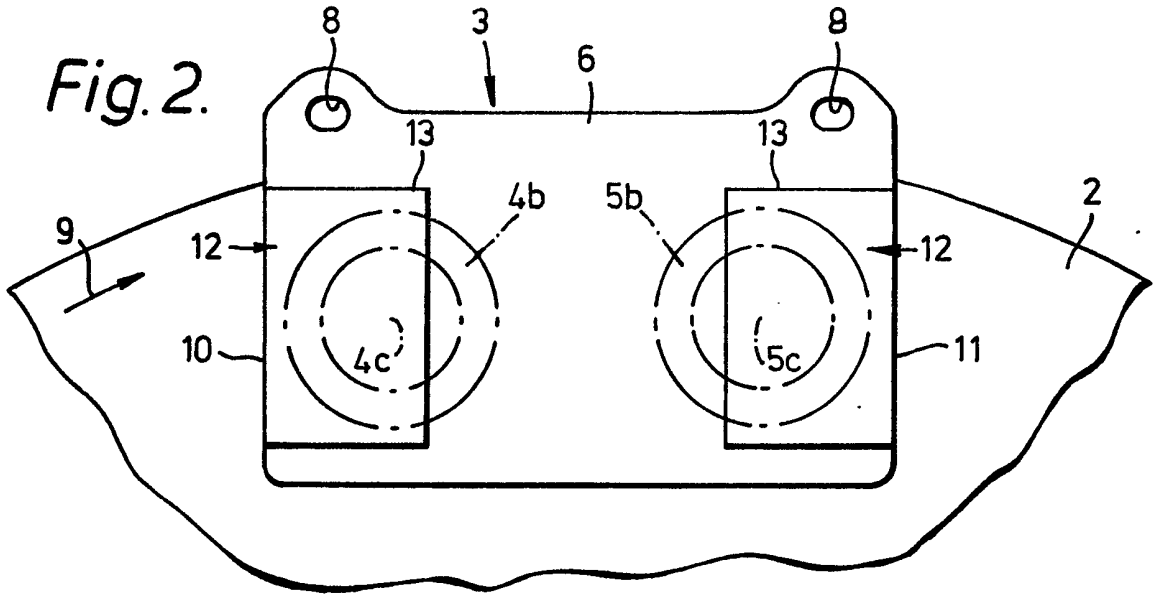

Fig. 3.

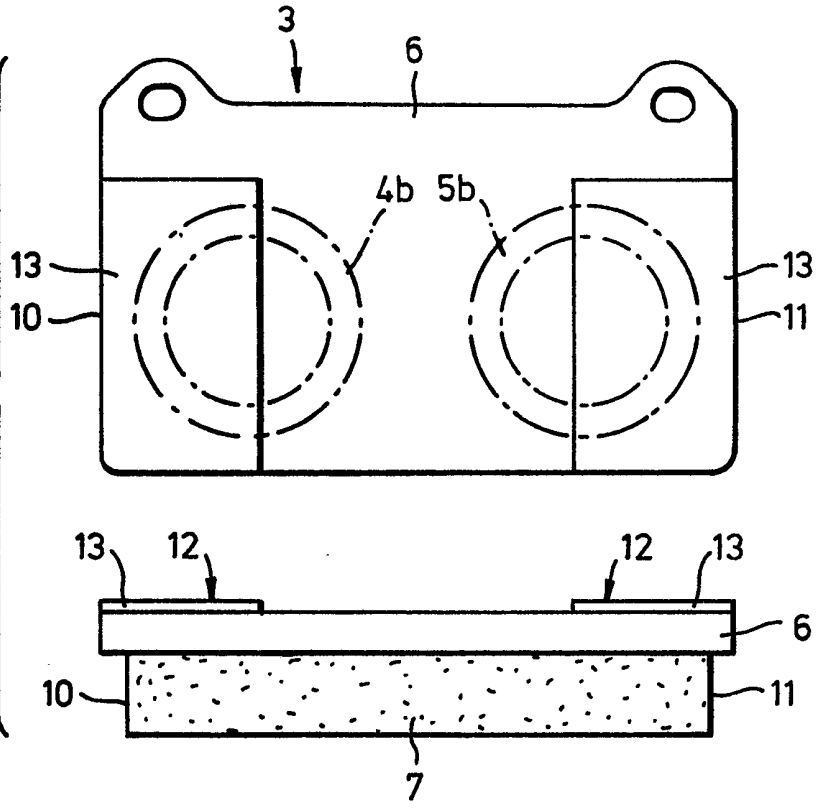

Fig. 4.

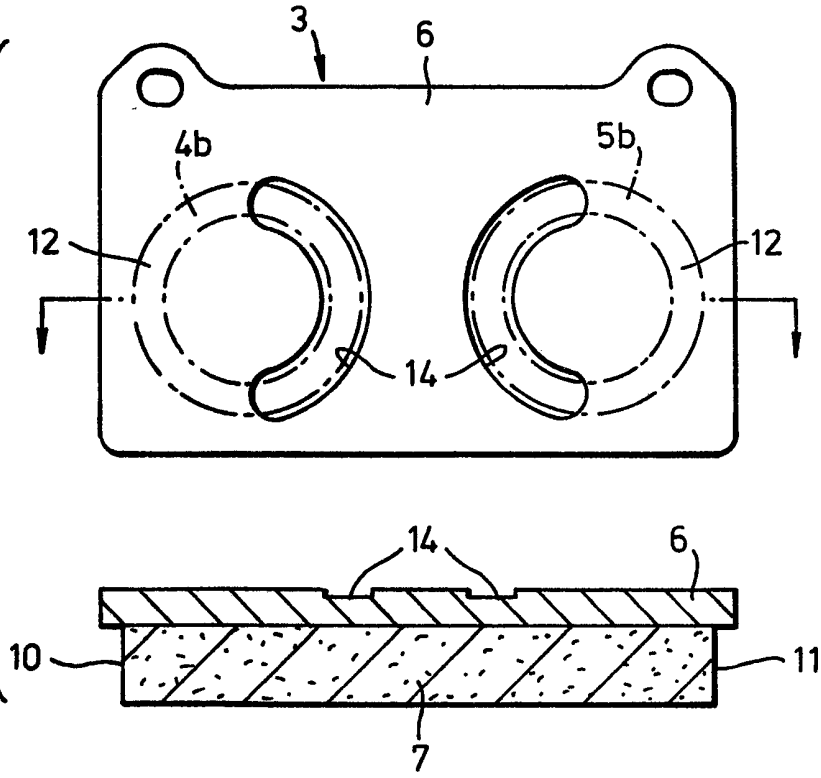

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Fig.5.

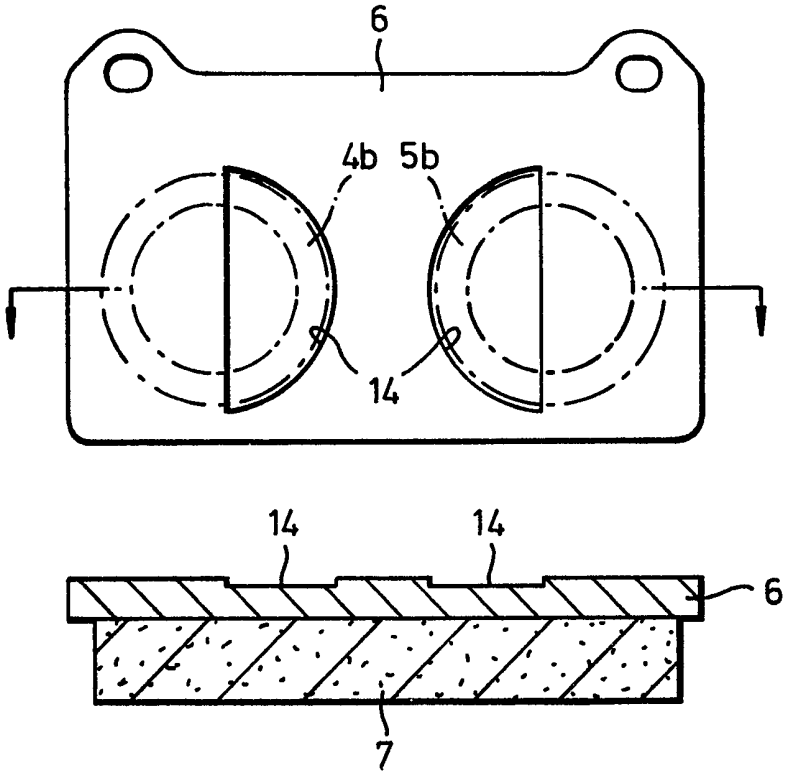


Fig.6.

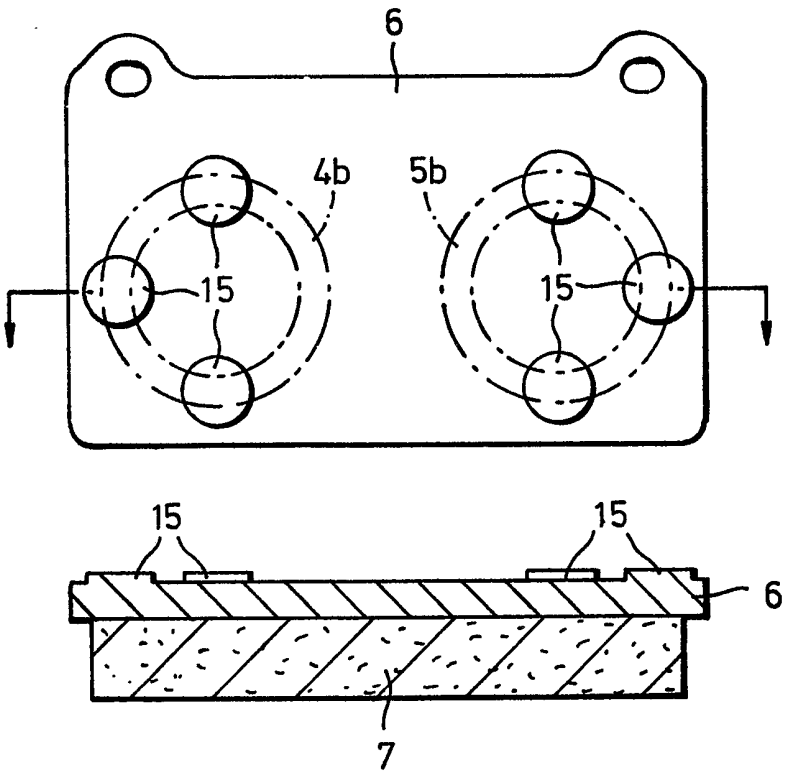


Fig.7.

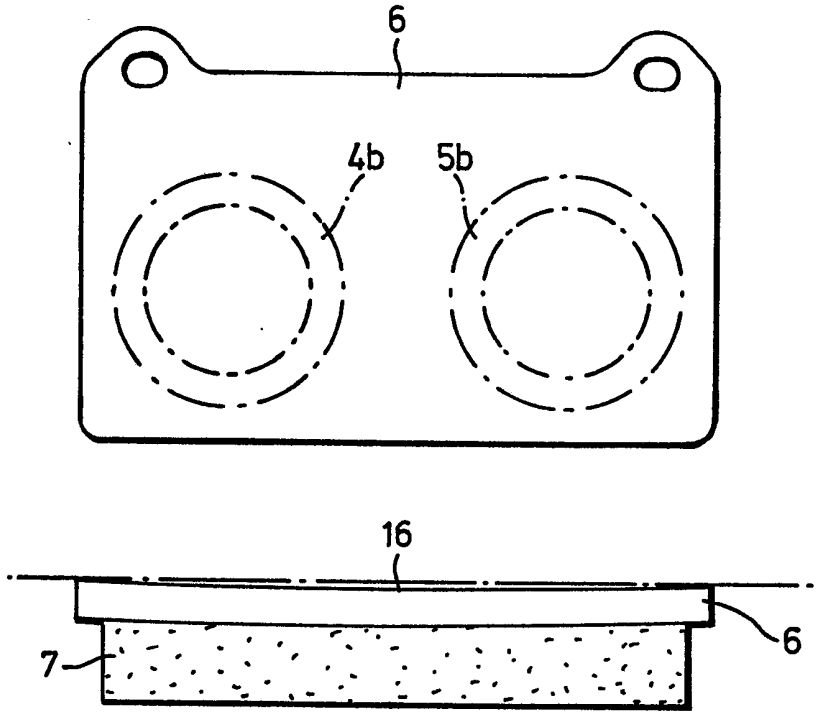


Fig.8.

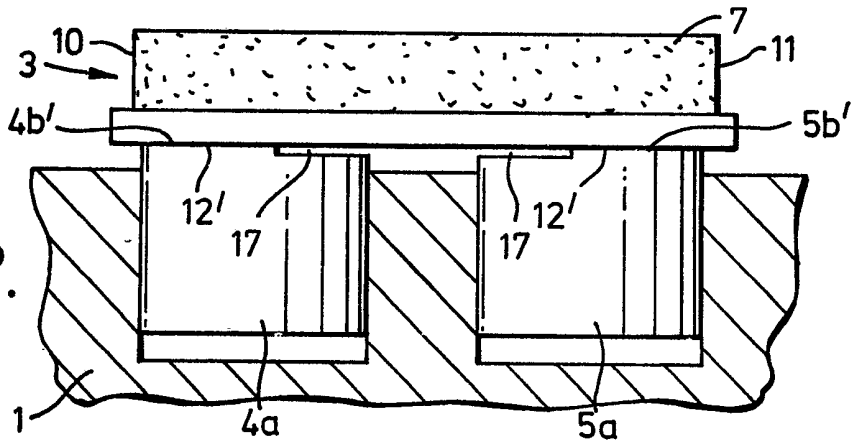


Fig.9.

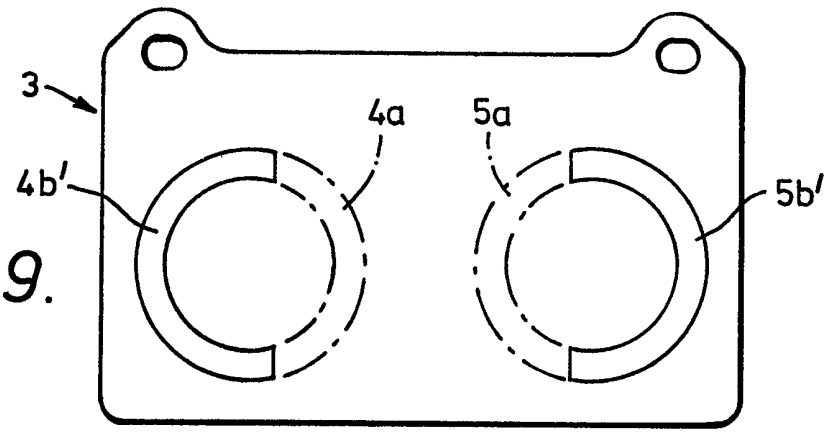


Fig.10.

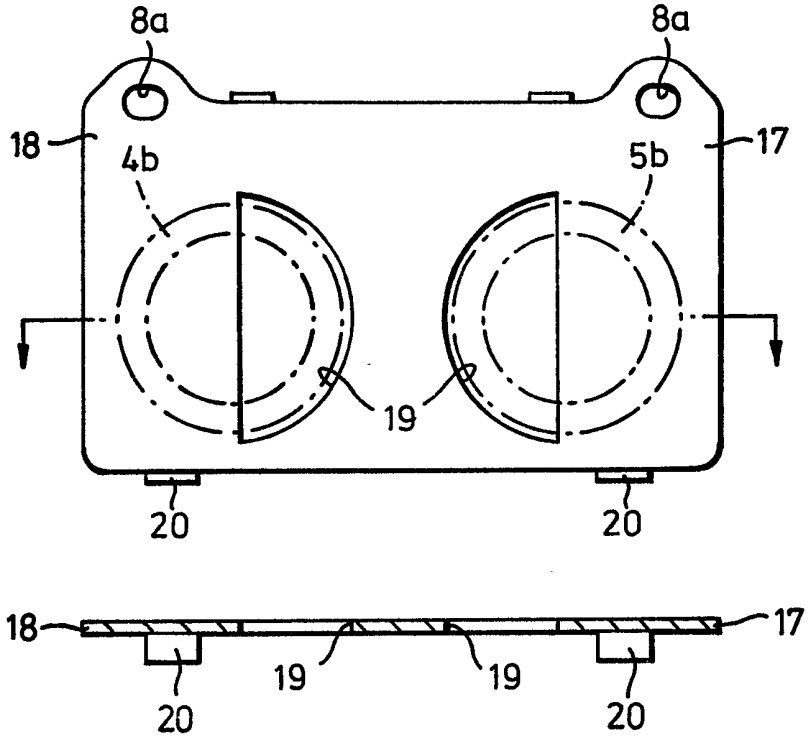
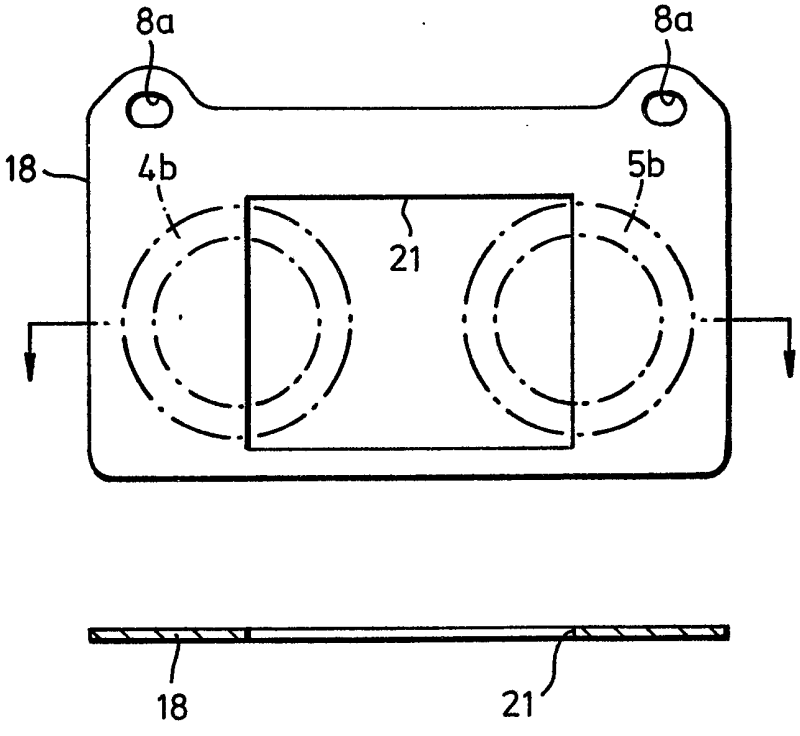


Fig.11



SPECIFICATION

A disc brake assembly

Technical Field and Background Art

This invention relates to a disc brake assembly of the type in which at least one brake disc is fixed for rotation with a body which is to be braked by means of brake pads movably mounted in a housing and which pads are arranged to be pressed towards opposite sides of the brake disc by means of fluid pressure (usually hydraulic) operated piston means acting upon each brake pad. In practice a disc brake assembly of the aforementioned type has a tendency to squeal when the brake pad is applied to the disc. This undesirable characteristic of squealing is discussed in our British Patent Specification No. 1,275,306 together with the belief that the amount of noise emitted by a disc brake is, to an extent, dependent upon the pressure distribution as applied from the piston across the brake pad. Our prior Specification discloses several techniques by which the aforementioned pressure distribution can be varied in an attempt to alleviate squeal. More particularly, in the case of a disc brake assembly having a single piston for each brake pad, the problem of brake squeal is often alleviated by arranging for the piston pressure as applied to the brake pad to be displaced from the geometrical centre of the brake pad into a position in which the pressure is applied for efficient braking with minimum squeal characteristics.

In a conventional assembly in which a brake pad is acted upon by a single piston the piston is usually located at the geometric centre of the pad. Disc brake assemblies are known however in which each brake pad has two or more pressurising pistons symmetrically disposed over the brake pad; this latter type of assembly is often noisy in operation due to a squeal which is emitted when the brake pad is applied to the rotating disc and there is a problem of alleviating this squeal in a manner which permits the maintenance of a generally symmetrical pressure distribution from the two or more pistons across the brake pad. It is an object of the present invention to provide a disc brake assembly which alleviates the above mentioned problem.

Statement of Invention and Advantages

According to the present invention there is provided a disc brake assembly comprising a rotatable disc to be braked; two fluid pressure operated pistons, and a brake pad having a backing plate carrying a friction slab with leading and trailing edges with respect to the direction of rotation of the disc; said pad being interposed between the disc and the pistons so that faces of the two pistons overlie the backing plate one at or towards each of the leading and trailing edges and a working surface of the slab engages the disc when pressure is applied on the pad by the pistons, and wherein pressure from the pistons is applied to the slab through pressure regions having centres of pressure which are displaced from the geometrical centres of the respective pistons to be nearer to the respective leading and trailing edges than are the geometrical centres of the respective pistons which are at or towards the said edges.

Our research indicates that squeal develops during operation of a disc brake assembly, to a substantial extent, from vibration induced in the disc and brake pad. This vibration is in a direction parallel to the axis about which the disc rotates and is believed to be in the form of a standing wave which is perpendicular to the plane of the disc face that the brake pad engages. It is also believed that as the amplitude of the vibratory wave changes stationary nodes are formed one of which is located substantially centrally between the leading and trailing edges of the slab of friction material in the brake pad. In a disc brake assembly as may be typically incorporated in a motor vehicle several nodes, usually six to eight, may be formed in the standing vibratory wave around the marginal edge region of the disc within which the brake pad is conventionally applied and the wave length of the vibration of the disc in this region will, in the majority of instances, be considerably greater than the distance between the leading and trailing edges of the friction slab. Because of this latter characteristic, the maximum amplitude of vibration of the brake pad in contact with the brake disc in a direction perpendicular to the plane of the working face occurs at the extreme ends of the friction slab (which ends are known in the art as the leading and trailing edges of that slab with respect to the direction of rotation of the disc). This vibration is in the direction in which the fluid pressure operated pistons are displaced and, if this vibration is efficiently transferred to the pistons, is consequently damped by the hydraulic or other fluid which is pressurised to bias the pistons to displace the brake pad into engagement with the disc.

By the present invention the pressure from the pistons is applied to the slab through pressure regions, the centres of pressure of which are displaced to be nearer to the respective leading and trailing edges than are the geometrical centres of the respective pistons (which latter, in conventional arrangements, would coincide with the aforementioned centres of pressure). As a consequence the pressure resulting from the pistons can be applied at positions of maximum vibration adjacent to the trailing and leading edges of the slab — our research indicates that by this arrangement maximum damping can be achieved to the vibration with a considerable reduction in squeal, without detriment to the desired braking characteristics, and whilst the generally symmetrical and conventional disposition of the pistons relative to the brake pad can be maintained.

The two pistons will usually have their geometrical centres at equal radii from the axis of rotation of the disc and preferably the centres of pressure for the respective pressure regions are located on a notional line parallel to a line which

interconnects the geometrical centres and are further apart than the geometrical centres. Usually, but not necessarily, the aforementioned notional line and the interconnecting line will coincide. Whilst we have referred to two pistons being located respectively at or towards the leading and trailing edges of the friction slab it will be realised that the brake pad can have associated therewith three or more pistons and usually these will be symmetrically disposed over the pad.

In a preferred arrangement one or more of the pressure regions is formed by a region of predetermined profile on the backing plate against which region an end face of a piston applies pressure so that the pressure is not applied through the whole end face of that piston due to a clearance provided between part of that end face and an area adjacent to the aforementioned profiled region. The predetermined profiled region may be defined by a rebate on the side of the brake pad remote from the slab such rebate being formed, for example by a cut-away part in the thickness of the material of the backing plate or by an aperture or slot in the backing plate in a similar manner to the technique discussed in our British Patent Specification No. 1,275,306. The region of predetermined profile can also be provided by a surface which is concave relative to the piston and against which a substantially flat end face of the piston applies pressure; by this technique the backing plate of the brake pad may be curved to present the aforementioned concave surface. The region of predetermined profile may also be formed by a protuberance or projection on the backing plate, for example, by extending the friction slab material through an aperture or slot in the backing plate. The region of predetermined profile can also be formed by a layer of material in the brake pad and which is carried at the side of that pad remote from the slab; such layer may be in the form of a metallic shim, a non-metallic gasket material or a solid polymer secured adhesively, by rivets or other convenient means to form part of the brake pad.

In an alternative arrangement one or more of the pressure regions can be formed by an intermediate member interposed between the brake pad and the piston or pistons respectively associated with those pressure regions so that pressure from an end face of a piston is applied to the brake pad through the intermediate member which latter is profiled so that the pressure is not applied through the whole end face of the piston. The intermediate member is conveniently in the form of a plate having one or more cut-away parts, rebates, recesses or is otherwise of varying thickness to determine the part of the piston end face through which pressure is not applied to the brake pad. Conveniently the intermediate member is mounted in the disc brake assembly by the same means by which the brake pad is mounted such as a caliper or pins. Alternatively or in addition the intermediate member can be mounted in the assembly by its attachment, for example by clip means, to the sides of the brake pad.

In a still further arrangement at least one of the pressure regions can be formed by a predetermined profiled end face of the piston associated with that region and through which end face pressure is to be applied to the brake pad. The predetermined profiled end face may be formed, for example, by a rebate or step in the piston or by a chamfer on the piston. Conventional pistons have a generally cylindrical profile and in such case it may be necessary to provide means by which a piston having a predetermined profiled end face is restrained from rotating in its cylinder to ensure that the centres of pressure of the pressure regions are maintained at their desired and predetermined location at or near the leading and trailing edges of the friction slab.

Drawings

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying illustrative drawings, in which:

Figure 1 schematically illustrates a plan view of a disc brake assembly constructed in accordance with the present invention;

Figure 2 is a side elevation of a brake pad and part of the brake disc incorporated in the arrangement of Figure 1;

Figures 3 to 7 illustrate modified forms of brake pads suitable for use in the assembly of Figure 1 and each Figure shows a plan and side elevation (some in section) of the respective brake pads;

Figure 8 illustrates a further embodiment of the present invention in which the pistons are profiled to provide the required pressure distribution to the brake pad, the pistons and brake pad being shown in plan view;

Figure 9 is a side elevation of the brake pad in Figure 8 and illustrates the manner in which the pistons engage the brake pad, and

Figures 10 and 11 each illustrate intermediate members suitable for use in an assembly in accordance with the present invention, the intermediate member in each Figure being shown in plan and sectioned end views respectively.

Description with Reference to Drawings

The disc brake assembly shown in Figure 1 has a caliper housing 1 which straddles a marginal edge portion of a rotatable brake disc 2 to be braked. The housing 1 carries a pair of brake pads shown generally at 3 which are adapted to be brought into and out of engagement with opposite faces of the disc 2 by hydraulically operated cylindrical piston and cylinder devices of which two such devices 4 and 5 are provided for each brake pad 3. Each brake pad 3 comprises a rigid metal backing plate 6 to which is bonded a slab 7 of friction material. Each pad 3 is interposed between the pistons 4*a* and 5*a* of its adjacent piston and cylinder devices and the disc 2 so that the side of each pad remote from its friction slab 7 is overlaid by annular end faces 4*b* and 5*b* of the respective pistons 4*a* and 5*a* and a working

surface of each friction slab 7 engages the disc 2 when pressure is applied from its piston and cylinder devices.

The backing plate 6 (as is best seen in Figure 2) has the general outline of a conventional type backing plate and includes holes 8 by which the brake pad is slidably mounted on pins (not shown) in the caliper housing 1 so that during application of the brake, the brake pads are slidably displaced along the respective pins towards the disc 2.

The brake pads 3 are symmetrically disposed and located opposite to each other within the housing 1 at the marginal edge portion of the disc 2 while the geometrical centres 4*c* and 5*c* of the pistons 4*a* and 5*a* respectively (and also the geometrical centres of the piston end faces 4*b* and 5*b* respectively) associated with each pad are positioned at equal radii from the axis of rotation of the disc 2. With the disc 2 rotating in the direction of arrow 9, the slab 7 of each brake pad may be considered as having a leading edge 10 and a trailing edge 11 with respect to the direction of rotation of the disc 2 and the pistons 4*a* and 5*a* are spaced to overlie their respective slabs 7 one each adjacent to the leading and trailing edges of those slabs.

In a conventional disc brake assembly where each brake pad is acted upon by two pistons which are disposed in a similar arrangement to that shown in Figure 1, the annular end faces of those pistons act on a flat rear face of the respective backing plates. Conveniently therefore pressure is applied to the slab from its associated two pistons through pressure regions having centres of pressure which coincide with the geometrical centres 4*c* and 5*c* of the respective pistons and these centres of pressure can be considerably remote from the leading and trailing edges 10, 11 which are adjacent to the pistons. As previously discussed, our research indicates that to alleviate squeal during actuation of the disc brake, vibration which develops in the disc 2 and brake pads 3 should be damped by the application of hydraulic pressure on the pistons as near as possible to the leading and trailing edges of the respective pads. With this in mind each brake pad 3 includes two regions 12 of predetermined profile on its backing plate against which regions the piston end faces 4*b* and 5*b* respectively apply pressure in such a manner that pressure is not applied through the whole of each annular end face due to a clearance provided between part of that end face and an area adjacent to the aforementioned profiled region.

These predetermined profiled regions 12 in the arrangement shown in Figures 1 and 2 are provided by layers 13 of material carried on the backing plate 6 to be interposed between that plate and the respective piston end faces 4*b* and 5*b*. The material of each layer 13 is intended to maintain clearance between part of the piston end face which overlies it and the rear face of the backing plate and as such the material should be capable of withstanding the actuating load on the piston without compressing sufficiently to cause contact between the piston and the backing plate and may, typically, be a steel or other metal shim, a fibrous gasket compound, or a rubber or resin based coating attached either by adhesive, rivets or direct adhesion of the aforementioned coating to the rear face of the backing plate. The two layers 13 are carried on the backing plates 6 of the respective pads to overlie the respective leading and trailing edges of the friction slabs 7 as shown in Figure 2. By virtue of the partial overlying relationship between the piston end faces 4*b* and 5*b* and the respective layers 13 it will be appreciated from Figure 2 that pressure from the pistons 4*a* and 5*a* is applied to the slab 7 associated therewith through pressure regions which are displaced from the geometrical centres 4*c* and 5*c* of the respective pistons to be nearer to the leading edge 10 and trailing edge 11 respectively than are the respective geometrical centres 4*c* and 5*c*. The aforementioned displacement of the centres of pressure is preferably such that the centres of pressure are located on a notional straight line which interconnects the geometrical centres 4*c* and 5*c*.

The brake pad shown in Figure 3 is similar to that shown in Figure 2 but has its layers 13 which form the profiled regions 12 of a different size to vary their extent of overlap with the respective piston end faces 4*b* and 5*b* and therefore the degree to which the centres of pressure of the pressure regions (through which pressure from the pistons is applied to the slab) are displaced towards the leading and trailing edges from the geometrical centres of the piston end faces.

The brake pad shown in Figure 4 has its predetermined profile regions 12 defined by two adjacent and part annular recesses 14 formed in the side of the backing plate 6 remote from the slab 7. The recesses 14 underlie, one each, part length of the respective annular piston end faces 4*b* and 5*b* and are of such a depth that no contact between the bottom of the recesses and the overlying parts of the piston end faces can occur. The depth of the recesses 14 will usually be greater than 0.1 mms. In this arrangement the piston end faces are intended to abut against a substantially flat rear face of the backing plate 6 so that, similarly to the Figure 1 arrangement, the centre of pressure from each piston will be displaced from the geometrical centre of that piston and towards the leading or trailing edge of the friction slab which is nearest to that piston. The recesses 14 can alternatively be in the form of segments of circles as shown in Figure 5 or in any other convenient form which provides the required displacement of the centres of pressure from the geometrical centres of the pistons. Conveniently the recesses 14 are formed by machining or pressing of the backing plate 6 although such recesses can be formed by extensions of the friction slab material within apertures or slots in the backing plate and part way through the thickness of the backing plate in the manner disclosed in our British Patent No. 1,275,306.

In the arrangement of the backing plate shown

in Figure 6 each pressure region for a piston end face 4*b* or 5*b* is formed by an array (conveniently three as shown) of protuberances or projections (such as studs or bosses) 15 extending outwardly from the rear face of the backing plate and against which the annular end faces of the pistons apply pressure for actuation of the brake. The studs or bosses 15 are so disposed to provide the required displacement of the centres of pressure from the geometrical centres of the respective piston end faces and towards the respective leading and trailing edges and, typically, extend outwardly from the rear faces of the backing plate to an extent greater than 0.1 mms. The studs or bosses are conveniently pressed or otherwise formed as an integral part of the backing plate; they may comprise layers of material adhesively or otherwise secured to the backing plate or they may be formed as projections of the friction slab material which is extended through apertures in the backing plate.

In the embodiment of Figure 7 the backing plate 6 of the brake pad is preformed with a curvature so that the rear face of the backing plate remote from the slab 7 presents a concave surface 16 to the piston end faces 4*b* and 5*b*. The surface 16 has a relatively small concave curvature which may be, for example, part spherical or part cylindrical so that when the piston end faces are pressurised on to the surface 16 part only of the annular extent of those faces engages with the surface 16 to provide the required positioning of the centres of pressure at or towards to the leading or trailing edges of the friction slab. Typically the surface 16 will be symmetrical and with its maximum depth at the centre of the pad in the order of 0.05 mms. to 0.5 mms.

In the embodiment shown in Figures 8 and 9 the pressure regions 12′ between the respective pistons 4*a* and 5*b* and the brake pad 3 are formed by predetermined profile end faces of the pistons through which pressure is to be applied to the brake pad. More particularly, the pistons have adjacent steps or rebates 17 so that the annular end faces mentioned above are cut away and the resultant effective end faces 4*b*′ and 5*b*′ of the respective pistons are of part annular form to provide the required displacement of the centres of pressure between the respective pistons and the brake pad from the geometrical centres of the cylindrical pistons. To ensure that the aforementioned displacement is maintained at the required orientation with respect to the leading and trailing edges, means (not shown) is provided to restrain the pistons 4*a* and 5*a* from rotating in their respective cylinders.

Figure 10 illustrates an intermediate member 18 which is intended to be interposed between a substantially flat rear face of a backing plate 6 on a brake pad and the annular end faces 4*b* and 5*b* of the pistons in a similar arrangement (without the layers 13) to that shown in Figure 1. The member 18, which may be regarded as a shim, is of similar shape to the backing plate and is profiled so that pressure from the end faces of the pistons is applied to the brake pad through the member 18 along part length only of each of those annular end faces. In this way the member 18 forms the pressure regions between the pistons and the brake pad to provide the required displacement of the respective centres of pressure from the respective geometrical centres of the pistons. In the arrangement of Figure 10 the plate 18 is cut away to provide segmental apertures 19 which underlie the required circumferential part length of the annular piston end faces 4*b* and 5*b*. The member 18 may be of a material similar to the layer 13 discussed with reference to Figure 2 and may be mounted in the assembly in a similar manner to that in which the pads 3 are mounted; for this latter purpose the member 18 is provided with apertures 8*a* by which it is slidably received on the same pins as the apertures 8 of the brake pad. In addition or alternatively the member 18 can be mounted in the assembly by its attachment to the sides of its adjacent brake pad, for example by clips 20 which engage over the edge of the adjacent backing plate 6.

Figure 11 shows a modification of the intermediate member 18 in which the segmental apertures are replaced by a single rectangular aperture 21. It will be appreciated that rebates can be substituted for the apertures 19 and 21 to provide the required displacement of the centres of pressure from the two pistons from the geometrical centres of those pistons.

There now follows two examples of tests carried out to verify the effectiveness of the present invention:

EXAMPLE 1

A small passenger car fitted with front disc brakes having brake pads actuated by two hydraulic pistons per pad was tested after conventional bedding-in of the brake pad over a brake pad test route comprising a mixed type of terrain. The disc brake as initially tested was conventional and substantially the same as in Figures 1 and 2 (but without the layers of material 13); it was found that squeal was produced during most brake applications when the vehicle speed was less than 10 m.p.h., the brake disc temperature was between 120°C to 220°C and the brake hydraulic pressure was between 2 and 10 bar. Pieces of asbestos based gasket material of 0.5 mm thickness were then attached to each of the brake pads in the manner of the layers 13 in Figures 1 and 2 at both the leading and trailing ends of the backing plate and so that contact between the piston end faces and the brake pad was restricted to slightly more than half of each piston end face annulus similar to the manner shown in Figure 2. The disc brake was again tested over the same route and no squeal could be produced. Upon removal of the aforementioned pieces of gasket material, the squeal immediately returned under the conditions noted above and upon further fitting of the gasket material no squeal could be obtained.

EXAMPLE 2

The conventional brake pads used for the initial test in example 1 were removed from the vehicle and part annular slots 0.5 mms deep were machined into the backing plates of the pads in such positions that on each backing plate two adjacent 160° sectors of the piston annular end faces did not contact the respective backing plates (similarly to the arrangement shown in Figure 4). On testing the vehicle over the same route as that referred to in example 1 no squeal could be obtained.

If required, the layers or shims or members of metallic material incorporated in the assembly of the present invention can be provided with a sound damping coating.

CLAIMS

1. A disc brake assembly comprising a rotatable disc to be braked; two fluid operated pistons, and a brake pad having a backing plate carrying a friction slab with leading and trailing edges with respect to the direction of rotation of the disc; said pad being interposed between the disc and the pistons so that faces of the two pistons overlie the backing plate one at or towards each of the leading and trailing edges and a working surface of the slab engages the disc when pressure is applied on the pad by the pistons, and wherein pressure from the pistons is applied to the slab through the pressure regions having centres of pressure which are displaced from the geometrical centres of the respective pistons to be nearer to the respective leading and trailing edges than are the geometrical centres of the respective pistons which are at or towards the said edges.

2. An assembly as claimed in claim 1 in which the two pistons have their geometrical centres at equal radii from the axis of rotation of the disc and wherein the centres of pressure are located on a notional line parallel to a line interconnecting the geometrical centres and are further apart than said geometrical centres.

3. An assembly as claimed in claim 2 in which said notional line and the interconnecting line coincide.

4. An assembly as claimed in any one of the preceding claims in which at least one of the pressure regions is formed by a region of predetermined profile on the backing plate against which region an end face of a piston applies pressure so that said pressure is not applied through the whole end face of the piston due to a clearance provided between part of that end face and an area adjacent to said profiled region.

5. An assembly as claimed in claim 4 in which said predetermined profile region is defined by a projection, or rebate on the side of the brake pad remote from the slab.

6. An assembly as claimed in claim 5 in which said rebate is formed by a cut-away part in the thickness of the material of the backing plate.

7. An assembly as claimed in claim 5 in which said rebate is formed by an aperture or slot in the backing plate.

8. An assembly as claimed in claim 4 in which said region of predetermined profile is provided by a surface which is concave relative to the piston and against which a substantially flat end face of the piston applies pressure.

9. An assembly as claimed in claim 8 in which said concave surface is provided by curvature in the backing plate.

10. An assembly as claimed in claim 4 or claim 5 in which the region of predetermined profile is formed by extension of the friction slab material through an aperture or slot in the backing plate.

11. An assembly as claimed in claim 4 or claim 5 in which the region of predetermined profile is formed by a layer of material in the brake pad and which is carried at the side of that pad remote from the slab.

12. An assembly as claimed in claim 11 in which said layer of material is metallic.

13. An assembly as claimed in claim 11 in which said layer of material is a non-metallic gasket compound or a solid polymer.

14. An assembly as claimed in any one of claims 11 to 13 in which said layer of material is adhesively secured or rivetted as part of the brake pad.

15. An assembly as claimed in any one of claims 4 to 7 and 10 to 14 in which said predetermined profiled region is formed by an array of stud or boss-like projections on the side of the brake pad remote from the slab.

16. An assembly as claimed in any one of the preceding claims in which at least one of the pressure regions is formed by an intermediate member interposed between the brake pad and the piston or pistons respectively associated with said pressure regions, and wherein pressure from an end face of a piston is applied to the brake pad through the intermediate member, which member is profiled so that said pressure is not applied through the whole end face of the piston.

17. An assembly as claimed in claim 16 in which the intermediate member is a plate having at least one cut-away part, rebate or recess which determines the part of the piston end face through which pressure is not applied.

18. An assembly as claimed in either claim 16 or claim 17 in which the intermediate member is the or a plate, said plate being metallic and having a sound damping coating.

19. An assembly as claimed in any one of claims 16 to 18 in which the intermediate member is mounted in the assembly by means by which the brake pad is mounted in the assembly.

20. An assembly as claimed in any one of claims 16 to 19 in which the intermediate member is mounted in the assembly by its attachment to the brake pad.

21. An assembly as claimed in any one of the preceding claims in which at least one of the pressure regions is determined by a predetermined profiled end face of the piston associated with that region and through which end face pressure is to be applied to the brake

pad.

22. An assembly as claimed in claim 21 in which said predetermined profiled end face is formed by a rebate or step in the piston.

23. An assembly as claimed in claim 21 in which said predetermined profiled end face is formed by a chamfer on the piston.

24. An assembly as claimed in any one of claims 21 to 23 in which the piston has a generally cylindrical profile and means is provided to restrain the piston from rotation in its cylinder.

25. A disc brake assembly substantially as herein described with reference to the accompanying illustrative drawings.

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