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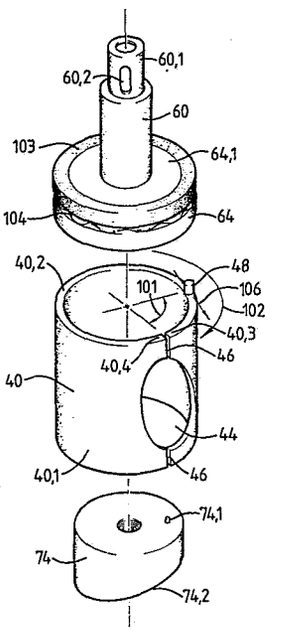
(71) Applicant: **Kriek, Gerhardus Cornelius, 8 Dromdaris Lane, Stellenbosch Cape Province (ZA)**

(72) Inventor: **Kriek, Gerhardus Cornelius, 8 Dromdaris Lane, Stellenbosch Cape Province (ZA)**

(74) Representative: **Burke, Steven David et al, R.G.C. Jenkins & Co. 12-15, Fetter Lane, London EC4A 1PL (GB)**

(54) Rotary valve assembly for an internal-combustion engine.

(57) A rotary valve assembly for an internal combustion engine which comprises a metallic or ceramic sealing sleeve (40) rotatably mounted inside a bore of an engine head which houses the valve assembly. The sleeve has a port (44) for periodic communication during rotation of the sleeve with inlet and outlet passages disposed in the engine head, a lower end of the sleeve being open and communicating with an engine cylinder in which a piston reciprocates and an upper end of the sleeve being sealingly closed. The sleeve is split longitudinally over its entire length by a slit (46) which is aligned with the port and a valve mechanism is disposed in the head above the upper end of the sleeve and is adapted by suitable drive trains to rotatively drive the sleeve by engaging a driving formation (48) located at the upper end of the sleeve. An exchangeable compression element (74) can be attached inside the upper end of the sleeve to a valve mechanism to set the required compression ratio of the engine. Without removing the head the sleeve can be exchanged or adjusted to vary valve timing and the element can be exchanged to vary compression ratio.



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TITLE MODIFIED
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COMBUSTION CHAMBER VALVES

FIELD OF THE INVENTION

This invention relates to combustion chamber valves, more particularly to combustion chamber assemblies including a rotary valve for use with an internal combustion engine (also mechanically applicable to air motors and compressors).

BACKGROUND OF THE INVENTION

Rotary valve assemblies for the control of inlet and exhaust gases to and from the combustion chamber of an internal combustion engine have been described comprising a rotary valve body containing a passage which communicates between the combustion chamber and periodically the inlet and exhaust passages, the body surrounded by a sealing sleeve which provides a gas seal during operation of the engine.

U.S. patent 3 130 953 by Carpenter describes a tensioned split sleeve which relies on the particular relative locations of an inwardly directed longitudinal key on one edge of the split (which key engages with a groove in the rotary valve body for pulling the sleeve around with the valve body during rotation) and a port in the sleeve. The edge of the sleeve which carries the key adjacent the split is thus described as the leading edge and the opposite edge of the sleeve adjacent the split as the trailing edge and the port is located close to the trailing edge and remote

from the leading edge so as to reduce any adverse effect on the sealing action attributed to the pulling action on the key. The key is inclined slightly relative to the radial direction so as to unlock the leading edge of the sleeve from binding contact with a bore in which the sleeve rotates while the port located near the trailing edge must nevertheless maintain sealing pressure.

U.S. patent 4 494 500 by Hansen describes a rotary valve assembly for an internal combustion engine which has a rotary valve body surrounded by a cylindrical member which is preferably of ceramic material. The member is relatively thick and rigid and is not split over its full longitudinal length but has limited lateral movement so that gas pressure in the combustion chamber operates to laterally move the cylinder to bring a surface which is close to the port into sealing relationship with a bore within which the member is rotated. A universal coupling permits an eccentric drive of the rotary valve assembly. Rotational drive is transmitted from the rotary valve body to the cylindrical sealing sleeve by means of a longitudinally oriented key running along the length of the body which is located diametrically opposite the port which periodically communicates with the inlet and outlet passages of the engine.

The rotary valve body which is surrounded by the split

sleeve or the cylindrical member in both the cases of Carpenter and of Hansen shields the full longitudinal length of the inner walls of the sleeve or cylindrical member from direct exposure to the combustion chamber.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a rotary valve assembly which allows direct exposure of the sealing sleeve to the combustion chamber and thus the heat and pressure which arises during operation of the engine. A metallic sleeve in this arrangement can give highly effective cooling to permit both a high compression ratio which gives thermal efficiency and turbo charging or super charging in a spark ignited engine without the problem of pre-ignition arising.

A further object in the provision of such low temperatures is to reduce undesirable exhaust emissions including nitrus oxide compound and lead compounds.

A further object of the invention is to provide such a sealing sleeve which may alternatively be made of a ceramic material for very high temperature combustion in a diesel cycle.

It is a further object of the invention to provide such a rotary valve assembly which can accept an exchangeable compression element within the bore of the rotary sealing

sleeve by which the compression ratio of an individual engine can be adjusted.

It is a further object of the invention to provide a rotary sealing sleeve of this kind in which the split of the sleeve extends over the full longitudinal length and is located directly on the port provided in the sleeve.

A final object of the invention is to provide a mechanism for rotatively driving such a sleeve from an upper end of the sleeve which preserves the sealing action of the sleeve.

A rotary valve assembly for an internal combustion engine in accordance with this invention comprises a sealing sleeve rotatively mounted inside a bore of an engine head which houses the valve assembly, the sleeve having a port for periodic communication during rotation of the sleeve with inlet and outlet passages disposed in the engine head, a lower end of the sleeve communicating with an engine cylinder in which a piston reciprocates and an upper end of the sleeve being sealingly closed, the sleeve directly exposed to a combustion chamber which is thus formed within the sleeve, the sleeve split longitudinally over its entire length by a slit aligned with the port and a valve mechanism disposed in the head above the upper end of the sleeve adapted to rotatively drive the sleeve by engaging a driving formation located at the upper end of the sleeve.

The rotary valve assembly preferably additionally comprises an exchangeable compression element adapted to be removably attached within the upper end of the bore of the sleeve to the valve mechanism. By exchanging one compression element for another the engine compression ratio can be varied.

The sealing sleeve may be of plain cylindrical form or it may have an inwardly directed integral flange at its upper end and may be made either of metal or of ceramic. The driving formation at the upper end of the sleeve may comprise a notch or a peg which engages with the corresponding formation on the valve mechanism. The driving formation at the upper end of the sleeve has an angular disposition with respect to the slit in which the angle between the driving formation and the leading edge of the sleeve adjacent the slit is less than the angle between the driving formation and the trailing edge of the sleeve adjacent the slit, more particularly the former angle is less than half the latter angle, preferably about one third the latter angle.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an exploded isometric view of a rotary valve assembly in accordance with the preferred embodiment of the invention,

Figure 2 is a partially cross section side elevation showing the rotary valve assembly assembled in an engine head,

Figure 3 is a partly cross section side elevation showing a rotary valve in assembly in accordance with another embodiment of the invention assembled in an engine head,

Figures 4a and 4b are a side elevation and plan view respectively of a sealing sleeve used in the embodiment shown in figure 3, and

Figure 5 is a cross sectional side elevation of a rotary valve assembly shown in part assembled in an engine head in accordance with another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to figures 1 and 2 the rotary valve assembly for an internal combustion engine comprises a sealing sleeve 40 which is rotatively mounted inside a bore 18 of the engine head 12 which in this case is provided with a bearing shell 20 of phosphor bronze. The engine head 12 houses the valve assembly and the sleeve 40 has a port 44 which periodically communicates during rotation of the sleeve with the inlet passage 30 and the exhaust passage 32 disposed in the head 12. A lower end 40,1 of the sleeve 40 is open and communicates with an engine cylinder 16 in which a

piston 16,1 reciprocates while an upper end 40,2 of the sleeve 40 is sealingly closed. The inner walls 40,3 of the sleeve 40 are directly exposed to a combustion chamber 100 which is thus formed within the sleeve and above the crown of the piston 16,1. The sleeve 40 is split longitudinally over its entire length by a slit 46 which is aligned with the port 44. A valve mechanism 50 is disposed in the head 12 above the upper end 40,2 of the sleeve 40 and is adapted to rotatively drive the sleeve 40 by engaging a driving formation 48 located at the upper end 40,2 of the sleeve 40.

An exchangeable compression or element 74 is removably attached within the upper end of the bore of the sleeve 40 to the valve mechanism. By replacing the element 74 the compression ratio of the engine can be adjusted.

The driving formation 48 (in this case depicted as a peg but which could alternatively be a slot engaged by a tooth depending from the valve mechanism) is disposed at the upper end 40,2 of the sleeve 40 at an angle 101 from the angular position of the slit 46. The direction of rotation 102 of the sleeve during operation gives rise to the definition of a leading edge 40,3 of the sleeve 40 adjacent the slit 46 and a trailing edge 40,4 of the sleeve 40 adjacent the slit 46. The peg 48 is angularly closer to the leading edge 40,3 than to the trailing edge 40,4, in fact the angle 101 is about 80^{o} in this example.

Referring to the construction arrangement generally the bearing shell 20 seats on the shoulder 22 at the lower end of the bore 18. The bearing shell has two ports 24 and 26 which are aligned with the inlet 30 and exhaust 32 ports respectively. The bearing shell 20 has a further opening 34 which exposes a spark plug 36 of the surface discharge type. The bearing shell 20 has an outwardly directed peripheral flange 38 at its upper end which seats in the cylinder head 12 around a groove at the top of the mouth of the bore 18.

The valve sleeve 40 is of plain hollow cylindrical form having the port 44 in it and the longitudinally arranged slit 46 aligned with the port and extending over the whole length of the sleeves, a drive peg 48 being located at the upper end 40,2.

The valve mechanism 50 drives the sleeve 40 rotatably at half engine speed in the direction indicated by arrow 102. The mechanism comprises a shaft 52 which carries a helix cut gear 52,1 which meshes with helical cut gear teeth 54 of a gear 56. The gear 56 is mounted on a stub shaft 60,1 with a suitable key 60,2 at the upper end of a shaft 60. The lower end of the shaft 60 carries a disc-like portion 64 against the lower surface of which the upper end 40,2 of the sleeve 40 bears. The disc 64 carries a graphite or ceramic ring seal 103 spring loaded by a spring washer 104, a polymeric ring, for example P.T.F.E. A neoprene ring

103,1 seats in a groove 103,2 in the disc 64 and seals against the ring 103. A journal 68 is bolted to the head 12 and journals the shaft 60 as well as providing a thrust bearing surface 70 against which the upper part 64,1 of the disk like portion 64 can bear when subjected to combustion chamber pressure. An oil passage 68,1 in the journal 68 leads excess oil away from the thrust surfaces via a channel 68,2 to the oil bath 108. The underneath of the disc-like portion 64 has a hole to receive the drive peg 48 of the sleeve 40. A bolt 58 extends, in the assembled condition, through a washer 58,1 and the entire shaft 60 and is screwed into the element 74, holding the assembled parts together. The small locating pin 74,1 ensures the correct alignment of the element 74. The element 74 has an oblique lower surface 74,2 and leaves a substantial gap 105 between the element 74 and the sleeve 40.

When the engine is running the driving force on the sleeve 40 is roughly tangential at the position of the driving peg 48. (This direction 106 can be seen also, for example, in the view of figure 4b). However, the tangential direction 106 can be modified inwardly or outwardly by giving the peg (or a slot) bearing surface an inclination as shown by broken lines 110. The frictional force acting on the outer surface of the sleeve 40 therefore tends to bring the areas near the leading edge 40,3 into firm sealing contact with the bore of the bearing shell 20. A peg and/or notch may,

however, be provided which presents an inclined flat surface which tends either to enhance the outward sealing pressure of the leading edge 40,3, or to reduce that sealing pressure. The sleeve 40 is assembled with a light spring tension acting to keep it engaged with the bearing shell 20 and positive pressure inside the combustion chamber enhances that sealing pressure. At the upper end 40,2 of the sleeve 40 gas leakage which may occur beyond the disk 64 is sealed at the bearing surface 70 by the sealing ring 103.

The walls of the sleeve 40 are thus substantially completely exposed to the combustion chamber and thus the heat and pressure of the combustion chamber. This assures a good seal by the sleeve and allows the selection of a metallic material for the sleeve for extremely good conduction of heat from the sleeve walls to the cooling passages 107 of the head 12. In tests over a six hundred hour run at full power the temperature of the wall of the sleeve was found to be in the vicinity of 230°C at 3500 r.p.m. engine speed. In this test a phosphor bronze bearing shell 20 was used and a 316 stainless steel sealing sleeve 40. The element was made of brass which also provided swift conduction of heat and a low surface temperature of the element. Due to these low temperatures of the walls of the combustion chamber formed in this way detonation was completely absent even with the use of a low octane fuel at high compression ratios (87 octane fuel with 14:1 compression ratio at sea level). This is of particular

importance considering the movement towards unleaded fuel for achieving improved exhaust emissions. Cooling is further provided by the oil bath 108 in the head 12 which is used to lubricate the drive train. The low temperatures are also responsible for minimal formation of nitrous oxide compounds which further improve the exhaust emission.

The valve assembly is so arranged that the sealing sleeve 40 and/or the element 74 can be exchanged without removing the head 12 from the engine. In this way the valve timing can be altered easily by exchanging the sleeve 40 for another which provides differing valve timing and the compression ratio of the engine can be changed easily by exchanging the element 74 for another.

Lubrication was provided by adding minute quantities of colloidal graphite to the petrol. It is also possible to use oil as a lubricant and this is preferably done by injection from the head at a position downstream of the inlet port every 40 or 50 strokes of the piston. The low temperatures contribute to preservation of the boundary layer and hence of the lubricating material, be it oil or graphite, in the bore of the bearing shell 20 despite the fact that the port 44 of the sealing sleeve 40 forms a window which sweeps over the lubricating material during operation. The quantity of lubricant can also be controlled according to load.

The shape of the port 44 in the sleeve 40 shown in figure 2 can be described as "rectangular" to be used within inlet and exhaust passages 24, 30 and ports 32, 44 in the bearing shell 20 which are of similar shape. However, for enhanced slow speed operation in particular, and for a simplified head construction using circular inlet and exhaust passages, a port shape can be used which is shown by the broken lines 109 in figure 4a. This provides that the port in the sleeve 40 is effectively relatively narrow while preserving a sufficient area for adequate gas flow and therefore enables a valve timing to be achieved which is favourable especially for low speed operation. The inwardly indented convex arcuate side edges of the port provide that opening and closing respectively are far less gradual than if, for example, the inlet and exhaust passages were circular and the port 44 was circular.

If the engine is designed to operate on a diesel cycle the sleeve 40 can be made of ceramic, thus having a low heat conductivity and allowing high thermal efficiency. A V-shaped lubrication groove is engraved on the outer surface of the sleeve 40 just "downstream" from the port 44 to enhance distribution of the lubricating material during operation.

In figures 3, 4a and 4b the valve mechanism illustrated is generally designated 10 and is carried by the cylinder head

12 of an internal combustion engine. Part of the block of the engine is shown at 14 and the upper part of one of the cylinders of the engine is shown at 16.

The cylinder head 12 is formed with a vertical counterbore 18 into which a bearing shell 20 is inserted from above. The shell 20 is pushed into the counterbore 18 until it seats on the shoulder 22 at the lower end of the counterbore 18. The bearing shell 20 is formed with two ports 24 and 26, the shell 20 being pressed into the counterbore 18 so that the ports 26 and 28 are aligned with the fuel inlet 30 and the burnt gases exhaust 32. The bearing shell has a further opening 34 in the wall thereof, a spark plug 36 (or a glow plug or an injector in the case of a diesel engine) being inserted through a threaded bore of the cylinder head 12 and into the opening 34.

The bearing sleeve 20 is formed, at the upper end thereof, with an outwardly directed peripheral flange 38 which seats on the cylinder head 12 around the mouth of the counterbore 18.

A valve sleeve 40 rotates within the bearing shell 20, the direction of rotation being shown by the arrow in figure 4b and the valve sleeve 40 being illustrated in detail in figures 4a and 4b.

The valve sleeve 40 is of generally cylindrical form and has

an inwardly directed flange 42 at one end thereof. A port 44 is provided in the cylindrical wall thereof, and there is also a slit 46 in the wall thereof. The slit extends upwardly and downwardly from the port 44 (see particularly figure 4a). A blind hole 48 is provided in the flange 42, this hole serving to receive a drive pin.

The valve sleeve 40 is rotated (at half engine speed) by a drive system which is generally designated 50 in figure 3. The drive system 50 comprises a shaft 52 which has a helical gear cut therein which gear meshes with helical gear teeth 54 cut in the periphery of a gear 56. The gear 56 is secured by a bolt 58 (which is co-axial with the sleeves 20 and 40) to a drive shaft generally designated 60. The shaft 60 comprises a shank 62, a disc-like portion 64, and a cylindrical extension piece 66 which enters the upper end of the bearing sleeve 20.

A bearing carrier 68 is bolted to the cylinder head, there being a thrust bearing 70 between the bearing carrier 68 and the disc-like portion 64 of the shaft 60, and a journal bearing 72 between the shank 62 and the bearing carrier 68. The bearings can be lubricated by oil under pressure which also serves to carry away excess heat.

The disc-like portion 64 carries a driving pin (not shown) which enters the blind hole 48 of the valve sleeve 40.

The bolt 58 extends beyond the extension piece 66 and into the valve sleeve 40. Within the valve sleeve 40 there is a compression element 74, the element 74 having a blind bore 76 therein into which the bolt 58 is screwed. The element 74 is of solid cylindrical form, its lower face 78 being skew to the axis of the bolt 58.

As will be seen from figure 1, the element 74 and the extension piece 66 together define a peripheral groove in which the flange 42 of the valve sleeve 40 lies. The flange is an accurate fit in the groove and this structure thus functions as a seal.

The outside diameter of the valve sleeve 40 is slightly larger than the inside diameter of the bearing sleeve 20, the slit 46 allowing the overall diameter of the sleeve 40 to be reduced sufficiently to enable it to be inserted into the bearing sleeve 20. The tendency of the sleeve 40 to open after insertion into the bearing sleeve 20 creates a sealing effect and this is enhanced when pressure is applied to the inside of the sleeve 40.

The sleeve 40 can be of steel, ceramic material, cast iron or nickel alloys.

The width of the slit 46, when the valve is at operating temperature, can be about 0,1 mm. The disc-like portion 64

has a radial clearance in the sleeve 20 of not more than 0,1 mm. Thus the actual area through which gas can escape is a square hole (measuring 0,1 mm by 0,1 mm) and having a total area of 0,01 mm^2. This small opening "sweeps" around the inner face of the sleeve 20 as the sleeve 40 rotates.

The sleeves 20 and 44 can be of any suitable material, e.g. anti-friction materials which are self-lubricating. A light oil with colloidal graphite or the like dispersed in it can be used as lubricant. Ceramics can also be considered because of their resistance to corrosion. If the temperatures are exceptionally high, low friction high temperature materials such as graphite and molybdenum disulphide compounds can be used.

It will be noted that the spark plug, injector or glow plug 36 is protected from the effects of combustion except when the opening 34 comes into register with it.

By replacing the element 74 with an element which is longer or shorter than that illustrated, the compression ratio of the engine can be altered. Additionally, it can be made of a material which has high thermal conductivity so that it assists in removing excess heat from the ignition chamber by conveying it to the shaft 60.

The valve timing can be altered by making an adjustment

between the shaft 52 and the gear 5. This advances or retards, to the same extent, opening and closing of the inlet and exhaust ports.

In figure 5, the arrangement includes a primary port 80 and, below it, a secondary port 82. The element 74 of figure 1 is replaced by a somewhat different shaped element 74.1 which extends downwardly beyond the primary port 80 so as partially to overlap the secondary port 82. The primary port is relatively small and its timing is such as to give optimum low speed efficiency. The secondary port 82 is timed for full power work at high speeds. The primary port 80 is connected to the primary barrel of a twin choke progressive carburettor. The secondary port 82 does not function at lower speeds and loads but comes into operation automatically as the speed and load demands which means that the secondary barrel of the carburettor is coming into use. A primary and secondary port can also be used on the exhaust side, the secondary port only being open (for example by a butterfly valve controlled from the engine manifold pressure or any other suitable point) upon speed and load increasing.

CLAIMS:

1. A rotary valve assembly which comprises a sealing sleeve rotatively mounted inside a bore of an engine head which houses the valve assembly, the sleeve having a port for periodic communication during rotation of the sleeve with inlet and outlet passages disposed in the engine head, a lower end of the sleeve communicating with an engine cylinder in which a piston reciprocates and an upper end of the sleeve being sealingly closed, the sleeve directly exposed to a combustion chamber which is thus formed within the sleeve, the sleeve split longitudinally over its entire length by a slit aligned with the port and a valve mechanism disposed in the nead above the upper end of the sleeve adapted to rotatively drive the sleeve by engaging a driving formation located at the upper end of the sleeve.

2. A rotary valve assembly as claimed in claim 1, which additionally comprises an exchangeable compression element adapted to be removably attached within the upper end of the bore of the sleeve to the valve mechanism.

3. A rotary valve assembly as claimed in claim 2, in which the valve element is removably attached to the valve mechanism by a coaxial bolt passing through the valve

mechanism.

4. A rotary valve assembly as claimed in claim 1, in which the driving formation at the upper end of the sleeve comprises one of a notch and a peg and the valve mechanism has a coacting formation engaging therewith.

5. A rotary valve assembly as claimed in claim 4, in which the driving formation is angularly displaced from a leading edge of tne sleeve adjacent the slit by an angle which is less than half the angular displacement from a trailing edge of the sleeve adjacent the slit.

6. A rotary valve assembly as claimed in claim 1, which comprises an additional slow running port in the sleeve located above the said port, also aligned on the slit, intermittently communicating during rotation with slow running inlet and exhaust passages provided in the engine head.

7. A rotary valve assembly as claimed in claim 1, in which the valve mechanism comprises a journalled shaft and below it an integral disc terminated above the upper end of the sleeve, the disc having an upper longitudinal thrust bearing surface, a spring loaded sealing ring assembly around the circumference of the disc, the driving formation located on the lower surface of the disc and the shaft carrying a gear

meshing with a gear on a drive shaft.

8. A rotary valve assembly as claimed in claim 1, in which the port in the sleeve has a shape bounded by straight upper and lower edges and convex circular left and right side edges indented towards each other, their curvature corresponding to a radius of curvature of inlet and outlet passages in the head.

9. In an internal combustion engine which includes a piston and cylinder and an engine head including an inlet and exhaust passage communicating with a bore in the head, a lower end of the bore communicating with the cylinder, a rotary valve assembly, which comprises a split sealing sleeve in the bore, spring loaded into sealing contact with the walls of the bore, a lower end of the sleeve open to the cylinder, a port provided in the sleeve aligned with the split, a valve mechanism located above an upper end of the sleeve and which comprises a disc which sealingly closes the upper end of the sleeve and carries an exchangeable compression element, the inwardly directed surfaces of the sleeve,disc and element enclosing a combustion chamber above the cylinder and fully exposed to the combustion chamber, the valve mechanism further comprising a journalled shaft joined to the disc upper surface and a valve drive train, the lower surface of the disc having inter-engaging drive formations for rotatively driving

the sleeve which are angularly displaced from the split.

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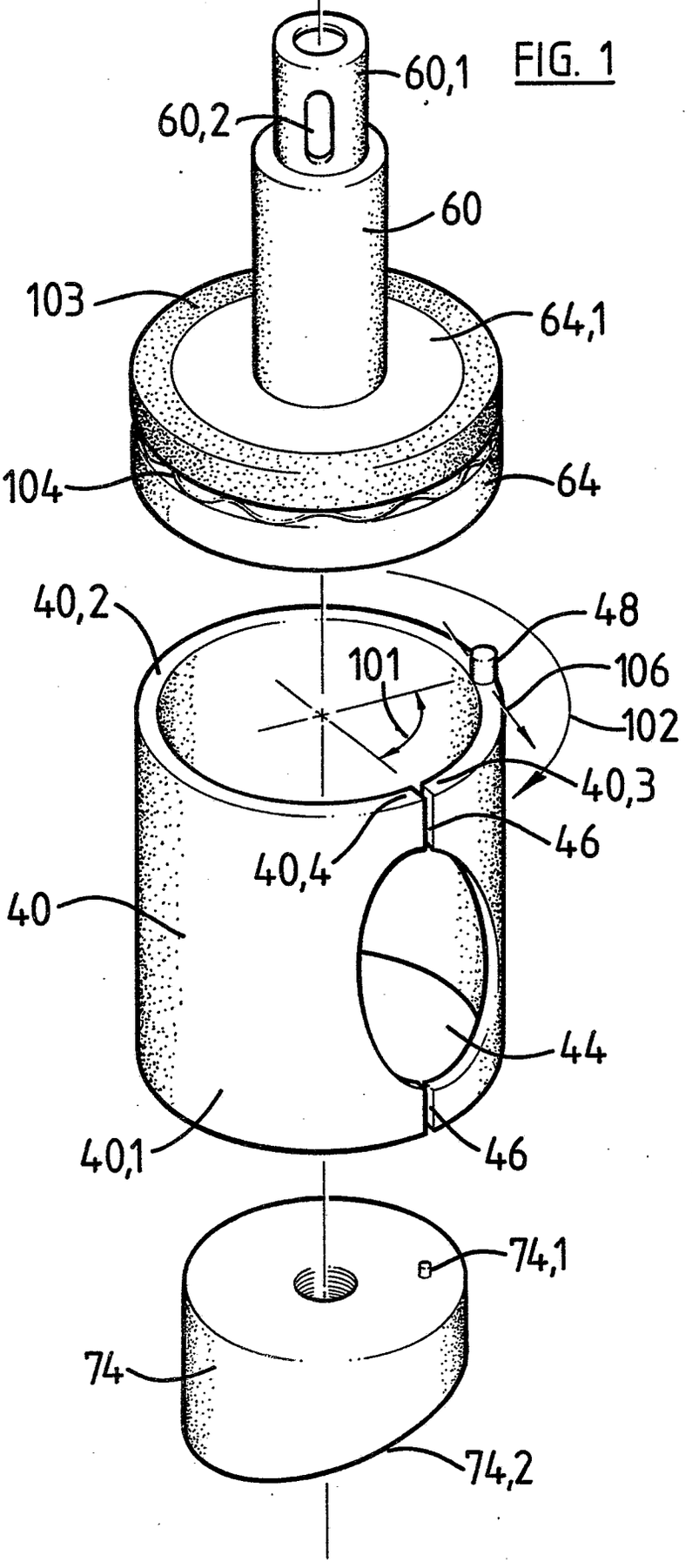


FIG. 1

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FIG.2

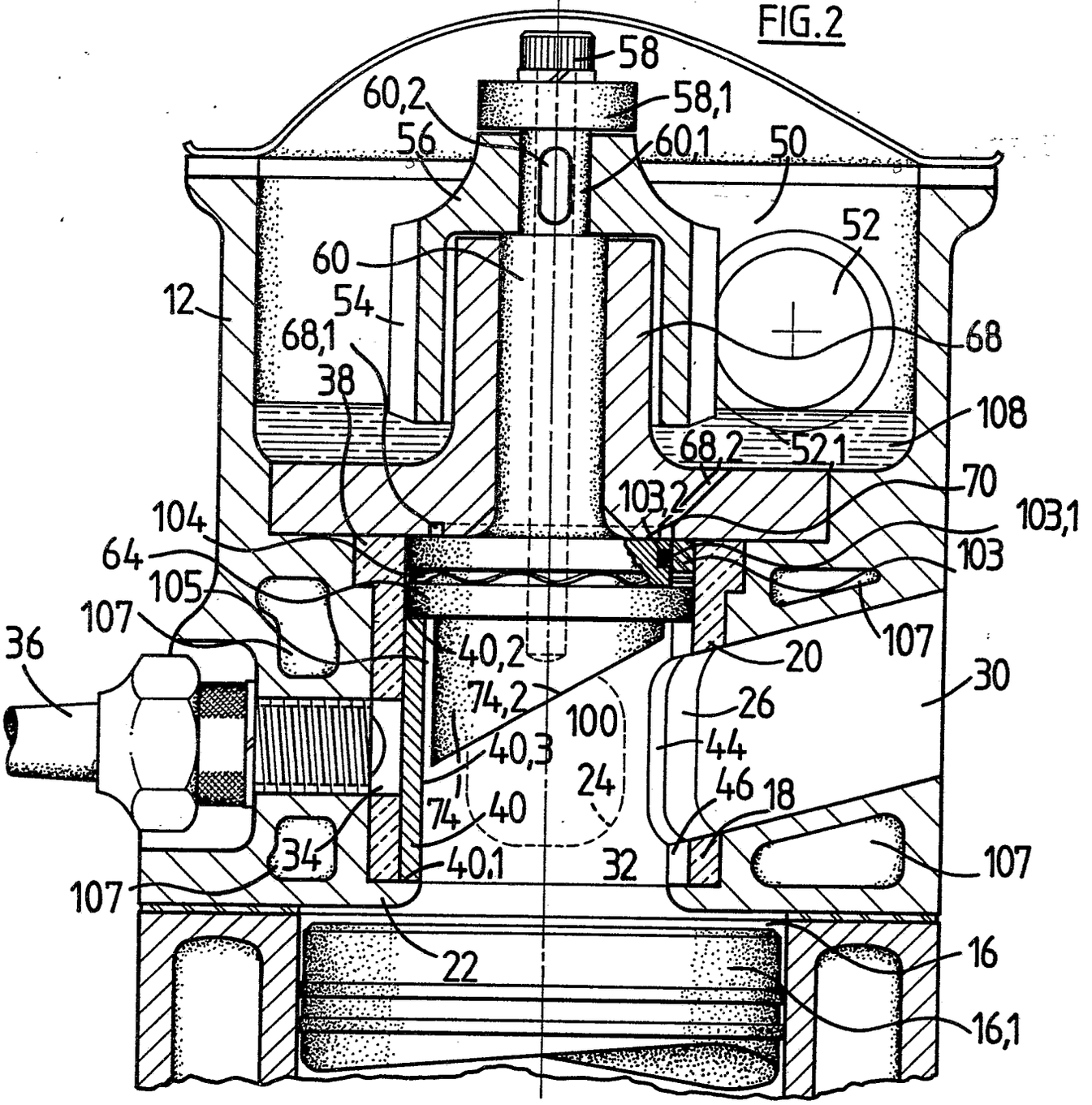


FIG.4a

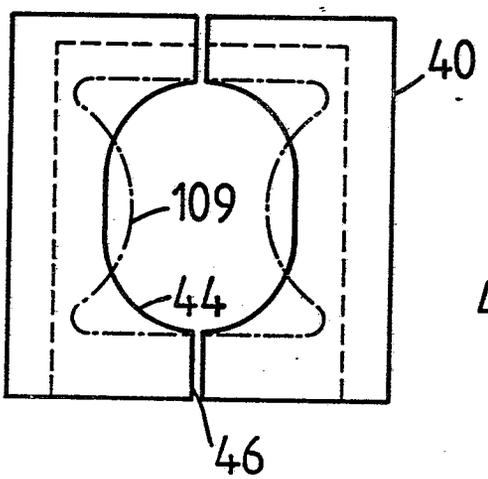
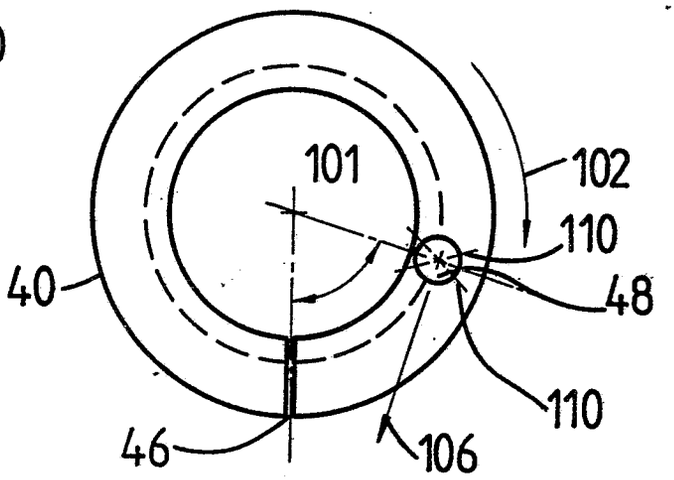
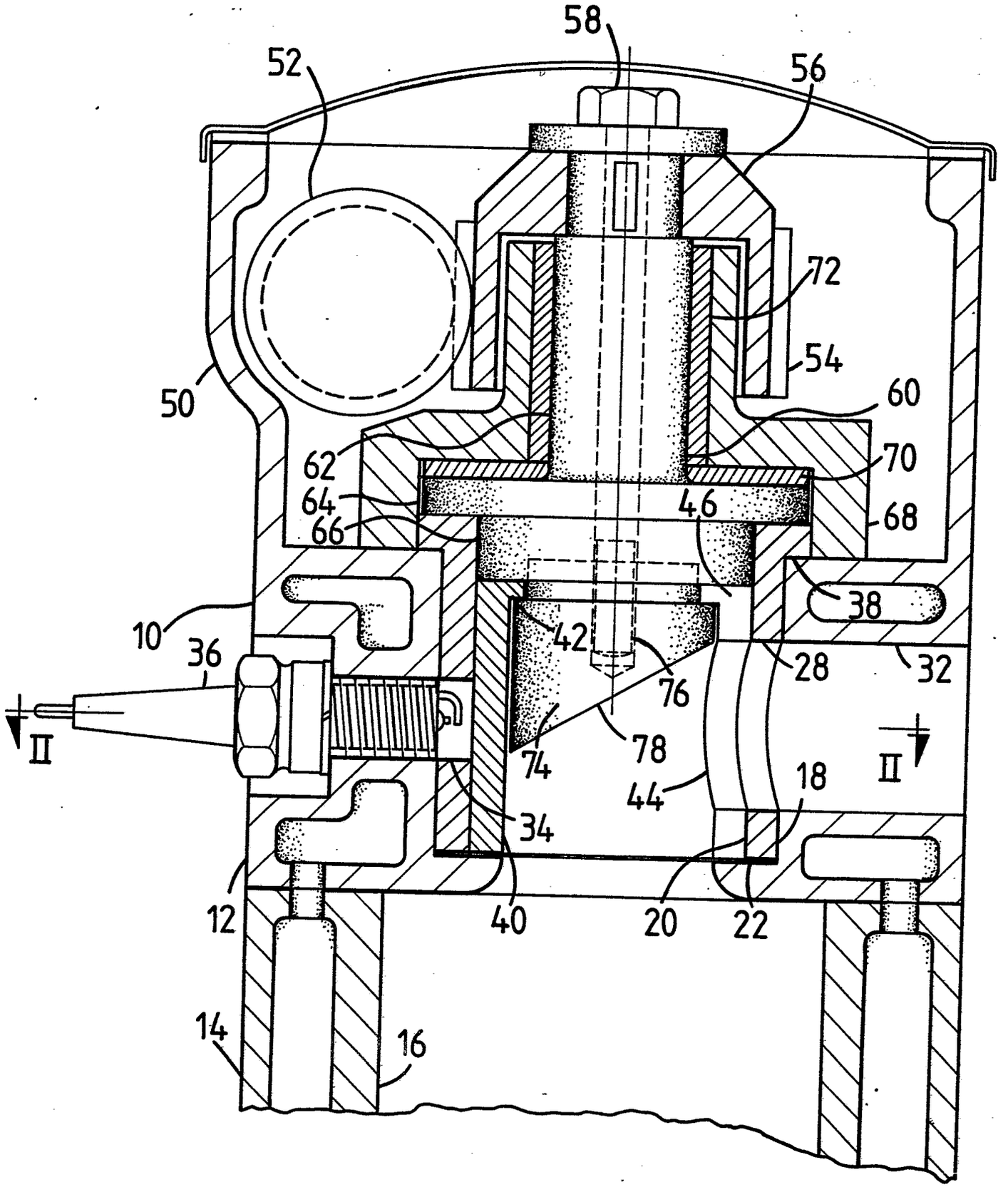


FIG.4b



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FIG.3



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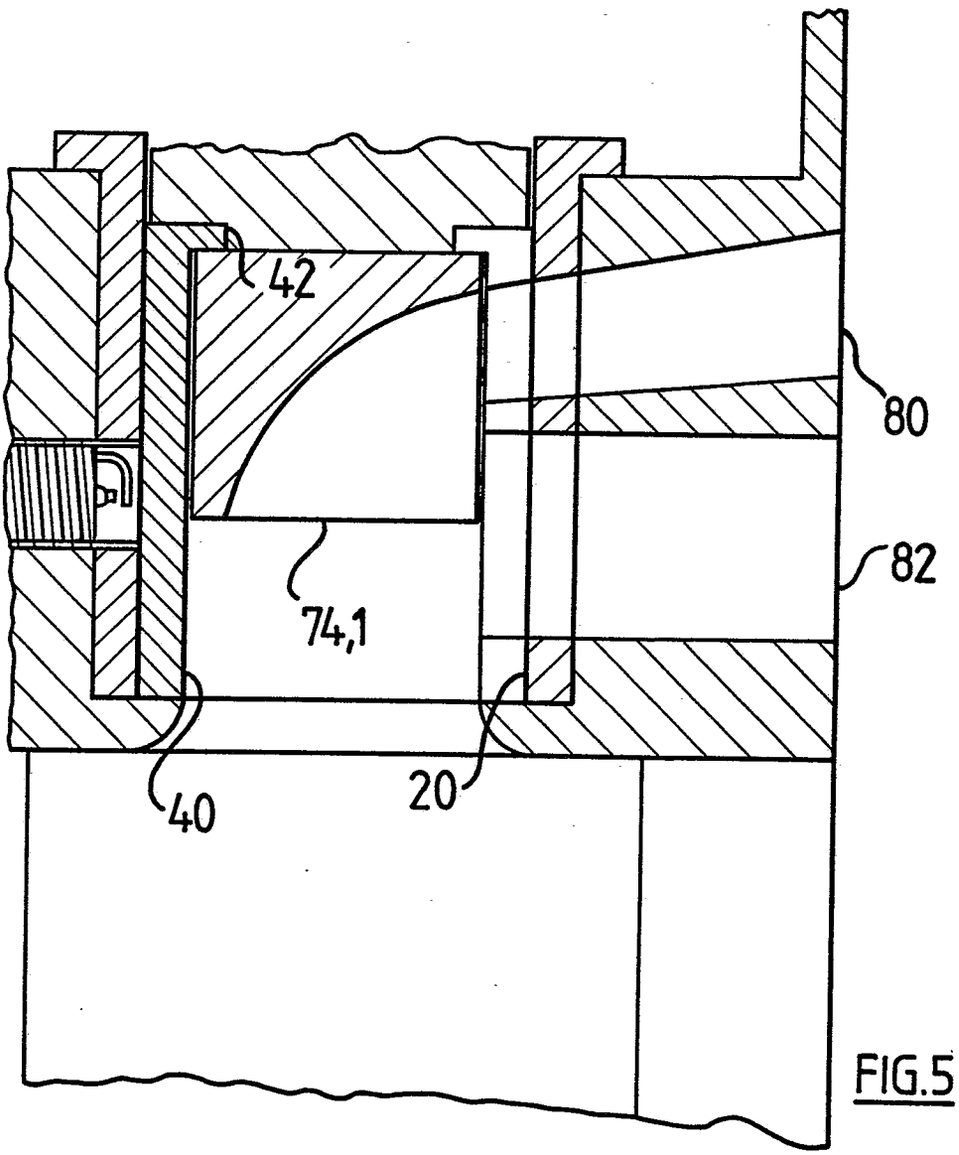


FIG.5

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 86 30 0852

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)
X	FR-A- 583 468 (REINHARD) * Page 1, line 56 - page 2, line 11; page 2, lines 37-45,53-71; page 3, lines 27-37; figures 1,3 *	1,2	F 01 L 7/02 F 01 L 7/16
A		3,4,9	
A	DE-C- 353 453 (RICHTER) * Page 1, lines 5-41; figure 1 *	1	
A	FR-A- 590 551 (LUCAS) * Page 2, lines 28-66; figures 1-3 *	1	
A	GB-A-2 103 712 (SUZUKI) * Page 1, lines 99-118; figure 1 *	6	TECHNICAL FIELDS SEARCHED (Int. Cl.4) F 01 L F 02 M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12-05-1986	LEFEBVRE L.J.F.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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