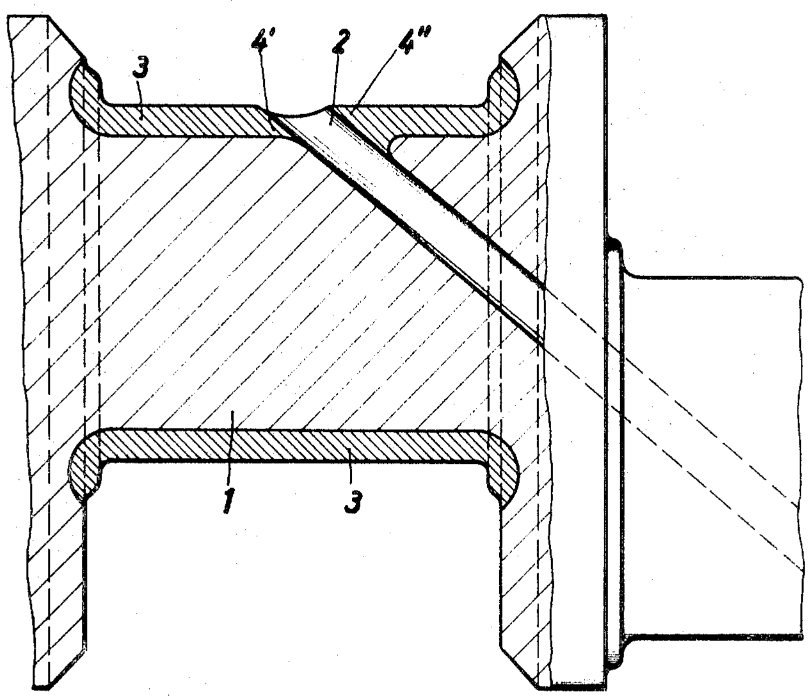
Fig.1



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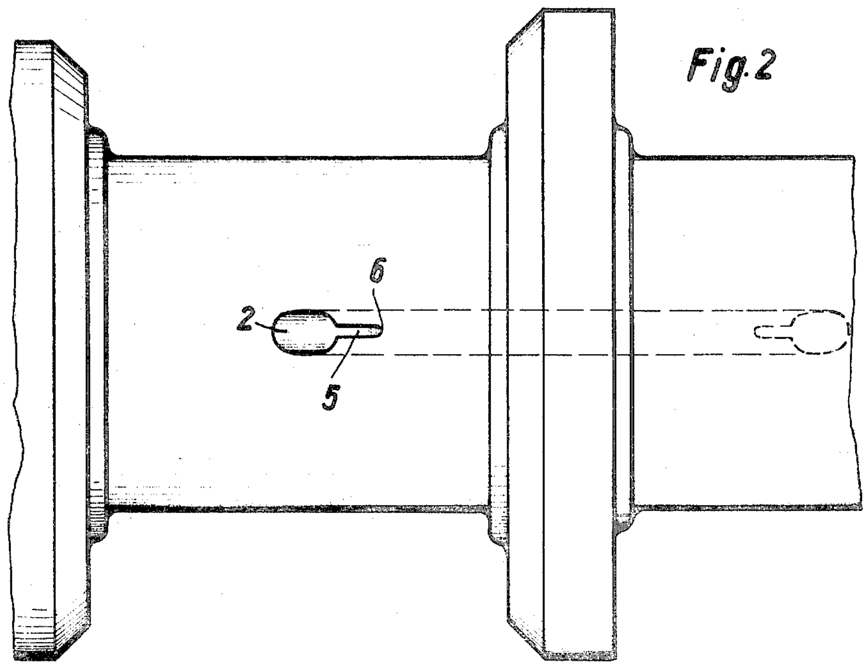

Fig.2

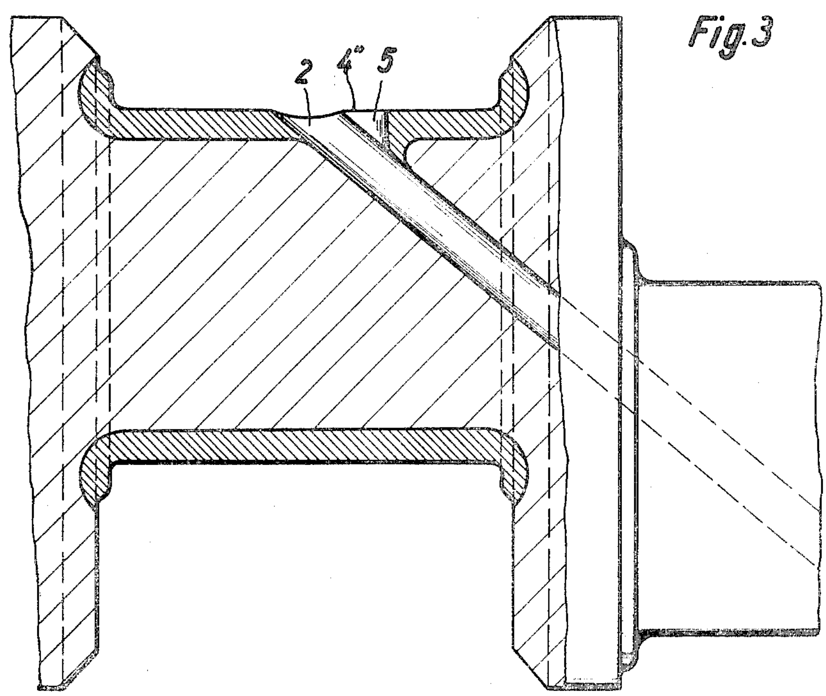

Fig.3

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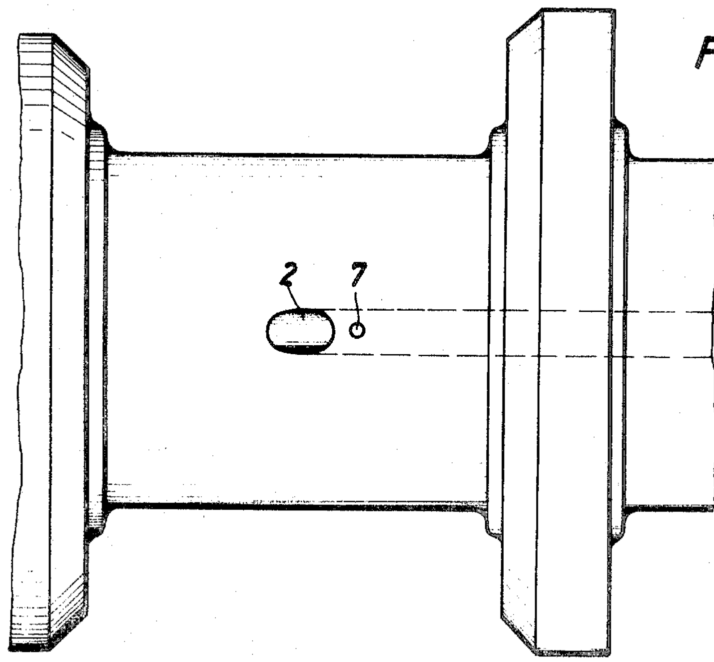

Fig. 4

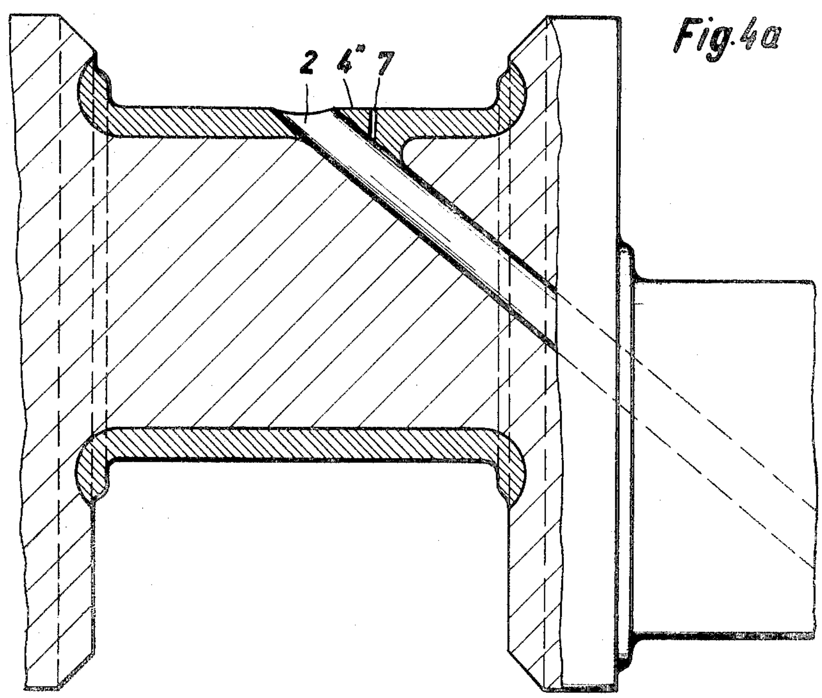

Fig. 4a

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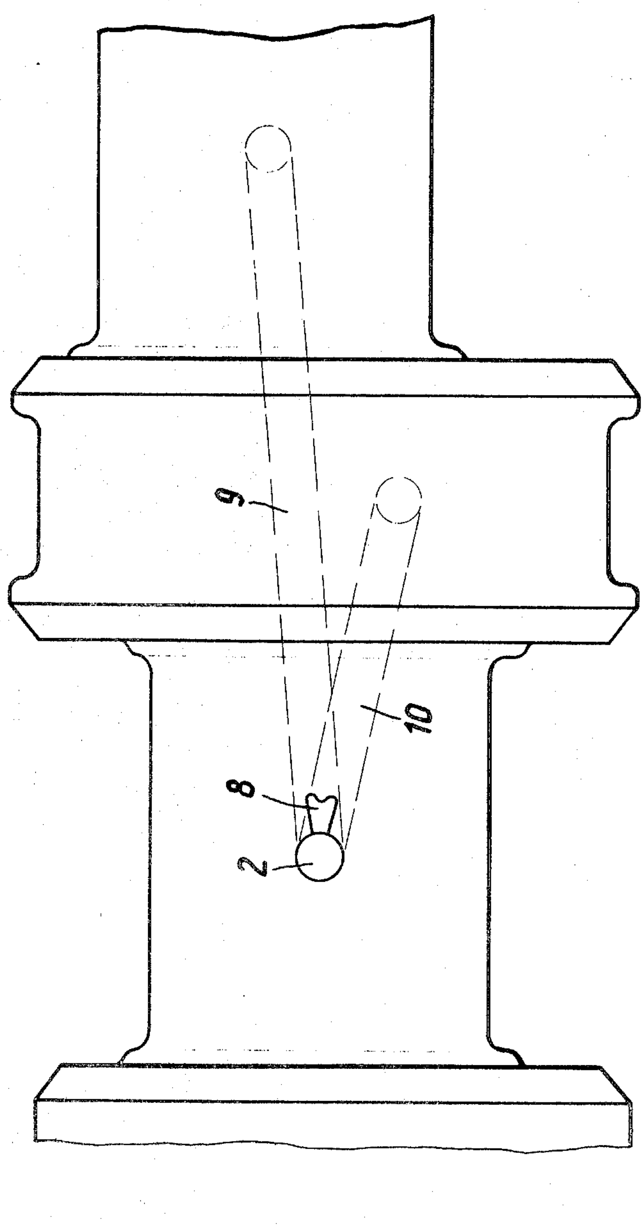

Fig. 5

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INDUCTIVELY-HARDENED STEEL COMPONENTS CONTAINING AN OIL DUCT

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Int. Cl. F16c *3/14*
U.S. Cl. 74—605 6 Claims

ABSTRACT OF THE DISCLOSURE

Inductively-hardened steel components containing an oil duct extending obliquely from a hardened surface thereof, e.g., crankshafts, tend to wear at the point where the oil duct meets the said hardened surface. The invention provides means whereby the wear is reduced, comprising a supplementary opening extending from the hardened surface to the oil duct on the side of the oil duct which makes an oblique angle with the hardened surface. In one embodiment of the invention the supplementary opening consists of a slot extending from the oil duct, and in another embodiment the supplementary opening consists of a bore extending to the said oil duct. Where two or more oil ducts extend from a common point on the hardened surface of the steel component the supplementary opening may be a complex slot having portions extending in the general direction of the said oil duct branches.

This invention relates to the improvement of the torsional and bending strengths of mechanical components, such as for example shafts, particularly crankshafts for spark-ignition and compression-ignition internal combustion engines, and compressors, pumps and the like.

For reasons of cost such components are usually made from unalloyed or low alloy structural steels. For improving their wear resistance as well as their torsional and bending strengths, it is known and is general practice inductively to harden the bearing surfaces and possibly the fillets at the ends of these surfaces of crankshafts and like components. This treatment improves the reverse bending and torsional strength of the shaft to such an extent that it is capable of transmitting 80 to 100% more power without risk of fatigue fracture.

However, the areas in such hardened components surrounding the openings of oil ducts are critical, because in these zones, particularly at the edges of the openings, the penetration of inductive hardening is greater than elsewhere. This increase in the depth of the hardened zone is due to the fact that the oil ducts impede the free flow of heat during hardening. Moreover, in inductive hardening the current filaments are more densely spaced around the edges of the oil ducts and thus generate a particularly large amount of heat in this region. When such components are inductively hardened it is therefore practically impossible to avoid the consequence that not only the depth of the hardened zone will be greater around the oil ducts but that the oil duct edges will also be undesirably overheated, causing the hardened structure to coarsen and become embrittled.

When the oil ducts are straight, i.e., when the oil ducts are perpendicular to the longitudinal axis of the workpiece, there is no significant impairment of the inductively hardened workpiece. However if the oil ducts are at an acute angle to the longitudinal axis of the workpiece the deterioration is greater as illustrated in FIG. 1 of the accompanying drawings, which is a longitudinal section of a crankpin containing an oil-hole. The crankpin 1 is traversed by an oil duct 2 which extends directly from the pin through the web to the surface of an adjoining crankpin. The hardened zone 3 in those parts of the surface that contain no oil-hole is parallel to the surface. There is also no increase in the depth of penetration in those regions of the side of the oil duct which make a right angle or as at 4′, an obtuse angle with the longitudinal workpiece axis. However where the wall of the oil duct makes an acute angle with the longitudinal workpiece axis, as at 4″, the increase in the depth of penetration in this zone where there is a minimum accumulation of material may assume dangerous proportions, i.e., the material may be sufficiently overheated for hardening cracks to appear when the workpiece is quenched.

After being in use for some length of time, portions of material around the lip of the oil hole tend to break away. Moreover after prolonged use hair cracks appear concentrated in the region of the acute angle at 4″ and these likewise cause surface portions or parts of the acute-angled edge to break off. There is a considerable danger that such a break-away of material may cause the bearings to seize by running hot and of the shaft eventually being completely destroyed. Moreover the cracks may be the starting points of fatigue fractures.

In order to avoid the deterioration arising from the presence of the oil ducts it has previously been proposed to insert metal plugs into the holes and thereby to eliminate the causes of overheating. However this method has not been much used because of the additional expense it involves.

According to another proposal the oil ducts are filled with substances that at a given temperature release water of crystallisation. Although this also leads to a reduction of excessive temperatures the effect thereby obtained is not sufficient.

It is an object of the present invention to provide a solution to the above-described problem with hardened mechanical parts made of steel, such as for example crankshafts, axle shafts or the like, which parts for the purpose of lubrication during service are provided with oil ducts, particularly oil ducts set at an angle, and has for its object to improve the wear resistance, as well as the torsional and flexural strength of such a part.

This improvement in resistance and strength is achieved according to the invention by providing in the region where the accumulation of material at the lip of the oil hole is a minimum, i.e., where the wall of the oil duct makes an acute angle with the adjoining workpiece surface, a supplementary opening between the hardened surface and the oil duct the cross-section of which is rounded at least on the side remote from the said oil duct. In one embodiment of the invention the said supplementary opening has the form of a slot extending from the wall of the oil hole and which is provided with fillets at the transistions between the base and the sides of the slot.

In another embodiment of the invention the said supplementary opening is a bore which extends from the hardened surface into the oil hole.

The width of the slot or the diameter of the bore constituting the supplementary opening of the invention will depend upon the size of the workpiece itself. For a conventional crankshaft of the type used in a motor vehicle, the width may for example be between 0.5 and 1.5 mm. It does not matter whether this supplementary opening is provided before or after inductive heating, as steel parts that have already been hardened can readily be machined by spark erosion or electrolytic techniques.

Embodiments of the invention are hereinafter described and illustrated in FIGS. 2 to 5 of the accompanying drawings, in which:

FIG. 2 and FIG. 3 are a plan view and longitudinal section respectively showing features of the invention;

FIG. 4 and FIG. 4*a* are a plan view and a longitudinal section respectively of a further embodiment of the invention, and

FIG. 5 shows a configuration of the slot according to the invention when several oil duct branches share a common entry hole in a crankshaft.

Referring to FIGS. 2 to 5 of the drawings, the plan view of the crankshaft of FIG. 2 has an oil duct **2** which extends in the direction of the workpiece axis from the surface of the left-hand bearing, traverses the web of the crank and ends in the surface of the underside of the right hand bearing. The course taken by this oil duct through the shaft is more clearly shown in FIG. 3. In the region of the acute angle **4**″ the oil ducts are provided with a slot **5** which has fillets **6** at its base.

A similar improvement of the properties of the crankshaft may be achieved if the slot is simply replaced by a bore **7** as in FIG. 4 and FIG. 4*a*. In this embodiment the occurrence of hardening cracks may not be avoided but it has been found from experience that all these cracks extend into the bore **7** and that they do not continue beyond the bore.

The invention may also be applied when the courses taken by the oil ducts are more complex, as indicated in FIG. 5 where two oil ducts **9** and **10** extending at different angles share a common entry hole **2**. Consequently in FIG. 5 two slots extending in the directions of the different oil ducts are provided instead of only one and the two ducts combine to form a slot **8**.

What is claimed is:

1. An inductively-hardened steel component containing an oil duct extending obliquely from a hardened surface thereof, in which a supplementary opening is provided in the region of the said oil duct where the wall of the said oil duct makes an acute angle with the said hardened surface and where the minimum material is between said oil duct and said surface, the said supplementary opening extending from the said hardened surface to the said oil duct.

2. An inductively-hardened steel component according to claim **1**, wherein the said supplementary opening is a slot extending from the wall of the said oil duct and

having a rounded surface at least on the side remote from the said oil duct.

3. An inductively-hardened steel component according to claim **1**, wherein the said supplementary opening is a bore extending from the said hardened surface to the said oil duct.

4. An inductively-hardened steel component containing a plurality of oil duct branches extending at an angle one to the other from a common point on the hardened surface thereof, in which a complex slot is provided in the region of the said oil ducts where the wall of the said oil ducts make an acute angle with the said hardened surface, the said slot extending from the said common point having slot portions extending in the direction of the said oil duct branches, and having rounded surfaces at least on the sides remote from the said common part.

5. An inductively-hardened steel crankshaft comprising at least one oil duct extending obliquely from a hardened surface thereof, and a supplementary opening extending from the said hardened surface to the said oil duct at a point where the said oil duct makes an acute angle with the said hardened surface, the cross-section of the said supplementary opening being rounded at least at a position remote from the said oil duct.

6. A component as in claim **1** wherein the width of said supplementary opening is smaller than the diameter of said duct.

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