Feb. 7, 1956 L. SAIVES 2,733,630

APPARATUS FOR INSPECTING MACHINED WORK, MORE PARTICULARLY APPLICABLE TO FUEL INJECTORS FOR INTERNAL-COMBUSTION ENGINES

Filed June 14, 1952 2 Sheets-Sheet 1

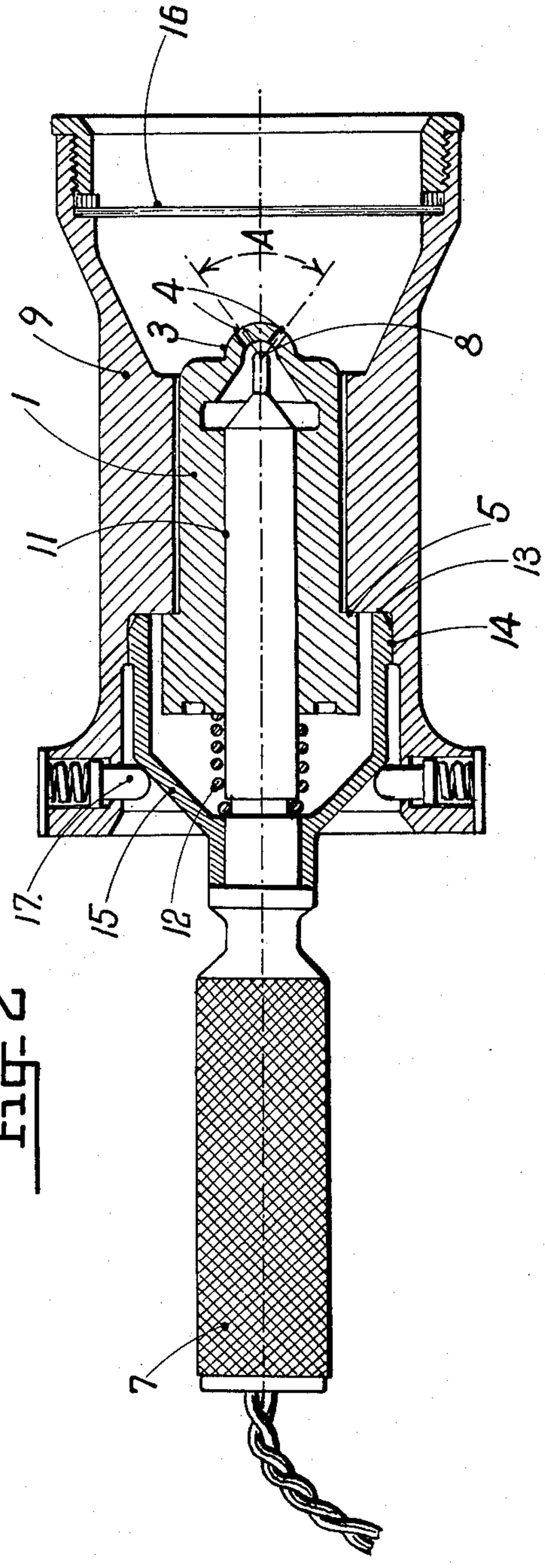

Fig-2

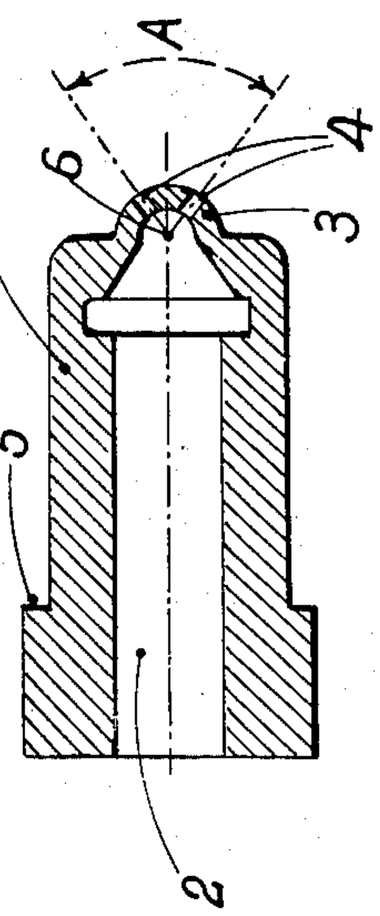

Fig-1

INVENTOR
LEON SAIVES
BY Robert E. Burns
ATTORNEY

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Fig 3

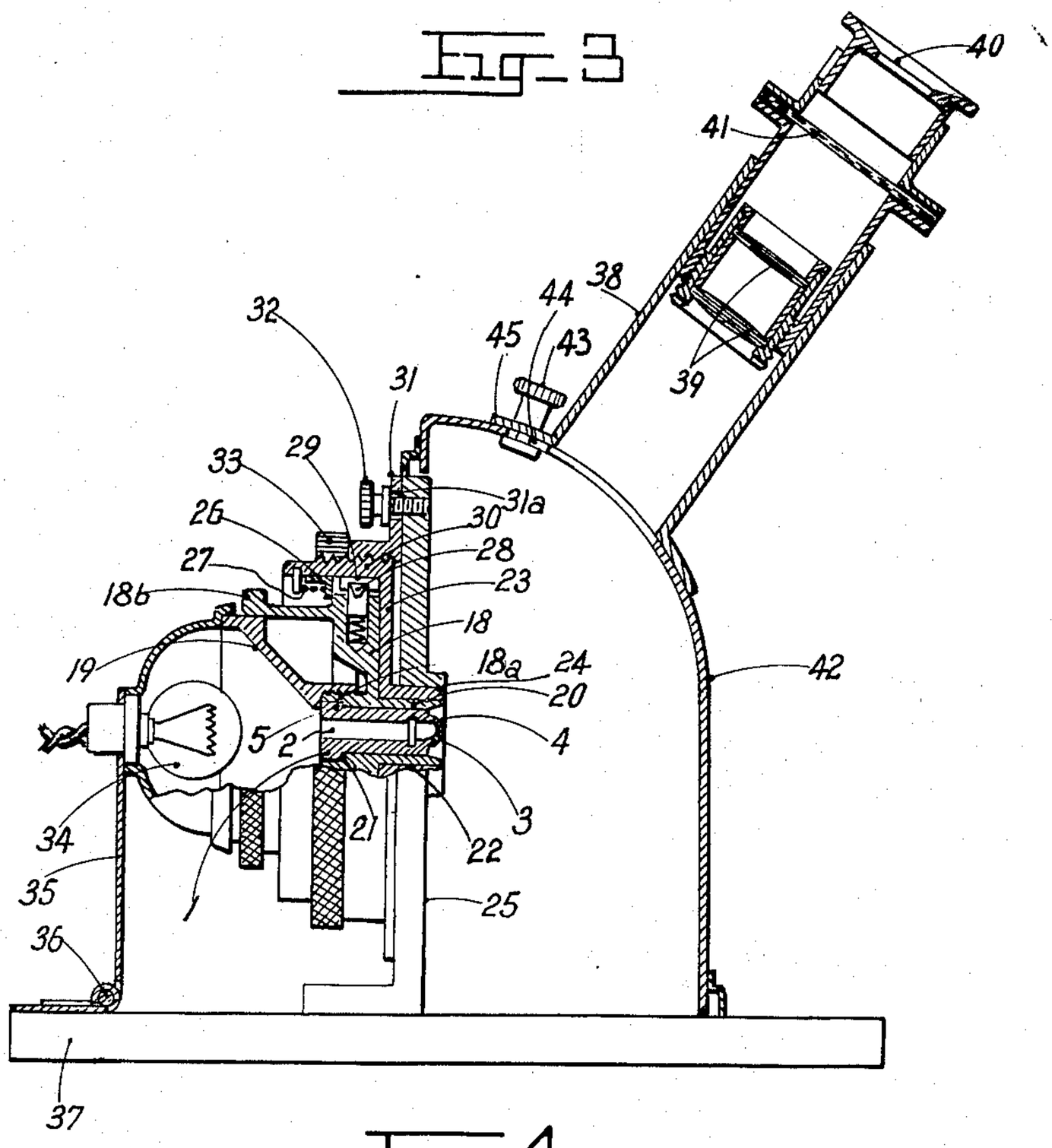
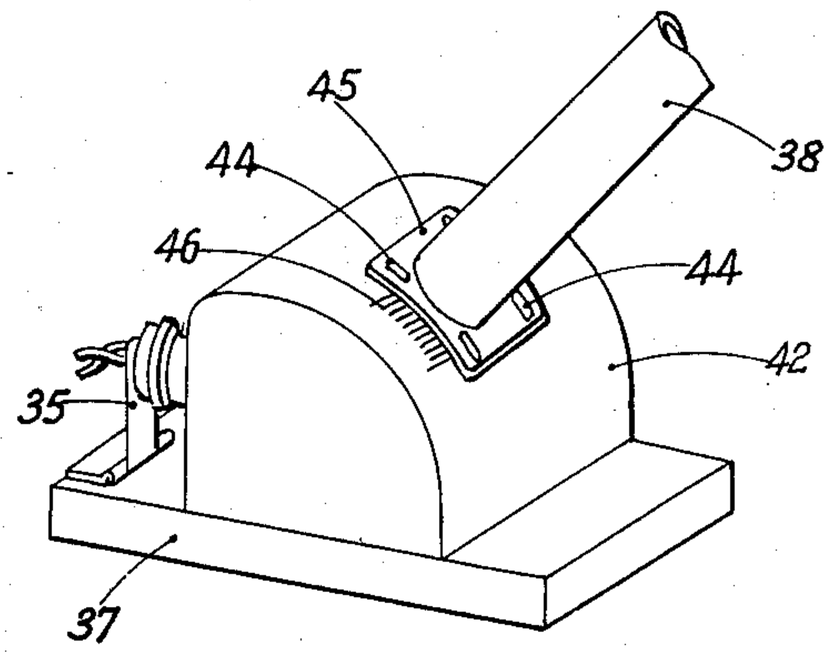


Fig 4



INVENTOR
LEON SAIVES
BY Robert E. Burns
ATTORNEY

United States Patent Office

2,733,630

Patented Feb. 7, 1956

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APPARATUS FOR INSPECTING MACHINED WORK, MORE PARTICULARLY APPLICABLE TO FUEL INJECTORS FOR INTERNAL-COMBUSTION ENGINES

Leon Saives, Billancourt, France, assignor to Regie Nationale des Usines Renault, Billancourt, France, a French corporation

Application June 14, 1952, Serial No. 293,628

Claims priority, application France June 22, 1951

4 Claims. (Cl. 88—14)

This invention relates to an apparatus for inspecting machined work, which apparatus is more particularly applicable to fuel injectors for internal combustion engines, but which may also be applied to the inspection of the machining of any other element or member of similar nature.

The position of the injection apertures in an injector, and the angle thereof, must be maintained within very narrow limits. Similarly, the degree of finish of the walls of the said apertures must be of such quality and constancy that the atomization of the fuel and the penetration of the jets are identical with those of a prototype and vary only slightly from one injector to the other.

The invention consists in employing an apparatus based on an optical method of carrying the necessary inspection.

In a first embodiment, the apparatus comprises essentially a plug having at its end a pin-point source of light which is introduced into the body of the injector, while the said body of the injector is centrally mounted in a sleeve which receives at the end adjacent the injection apertures either a frosted glass screen or a plate, film or photographic paper, or again a screen provided with one or more photoelectric cells. The luminous spots produced on the screen, for example by the pin-point source situated behind the injection apertures, indicate the degree of precision of the machining by their presence or absence, by their position, by their form and by their intensity.

In a modification, there is employed instead of a pin-point source of luminous radiation a pin-point source emitting radiations of any desired type, such as radioactive, radioelectric, supersonic or other radiations.

In another embodiment, the sleeve which receives and centers the body of the injector is mounted on a fixed frame in which it is adjustable longitudinally and in orientation in order that it may be possible to present successively the apertures which it is desired to observe directly or by comparison with a standard injector, in combination with a source of light of other than pin-point form which illuminates the interior of the injector, including the injection apertures which are examined directly by means of an optical viewing device, the axis of which converges with that of the sleeve and the lens system of which is adjustable longitudinally and angularly in the viewing plane.

In the accompanying drawings:

Figure 1 shows in axial section an injector body illustrated diagrammatically;

Figure 2 shows in axial section an inspection apparatus according to the first embodiment of the invention, with the injector of Figure 1;

Figure 3 shows in elevation, partly in axial section, the second embodiment of the invention, and

Figure 4 shows in perspective, on a reduced scale, the apparatus according to Figure 3.

Referring to the drawings and more especially to

Figure 1, it will be seen that the body **1** of the injector has in its diagrammatic form, an axial duct **2** closed at one end by a wall **3**, in which there are formed injection holes **4**, **4** enclosing an angle A. The body has a shoulder **5**. In an injector, it is particularly important to check, for example, the distance between the point **6** at which the axes of apertures **4**, **4** meet, the shoulder **5**, and the angle A.

The apparatus serving for the inspection of machined work comprises a plug **7** provided at its end with a pin-point source of light **8** and a sleeve **9** adapted to receive at its one end a frosted glass screen **16**, a plate, a photographic film or paper, or a screen provided with one or more photoelectric cells. The said sleeve **9** may also be connected to the objective of a camera.

The injector body **1** to be tested is placed in the sleeve **9** against which it bears by its shoulder **5**. The plug **7** is introduced into the body of the injector. It is then exactly centered by its cylindrical portion **11** in the bore of the injector body serving to guide the injection needle. A light spring **12** attached to the plug **7** urges the injector body against the face **13** of the sleeve **9**. When the plug **7** reaches its final position, it is centered in relation to the socket **9** and to the screen **16** by the centering portion **14** situated at the upper end of the sleeve and held at the correct height by its conical centering part **15**.

The three elements, that is, the socket, the injector and the plug, are maintained one against the other by a number of spring-loaded push members **17** acting on the conical part **15** of the plug (or by any other effective quick-locking system). The said elements can then be placed in any suitable position for the examination of the luminous spots.

The luminous spots on the screen make it possible to judge, by their presence or their absence, their position, their shape and their intensity, the degree of position of the position of the apertures, of their angle, of their finish, etc. The acceptance limits of the positions of the luminous spots may be indicated on the frosted glass screen, or photoelectric cells may be provided to indicate directly which parts are to be accepted or rejected. They may also take account of the luminous intensity. Also, a standard injector, or photographs, may be employed as references for comparison.

In a modification, there is employed instead of a luminous source a source of any desired radiation, such as radioactive, radioelectric, supersonic or any other type of radiation for carrying out the necessary inspection.

An apparatus similar to that hereinbefore described will be employed which comprises a plug having at its end, for example, a particle of radium. This plug is introduced into the body of the injector and maintained in a central position therein. The apertures in the injector, of which it is desired to inspect the conditions, the inclination and the point of convergence of their axes, will allow the radiations emanating from the pin-point source to pass, or will obstruct them, and these radiations may be observed on a sensitive screen by means of a photoelectric device or any other radiation detector suitable for the radiation employed.

Referring now to Figures 3 and 4, it will be seen that the injector body to be inspected is placed in a casing **18** and locked by a nut **19** screwed on a boss **18***a* of the casing under the same centring and bearing conditions as when it is mounted on the cylinder head of an engine, that is to say, the body of the injector is centred in the bore of a sleeve **20** of the casing and its collar **5** is applied against a shoulder **21** on the said sleeve.

The assembly comprising the injector, the casing and the nut is exactly centred by the sleeve **20** in the bore of the boss **22** of a cup **23**, which is in turn centred in a bearing **24** of the frame **25** of the apparatus. It is

maintained laterally by an annular plate 26 subjected to the thrust of a spring 27, and its orientation is adjusted by spring-loaded lugs 28 located in recesses 29 formed in the cylindrical wall of the cup 23, the number of recesses and the orientation thereof corresponding to the apertures to be inspected in the body of the injector.

The cup 23 with the elements enclosed and supported thereby is screwed more or less deeply into an annular support 30 provided with a flange 31 adapted to secure it adjustably on the frame 25 by means of knurled screws 32 extending through slots 31*a*. A nut 33 serves to lock the cup 23 in each position of adjustment on the annular support. The axial movement of the cup may be measured on a graduated scale.

The source of light consists of a lamp 34 of high power mounted on a flap 35 hinged at 36 to the base plate 37 of the frame.

The direct-reading optical device consists of a viewing device 38 comprising a system of lenses 39 adjustable for focusing onto the apertures 4 of the injector to be inspected, the enlarged image of which apertures, observed through an eye-piece 40, may be measured on a transparent cross-lined plate 41, which enables the form and the positioning of the apertures to be appreciated. The viewing tube 38 may be angularly adjusted in the plane defined by its axis and the axis of the injector, by reason of the fact that it is secured on the supporting casing 42 by knurled screws 43 adapted to move in slots 44 in the flange 45 of the viewing tube. The angular movements of the latter can be measured on a graduated scale 46 traced on the casing opposite one of the edges of the flange 45.

The operation of this apparatus will readily be understood: When it is desired to check the orifices 4 in the injection nozzle, the flap 35 carrying the lamp is first turned down about the hinge 36, whereafter the nut 19 is unscrewed so that the nozzle 1 may be introduced into the bore of the sleeve 20. The said nozzle is then locked in position by applying the collar 5 thereof against the shoulder 21 of the sleeve by screwing the nut 19. The flap 35 provided with the lighted lamp 34 is then brought into the position illustrated in Figure 3.

In order to operate, the casing 18 is so turned in the cup 23 with the aid of the knurled part 18*b* as to bring one of the orifices 4 into the plane of the optical axis of the viewing tube and of the axis of the nozzle, and the support 31 is so angularly adjusted by moving the slots thereof on the screws 32 that, in this position, the spring-loaded lug 28 mounted on the casing 18 is engaged in one of the recesses 29 in the cup 23. It is then sufficient to orient the tube of the viewing device 38 so as to bring it into alignment with the axis of the orifice 4 to be examined, and so on.

The scale 46 permits of measuring the inclination error of the axis of the apertures 4. By angularly adjusting the annular support 30 by means of the screws 31 and the corresponding slots 31*a*, it is possible to measure the angular error in the spacing of the apertures 4, while by axially moving the cup 23 the error in the drilling thereof in relation to the collar 5 of the injector can be measured.

Instead of examining the illuminated orifices with the aid of a viewing device, the intensity of the light passing through them can be directly appreciated or measured, for example by means of a photoelectric cell.

The viewing device may also be replaced by a camera,

the images obtained permitting of appreciating the luminous intensity, the dimensions, the form and the position of the apertures.

I claim:

1. In apparatus for inspecting fuel injectors for internal combustion engines, a dark chamber having one wall with a bore opening into the chamber and an inwardly concave facing wall with an aperture, a socket for receiving and centering said injector, said socket being rotatable and axially adjustable in said bore and the injector being received in said socket with the tip end of the injector in said chamber, a tube having a flange with a curvature corresponding to that of said concave wall, said flange being adjustably mounted on said concave wall with an inner end of said tube communicating with said aperture, an eyepiece at the outer end of said tube, a cross ruled screen in said tube and a light arranged to shine inside said injector and out through the injection holes of said injector, a lens for forming an image on said screen, said socket, tube, lens and screen being so positioned that an image of at least one injection hole of the injector is projected onto said screen where it can be viewed through said eyepiece.

2. Apparatus according to claim 1, in which said lens is disposed in said tube between said screen and said injector to focus the image of said injection hole on said screen.

3. In apparatus for inspecting fuel injectors for internal combustion engines, said injectors having a collar and a tip portion with injection holes, a dark chamber having one wall with a bore opening into the chamber and a facing wall with an aperture, a cup member having a bushing portion rotatably received in said bore, a radially projecting flange portion at the outer end of said bushing portion and a threaded portion at the periphery of said flange portion, a threaded collar adjustably mounted on said first-mentioned wall concentric with said bore and engaging said threaded portion of said cup member to provide axial adjustment of said cup member relative to said first-mentioned wall, a holder having a sleeve portion received in the bushing portion of said cup member and a radial flange portion overlying the flange portion of said cup member, cooperating spring latch means on said cup member and the flange portion of said holder for releasably holding said holder in a plurality of predetermined angular positions relative to said cup member, said holder having an internal diameter closely to receive said injector and having a shoulder engaging said collar on the injector to position the injector axially relative to the holder with the tip of the injector inside said chamber, means for locking said injector in said holder, a tubular member adjustably mounted on said chamber in communication with said aperture, a screen in said tubular member and a light arranged to shine inside said injector and out through said injection holes, a lens for forming an image on said screen, said injector, light, lens and screen being so positioned that an image of at least one injection hole of the injector is projected onto said screen.

4. Apparatus according to claim 3, in which said screen is cross ruled.

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