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(54) Fuel injection device for diesel engine, method for manufacturing the same, and valve unit

Kraftstoffeinspritzvorrichtung für Dieselmotor, Verfahren zu deren Herstellung und Ventileinheit

Dispositif d'injection de carburant pour moteur diesel, son procédé de fabrication, et unité de soupape

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a fuel injection device for a diesel engine, and a valve unit, wherein a needle valve is moved in the inside of a nozzle body to which fuel is fed, to open or close seating faces through which the nozzle body and the needle valve come into contact with each other, thereby controlling the injection of fuel from a nozzle hole which is open to the nozzle body. Particularly, the present invention is concerned with a technique for improving the durability of seat portions.

2. Description of the Prior Art

[0002] Generally, a fuel injection device for a diesel engine is provided in the inside thereof with a nozzle body into which fuel is supplied and a needle valve which is slidable in the inside of the nozzle body. When fuel is to be injected, the needle valve moves under the pressure of fuel which is supplied to the nozzle body, so that seating faces through which the nozzle body and the needle valve are in contact with each other open in the inside of the nozzle body, then fuel is injected from a nozzle hole formed in the nozzle body. When fuel is not injected, the needle valve which is urged with a load such as a spring comes into abutment against the nozzle body to close the seating faces, thereby stopping the injection of fuel from the nozzle.

[0003] Thus, the seat portions of the fuel injection nozzle for a diesel engine undergo a high impact force repeatedly with closing of the valve, resulting in occurrence of wear or spalling. The spalling is a phenomenon such that a crack is developed in a boundary between a surface hardened layer and a base material, resulting in peeling-off of the surface hardened layer. Particularly, with the recent tendency to a higher injection pressure, a shortening of life of the seat portions caused by wear or spalling in an early stage is becoming an issue. Wear occurs in both needle valve and nozzle body, but the nozzle body tends to become worn to a greater extent. Spalling occurs in the nozzle body. For making a stable long-hour operation of the diesel engine, it is important to improve the resistance to wear and to spalling of the seat portions.

[0004] In the conventional fuel injection nozzle for a diesel engine, for example, SKH51 refined material is used as the material of the needle valve and SNCM420 carburized material or SKD61 nitrided material is used as the material of the nozzle body. The refined SKH51 for the needle valve is a high speed steel called Mo high speed steel and is superior in toughness and wear resistance. A microstructure thereof includes a relatively large, angular eutectic carbide (MC, M_6C) and a fine precipitated carbide ($C_{r23}C_6$, Mo_2C) produced by tempering, both precipitated on a high temperature tempered martensite base material. The carburized SNCM420 for the nozzle body includes a fine carbide precipitated on a low temperature tempered martensite base material. It softens if used at a temperature of not lower than the tempering temperature because it is influenced by the tempering temperature. The nitrided SKD61 includes a fine double carbide (M_6C) dispersed in a high temperature tempered martensite base material, with a hard nitride being dispersed in a diffusion layer.

[0005] Having made extensive studies about the wear and spalling which occur in the seat portions of the conventional fuel injection device for a diesel engine, the present inventors obtained the following knowledge.

A relatively large eutectic crystal (MC, M_6C) precipitated in SKH51 may be a factor which exerts an influence on the wear resistance of the seat portions. This carbide precipitated in the seat portion of the needle valve is angular and rises to the surface without becoming worn because it is harder than the base material, resulting in shaving the seat portion on the nozzle body side. Particularly, if the quenching temperature is too high or the holding time is too long, the carbide in question becomes angularized and coarse, so care should be taken on this point.

[0006] As to spalling of the seat portions, a shear stress induced by contact poses a problem. It is presumed that with a turning-up force developed upon sitting on the seat, the aforesaid carbide increases a shear stress in the vicinity of the surface, thereby facilitating the occurrence of spalling.

[0007] A nitride layer such as the nitrided SKD61 is generally considered to be divided in two, one being a compound layer as an outermost surface layer and the other being an inside diffusion layer. The outermost surface compound layer is brittle and weak against an impact force, so it is generally removed by grinding before use.

[0008] However, in the seat portions of the fuel injection device for a diesel engine, there has been a case where the seating faces undergo fatigue fracture (spalling) due to a repeated impact force even after removal of the compound layer.

Document US 2007/0069576 A proposes removal of the compounds that are concomitantly produced due to a nitrocarburizing treatment.

[0009] The present invention solves the above-mentioned problems and it is an object of the invention to make the occurrence of wear and spalling difficult in seat portions of a fuel injection device for a diesel engine which undergoes a high impact force repeatedly at the time of closing of a valve.

SUMMARY OF THE INVENTION

[0010] The present inventors have analyzed a damaged article in order to clear up the cause of seating faces undergoing fatigue fracture due to a repeated impact force even after removal of the compound layer in each seat portion of a fuel.injection device for a diesel engine. As a result, the present inventors have found out a new fact that this phenomenon occurs in a specific site present within a diffusion layer.

[0011] In the case where the surface of an alloy steel is nitrided for enhancing the hardness, an outermost surface compound layer and a diffusion layer region (first layer) present just under the compound layer and having a relatively high nitrogen content are brittle because a hard nitride is precipitated in grain boundaries and within grains, so are apt to be damaged due to a high impact force acting thereon repeatedly. However, according to the knowledge of the present inventors, the diffusion layer region lying just under the compound layer is made up of a diffusion layer region (first layer) relatively high in nitrogen content and a diffusion layer region (second layer) being tough and low in nitrogen content. The diffusion layer region (second layer), which is tough and low in nitrogen content, can be made to be a seating face by removing the first layer, whereby it is presumed possible to enhance the durability against impact fatigue at the time of closing a valve in a nozzle.

[0012] The present invention has been accomplished on the basis of the above finding or knowledge of the present inventors. According to the present invention there is provided a fuel injection device for a diesel engine wherein the portions serving as seat portions of both nozzle body and needle valve are constituted by a nitrided alloy steel and the second layer, which is tough and low in nitrogen content, is made to be a seating face by removing the compound layer and the first layer in the diffusion layer from the surface of each seat portion.

[0013] Moreover, the present invention provides a technique for exposing the second layer in the diffusion layer of the nitrided alloy steal to the surface. More particularly, the present invention provides an etching technique which has not been conducted heretofore as a steel texture observing technique but has been found out for the first time as a result of trial-and-error experiments made by the present inventors. According to this technique, the first and second layers in the diffusion layer are separated from each other in an observable manner, then a grinding quantity necessary for exposing the second layer to the surface is determined, and grinding is performed by only the grinding quantity, thereby allowing only the compound layer and the first layer in the diffusion layer to be removed from the surface of each seating face formed by the nitrided alloy steel, to expose the second layer to the surface.

[0014] In a first aspect of the present invention, there is provided a fuel injection device for a diesel engine, wherein a needle valve is moved in the inside of a nozzle body to which fuel is supplied, thereby opening or closing seat portions through which the nozzle body and the needle valve come into contact with each other to control injection of fuel from a nozzle hole, the nozzle hole being opened to the nozzle body,
wherein a portion serving as the seat portion of the nozzle body and a portion serving as the seat portion of the needle valve are formed by a nitrided alloy steel, and a compound layer and a first layer in a diffusion layer are removed from a surface of at least the portion serving as the seat portion of the nozzle body.

[0015] In a second aspect of the present invention there is provided, in combination with above first aspect, the fuel injection device for a diesel engine wherein the compound layer and the first layer in the diffusion layer are removed from the surface of the portion serving as the seat portion of the needle valve.

[0016] In a third aspect of the present invention there is provided, in combination with the first or the second aspect, the fuel injection device for a diesel engine
wherein the portion serving as the seat portion of the nozzle body is a second layer in the diffusion layer having a smoothness of at least less than Ra 0.4 in terms of surface roughness attained by grinding.

[0017] In a fourth aspect of the present invention there is provided a method for manufacturing a fuel injection device for a diesel engine wherein a needle valve is moved in the inside of a nozzle body to which fuel is supplied, thereby opening or closing seat portions through which the nozzle body and the needle valve come into contact with each other to control injection of fuel from a nozzle hole, the nozzle hole being opened to the nozzle body, the method including the steps of:

forming the nozzle body and the needle valve with an alloy steel;
nitriding a whole surface of the nozzle body and a whole surface of the needle valve;
grinding a surface of a portion serving as the seat portion of the nozzle body and a surface of a portion serving as the seat portion of the needle valve to remove a compound layer and a first layer in a diffusion layer from each of the surfaces; and
assembling the nozzle body and the needle valve.

[0018] In a fifth aspect of the present invention there is provided, in combination with the fourth aspect, the method for manufacturing a fuel injection device for a diesel engine, further including the steps of specularly grinding a section of an alloy steel of the same material as the material of the nozzle body and the needle valve and similarly nitrided, etching the section with 10% or more of alcohol nitrate, thereafter observing the section through a microscope to recognize a boundary between the first layer and a second layer in the diffusion layer, and determining a grinding quantity necessary for grinding the surfaces of the portions serving as the seat portions of the nozzle body and the needle valve to remove the compound layer and the first layer in the diffusion layer.

[0019] In a sixth aspect of the present invention there is provided a valve unit provided in a fuel injection device for a diesel engine and having a valve element, the valve

element being moved in the inside of a body to which fuel is supplied from an inlet of the body, thereby opening or closing seat portions through which the body and the valve element come into contact with each other to let the fuel flow out from an outlet of the body,
wherein a portion serving as the seat portion of the body and a portion serving as the seat portion of the valve element are formed by a nitrided alloy steel, and a compound layer and a first layer in a diffusion layer are removed from a surface of each of the portions serving as the seat portions of the body and the valve element.

[0020] In a seventh aspect of the present invention there is provided, in combination with the sixth aspect, the valve unit including:

> a body having an inlet for the flow of fuel into the body and an outlet for the flow of fuel out of the body, with a tapered body seat portion formed in the inlet;
> a valve element accommodated movably in the inside of the body and having a valve element seat portion adapted to abut the body seat portion to close the inlet; and
> urging means disposed in the inside of the body, the urging means exerting a predetermined urging force on the valve element seat portion of the valve element to bring the valve element seat portion into abutment against the body seat portion, thereby closing the inlet,

wherein when a force based on fuel pressure in the inlet and acting on the valve element becomes larger beyond the urging force than a force based on fuel pressure in the outlet and acting on the valve element, the valve element seat portion and the body seat portion move away from each other and the fuel flows from the inlet to the outlet, and
when the force based on the fuel pressure in the inlet and acting on the valve element becomes smaller than the sum of the force based on the fuel pressure in the outlet and acting on the valve element and the urging force, the valve element seat portion and the body seat portion come into contact with each other to shut off the fuel flow path,
the body seat portion and the valve element seat portion being formed of a nitrided alloy steel, with a compound layer and a first layer in a diffusion layer removed from surfaces of the body seat portion and the valve element seat portion.

[0021] In the fuel injection device for a diesel engine or a valve unit, the nitrided alloy steel applied to both nozzle body (or body) and needle valve (or valve element) has an outermost compound layer, a first layer in a diffusion layer which underlies the compound layer, and a second layer underlying the first layer and having toughness. However, a boundary between the first layer and the second layer in the diffusion layer cannot be recognized by etching using about 3% (3 to 5% or so) of alcohol nitrate which has heretofore been used for observing the texture of steel. In connection with the method for measuring the depth of a nitrided layer in iron or steel defined by JIS G 0562, there is clearly described a metallographic test method for measuring the depth of a nitrided layer by etching with use of about 3% alcohol nitrate. But it is only two types, one being the depth of a compound layer and the other being the depth of a diffusion layer, that are defined therein, with no recognition found therein about the presence of a second layer. Of course, according to the measurement method described therein it is impossible to separate the boundary between the first and second layers in the diffusion layer.

[0022] According to the method of the present invention, by etching a section of a nitrided alloy steel for several tens seconds within an ultrasonic cleaner using 10% or more, e.g., 15% or so, alcohol nitrate and thereafter observing the section through a scanning electron microscope, it is possible to separate the boundary between the first and second layers in the diffusion layer.

[0023] Analysis of a conventional damaged article revealed that fatigue fracture of a seat portion occurred in a specific site of the diffusion layer and that the site corresponded to a boundary between a surface-side first layer and an inside second layer in a diffusion layer. As to the seat portions of the fuel injection device for a diesel engine or the valve unit according to the present invention, by measuring the depth of the first layer in accordance with the foregoing method, determining a grinding quantity on the basis of the measurement results and removing by grinding the portion corresponding to each seat portion of the nitrided alloy steel to only the degree equal to the determined grinding quantity, only the second layer which is more tough can be exposed to the surface and used.

[0024] Thus, in the fuel injection device for a diesel engine or the valve unit according to the present invention, since a nitrided alloy steel is used as the material of both nozzle body (or body) and needle valve (or valve element) and the compound layer, as well as the first layer in the diffusion layer, are removed from the surface of the alloy steel, the second layer having high toughness serves as each seat portion and hence it is possible to enhance the durability against impact fatigue at the time of valve closing in the nozzle (at the time of movement of the valve element). That is, both wear resistance and fatigue resistance are improved and the frictional force is decreased, whereby a shear stress induced near the surface upon sitting on the seat can be diminished and it is possible to prevent the occurrence of spalling of the seat portion of the nozzle body (or body).

[0025] Since the wear and damage of the seat portions of the fuel injection valve for a diesel engine or the valve unit are decreased, it is possible to prevent a secular change of injection characteristics and fuel leakage caused by a seat defect. Such secular change of injection characteristics and fuel leakage caused by a seat defect deteriorate the engine performance (especially exhaust gas components). However, according to the present invention, the engine performance can be maintained in a satisfactory condition over a long period by improving the durability of the seat portions of the fuel injection nozzle or the valve unit. Consequently, it is possible to prolong the replacement cycle of the fuel injection device or an assembly thereof and hence possible to reduce the replacement expenses.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]

Fig. 1 is a sectional view of a fuel injection device for a diesel engine according to an embodiment of the present invention;
Figs. 2A and 2B are sectional views showing a machining process for a nozzle body 21 in the fuel injection device for a diesel engine;
Figs. 3A and 3B are sectional views showing a machining process for a needle valve in the fuel injection device for a diesel engine;
Fig. 4 is an electron microphotograph showing the form of a nitrided layer in a nitrided alloy steel (SKD61) used as the material of the fuel injection device for a diesel engine;
Fig. 5 is a schematic diagram showing an outline of a reciprocating wear test applied to materials used in the embodiment and a comparative example;
Fig. 6 is a diagram showing in what manner a seizure test is conduced in the reciprocating wear test;
Fig. 7 is a diagram showing in what manner a sliding speed varying test is conducted in the reciprocating wear test;
Fig. 8 is a diagram comparing frictional forces of the materials used in the embodiment and the comparative example, which were obtained in the reciprocating wear test;
Figs. 9A and 9B are diagrams showing appearance photographs of comparative test pieces after the reciprocating wear test;
Figs. 10A and 10B are diagrams showing appearance photographs of test pieces of the embodiment after the reciprocating wear test;
Figs. 11A and 11B are diagrams showing appearance photographs of test pieces of the embodiment after the reciprocating wear test;
Figs. 12A and 12B are diagrams showing appearance photographs of test pieces of the embodiment after the reciprocating wear test; and
Fig. 13 is a sectional view of a valve unit applied as a check valve or a relief valve to a fuel injection device for a diesel engine according to another embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0027] Embodiments of the present invention will be described below with reference to Figs. 1 to 13.

Fig. 1 is a sectional view of a fuel injection device for a diesel engine according to an embodiment of the present invention.

Figs. 2A and 2B are sectional views showing a machining process for a nozzle body in the fuel injection device, Figs. 3A and 3B are sectional views showing a machining process for a needle valve in the fuel injection device, and Fig. 4 is an electron micrograph showing the form of a nitrided layer in a nitrided alloy steel (SKD61) used as the material injection device.

Fig. 5 is a schematic diagram showing an outline of a reciprocating wear test applied to materials used in the embodiment and a comparative example, Fig. 6 is a diagram showing in what manner a seizure test is conducted in the reciprocating wear test, and Fig. 7 is a diagram showing in what manner a sliding speed varying test is conducted in the reciprocating wear test.

Fig. 8 is a diagram comparing frictional forces of the materials used in the embodiment and the comparative example, Figs. 9A and 9B are diagrams showing appearance photographs of comparative test pieces after the reciprocating wear test, Figs. 10A and 10B are diagrams showing appearance photographs of test pieces of the embodiment after the reciprocating wear test, Figs. 11A and 11B are diagrams showing appearance photographs of test pieces of the embodiment after the reciprocating wear test, and Figs. 12A and 12B are diagrams showing appearance photographs of test pieces of the embodiment after the reciprocating wear test.

Fig. 13 is a sectional view of a valve unit applied as a check valve or a relief valve to a fuel injection device for a diesel engine according to another embodiment of the present invention.

1. Structure of the fuel injection device for a diesel engine according to an embodiment of the invention (Fig. 1)

[0028] As shown in Fig. 1, the fuel injection device for a diesel engine according to this embodiment has a nozzle body 1 to which fuel is supplied and a needle valve 2 which is movable in the inside of the nozzle body 1.

[0029] The nozzle body 1 is a tapered, generally cylindrical block body and a guide bore 3 for the needle valve 2 is formed centrally of a base end portion of the nozzle body 1. A front end portion of the guide hole 3 is expanded in diameter to form a fuel reservoir 4. Fuel is supplied from the exterior into the fuel reservoir 4 through a fuel supply hole 5. A tapered seat portion 6 is formed at a front end of the fuel reservoir 4. On a more front side of the seat portion, a hole 7 of a small diameter is formed which is in communication with the fuel reservoir 4. Nozzle holes 8 are formed in the wall portion of the hole 7 so as to communicate with the exterior.

[0030] The needle valve 2 has a round rod-like base portion 10 (needle diameter ϕD) which is held slidably by the guide hole 3 of the nozzle body 1 and a round rod-like front end portion 12 formed integrally with the base portion 10 and having a diameter smaller than the inside diameter of the fuel reservoir 4, the front end portion 12 being formed at the tip thereof with a tapered seat portion 11 which is in contact with the seat portion 6 of the nozzle body 1, (seat diameter ϕd<D).

[0031] The seat portion 11 of the needle valve 2 is urged at a load W by urging means such as a spring in a direction of abutment against the seat portion 6 of the nozzle body 1. In an external force-free state the seat portion 11 of the needle valve 2 is in contact with the seat portion 6 of the nozzle body 1 to close between the seat portions 6 and 11, blocking communication between the fuel reservoir 4 and the nozzle holes 8. When fuel is to be injected, fuel of a predetermined pressure is supplied into the fuel reservoir 4 through the fuel supply hole 5, and with a rise of the internal pressure, the needle valve 2 undergoes a force and moves upward while being guided by the guide hole 3, so that the seat portions 6 and 11 separate from each other and the fuel is injected to the exterior from the nozzle holes 8.

2. Manufacturing Process (Figs. 2A to 4)

[0032] In the fuel injection nozzle for a diesel engine according to this embodiment, SKD61 or another steel similar thereto, whose surface has been subjected to a nitriding treatment under predetermined conditions, is used as the material of both nozzle body 1 and needle valve 2. Since the nozzle body 1 is required to have all of high strength, impact resistance and wear resistance, it cannot be substituted by any other metallic material than steel. Steel having an alloy component which forms a stable nitride such as Al, Cr, Mo, V, or Ti is preferred. After forming the nozzle body 1 and the needle valve 2 with SKD61, a nitriding treatment is performed.
Thereafter, in the seat portions 6 and 11 of the nozzle body 1 and the needle valve 2, a compound layer and a first layer in a diffusion layer are removed by grinding, and a second layer which is tough is used as the seat portions 6 and 11.

[0033] More specifically, in Figs. 2 and 3 showing a nitriding/grinding process, C and D portions correspond to the seat portions 6 and 11, and the first layer is removed after nitriding. In grinding the seat portions, the surface roughness of a finished surface including the second layer is made small to finish the surface in a smoother condition. As an example, it is preferable to attain a smoothness of less than Ra 0.4 in terms of surface roughness by grinding with use of sand paper of #800 or so. With such a surface finish, it is possible to diminish the influence of the carbide, etc. precipitated from the material on friction and thereby to decrease the coefficient of friction.

[0034] In Figs. 2A to 3B showing the nitriding/grinding process, B, E and F portions are grinded because of necessity in point of function, but even if there remains the first layer, there arises no problem. The portion A plays the role of a stopper when the injection valve opens, thus generating a large shock, with the result that the nitrided layer is peeled off. As to the nitrided layer of the portion A, therefore, both first and second layers are removed completely. The portion G is nitrided in a conical shape as shown in Fig. 3A for a reason related to machining, but the conical portion is cut off eventually as shown in Fig. 3B. As to the portions A and G, machining differs depending on machining equipment and method.

[0035] In the grinding process of removing the compound layer and the first layer in the diffusion layer in the seat portions 6 and 11 by grinding, allowing the second layer as a tough layer to remain as each seat portion, it is necessary to clearly recognize the boundary between the first and the second layer in the diffusion layer and determine a grinding quantity (grinding thickness). This is because the state of nitriding at the surface differs depending on the kind of steel and nitriding conditions adopted and it is necessary to check beforehand by experiment and observation how deep the boundary between the first and the second layer in the diffusion layer is from the surface and grind by an amount corresponding to the depth in the manufacturing process, allowing the second layer to be exposed to the surfaces of the seat portions 6 and 11.

[0036] With the conventional etching using 5% alcohol nitrate defined in the foregoing JIS, the boundary between the first and the second layer in the diffusion layer cannot be recognized. According to the knowledge which the present inventors obtained by trial-and-error experiments, if a predetermined kind of steel whose surface has been subjected to a nitriding treatment under predetermined conditions is cut perpendicularly to the surface and the resulting section is etched for several tens seconds within an ultraviolet cleaner using about 10% or more, preferably about 15%, of alcohol nitrate, the boundary between the first and second layers can be recognized by observing the section through a scanning electron microscope.

[0037] Fig. 4 is an electron micrograph showing the form of a surface nitrided layer of alloy steel (SKD61) adopted as the material of the fuel injection device for a diesel engine according to this embodiment. In the same figure, white bars (micron bars) appearing at a lower portion of the photograph each represent 200 μm. A compound layer occupies approximately the top 10 μm of the surface layer in the section, corresponding to the black surface layer in the figure. By observing the nitrided surface layer in the section, there is determined a grinding quantity (size) necessary for removing the compound layer and the first layer to expose the second layer.

[0038] The purpose of nitriding the steel surface in this embodiment is for enhancing the hardness. With any other special steel, such a degree of hardness as is required in view of the purpose of this embodiment is not obtained. Further, when wear resistance is taken into account, steel-to-steel contact is apt to cause adhesion and expedite wear, but nitride-to-steel or nitrided steel-to-nitrided steel contact is advantageous in that adhesion is difficult to occur, the coefficient of friction is low and wear is slow. Moreover, even as to the second layer, since it is a nitrided layer, it has a sufficient hardness as compared with other unnitrided steels. Further, at a lower coefficient of friction, there accrues an advantage that the shear force induced by surface friction becomes smaller and the resistance to spalling is improved.

[0039] Also in SKD61 adopted in this embodiment, the precipitated carbide comes up to the surface, but as compared with SKH51 so far adopted, SKD61 is a small and roundish carbide, causing little damage, e.g., wear, to the mating material, whereas SKH51 is a large and angular carbide, causing great damage, e.g. , wear, to the mating material. In this embodiment, since not only the nozzle body 1 but also the needle valve 2 is nitrided to lower the coefficient of friction, both spalling resistance and wear resistance are improved. Additionally, as noted above, by making the surface roughness smaller to make the surface smoother, the influence of the precipitated carbide, etc. on friction is diminished.

3. Reciprocating Wear Test (Figs. 5 to 12B)

(1) Testing Method (Figs. 5 to 7)

[0040] To check the effect of the fuel injection device for a diesel engine manufactured in the above manner, a test piece of the same material as that used for the nozzle body 1 and the needle valve 2 in this embodiment is provided and is applied, together with a comparative test piece, to a reciprocating wear test. Then, the results obtained are compared with each other.

[0041] In the reciprocating wear test, as shown in Fig. 5, a pin test piece having a spherical front end shape 50 mm in radius is brought into abutment at a predetermined load against an upper surface of a plate-like test piece having a predetermined size (14×10×115 mm) and the pin test piece is reciprocated at a stroke of 100 mm in the longitudinal direction of the plate-like test piece while dropping lubricating oil at a rate of 9 ml/h onto a sliding area defined on the upper surface of the plate-like test piece.

[0042] Fig. 6 shows in what manner a seizure test is conducted, which test is continued while increasing the load with the lapse of test time until the occurrence of scuff in accordance with the technique of the reciprocating wear test. Test conditions are as follows.
Test Load: stepping up while holding 5 kgf/5 min and loading up to 100 kgf Test Temperature: plate-like test piece heating temperature 150°C constant, room temperature as lubricating oil vessel temperature

Average Sliding Speed: 1.5 m/s
Stroke: 100 mm
Lubricating Oil Dropping Quantity: 9 ml/h
Lubricating Oil: MARINE T204 (a product of Shin Nippon Sekiyu Co., Ltd.)

[0043] The following are the materials of the test pieces applied to the test and surface treatments.
Plate-like Test Piece: two kinds, one being SKD61 grinded after nitriding, the other SKD61 grinded after nitriding and further subjected to #800 grinding finish
Pin Test Piece: two kinds, one being SKD61 and the other SKD61 grinded after nitriding

[0044] Fig. 7 shows more concretely a sliding speed varying mode of a sliding operation of the pin test piece relative to the plate test piece, as well as a load step up mode, in the seizure test which is outlined in Fig. 6.
After starting, the sliding speed is set to 0.02 m/s and the load is set to 5 kgf and this condition is held for several cycles (a). Next, the sliding speed is increased to 1.5 m/s and this condition is held for 5 minutes (b). Then, the speed is decreased to 0.02 m/s and this condition is held for several cycles (c). Next, the load is stepped up to 10 kgf and this condition is held for several cycles (d). Subsequently, the load is stepped up to 100 kg (e).

(2) Test Results (Figs. 8 to 12)

[0045] Fig. 8 shows the results of a seizure test conducted using two types of test pieces, one being SKD61 and the other SKD 61 grinded after nitriding, and also using SKD61 grinded after nitriding and SKD61 grinded after nitriding and further subjected to an additional #800 grinding finish. The test results indicate that if there is used a nitrided and grinded pin, in comparison with the use of an unnitrided pin, the frictional force is low continuously up to the load of 100 kgf.

[0046] Figs. 9A to 11B show appearance photographs of the pin test pieces and the plate test pieces after the sliding speed varying test.
A combination of the test piece SKD61 unnitrided and the plate-like test piece SKD61 grinded after nitriding is worn to such a degree as the spherical surface of the pin test piece being extinguished completely, as shown in Fig. 9.

[0047] On the other hand, a combination of the pin test piece SKD61 grinded after nitriding and the plate-like test piece SKD61 grinded after nitriding is to such an extent that a small wear trace is observed at the central part of the spherical surface of the pin test piece, as shown in Fig. 10. This indicates that seizure was extinguished as a result of grinding the pin test piece after nitriding.

[0048] As to a combination of the pin test piece SKD61 unnitrided and the plate-like test piece SKD61 grinded after nitriding and further subjected to an additional #800 grinding finish to lower the surface roughness, as shown in Fig. 11, it is seen that seizure decreases and the state is improved in comparison with Fig. 9 even without nitriding of the pin test piece.

[0049] Further, in a combination of the pin test piece SKD61 grinded after nitriding and the plate test piece SKD61 grinded after nitriding and further subjected to an additional #800 grinding finish to lower the surface roughness, as shown in Fig. 12, the wear trace becomes no longer clear, affording the best results.

[0050] According to the results of shape measurement of the pin test pieces after the test, the combination of the pin test piece SKD61 grinded after nitriding and the plate test piece SKD61 grinded after nitriding and further subjected to an additional #800 grind finish to lower the surface roughness was the smallest in the amount of wear.

[0051] A description will be given about the results of having measured the size (diameter) of a wear trace of each pin test piece after the sliding speed varying test. In the combination of the pin test piece SKD61 unnitrided and the plate test piece SKD61 grinded after nitriding, a wear trace was 7.81 mm, which was close to the outside diameter of the pin test piece, due to the occurrence of scouring at a load of 30 kgf (corresponding to Figs. 9A and 9B).

[0052] Next, in the combination of the pin test piece SKD61 unnitrided and the plate test piece SKD61 grinded after nitriding and further subjected to #800 grinding finish, there were observed in two tests almost the same wear trace widths of 1.51 mm and 1.58 mm in a sliding trace direction (corresponding to Figs. 11A and 11B).

[0053] Next, in the combination of the pin test piece SKD61 grinded after nitriding and the plate test piece SKD61 grinded after nitriding, a wear trace width in a sliding trace direction is 1.54 mm, indicating a good result as compared with the pin test piece SKD61 unnitrided (corresponding to Figs. 10A and 10B).

[0054] Further, in the combination of the pin test piece SKD61 grinded after nitriding and the plate test piece SKD61 grinded after nitriding and further subjected to #800 grinding finish to lower the surface roughness, there were observed in two tests almost the same wear trace widths of 1.44 mm and 1.43 mm in a sliding trace direction, affording good results as compared with the pin test piece SKD61 unnitrided (corresponding to Figs. 12A and 12B).

[0055] From the above results it turned out that it was possible to reduce the frictional force and improve the wear resistance by nitriding and grinding both pin test piece and plate test piece. It also turned out that the wear resistance was further improved by lowering the test piece surface roughness.

[0056] Thus, in the fuel injection device for a diesel engine, if at least the seat portions of the nozzle body and the needle valve are each nitrided and grinded to expose the second layer in the diffusion layer, or if the seat portion of at least the nozzle body is grinded to expose the second layer in the diffusion layer, a good result is obtained.

[0057] Moreover, if the seat portion with the second layer exposed by grinding is further grinded, separately from removing the compound layer and the first layer in the diffusion layer by grinding to prevent spalling from the nitrided surface, the influence of the carbide, etc. precipitated on the surface is diminished to lower the surface roughness and the coefficient of friction, whereby a better result is obtained.

4. Effect of the embodiment

[0058] With respect to the fuel injection device for a diesel engine according to this embodiment and a conventional counterpart, the state of wear of seat portions was compared after mounting and using of each device on a diesel engine.
In the fuel injection device for a diesel engine according to this embodiment, the seat portions of the nozzle body and the needle valve were subjected to SKD61 grinding after nitriding to remove the compound layer and the first layer in the diffusion layer.
In the conventional counterpart, the nozzle body is SKD61 and the needle valve is SKH51 (the nozzle body is nitrided).
As a result of having used the two, the wear in the conventional counterpart was 3 to 4 μm, while the wear in this embodiment was decreased to 2 μm.

[0059] In the above embodiment, the nozzle body 1 and the needle valve 2 both formed of an alloy steel were nitrided throughout the whole surfaces thereof, followed by removing the compound layer and the first layer in the diffusion layer from the surfaces of both seat portions 6 and 11, thereby affording the foregoing effect. However, only the seat portions 6 and 11 of the nozzle body 1 and the needle valve 2 may be formed by an alloy steel and the other portions of the nozzle body 1 and the needle valve 2 may be formed inexpensively using another metallic material. Further, even if the seat portions 6 and 11 of the nozzle body 1 and the needle valve 2 are formed of a nitrided alloy steel and the compound layer and the first layer in the diffusion layer are removed from the surface of the seat portion 6 of the nozzle body 1, while only the compound layer is removed from the surface of the seat portion 11 of the needle valve 2, there is obtained the effect of making wear and spalling difficult to occur in the seat portion 6 of the nozzle body 1 which is likely to cause a problem in point of durability.

[0060] 5. Another Embodiment (Fig. 13) The embodiment described above is related to the nozzle portion for fuel injection in the fuel injection device for a diesel engine, but a valve unit according to another embodiment of the present invention is disposed in a fuel system of a fuel injection device for a diesel engine and is applicable to, for example, a check valve (intake valve, discharge valve, constant pressure valve) in a fuel pressure-feed pump or a relief valve (safety valve) which operates to prevent pressure from increasing beyond a predetermined value.

[0061] A description will be given below about the structure of this valve unit.
A body 21 of this valve unit has an inlet 23 for fuel to flow in and an outlet 24 for fuel to flow out, the inlet 23 and the outlet 24 being in communication with each other through an inside space 25. A tapered body seat portion 26 is formed in the inlet 23. A valve element 22 is accom-

modated movably within the inside space 25 of the body 21. A tapered valve element seat portion 27 for abutment against the body seat portion 26 to close the inlet 23 is provided at an inlet 23-side one end portion of the valve element 22. In the inside space 25 of the body 21, a spring 29 as urging means for biasing the valve element 22 toward the inlet 23 with a predetermined urging force is mounted between the outlet 24 and a spring seat 28 formed on an opposite end portion of the valve element 22. As will be described later, when the fuel pressure on the inlet 23 side is low, the valve element seat portion 27 is brought into abutment against the body seat portion 26 to close the inlet 23 by means of the spring 29. Although in this embodiment the valve element seat portion 27 is tapered, it may be of any other shape, e.g., a planar shape.

[0062] A relation between the urging force of the spring 29 and the pressure of fuel is set as follows.
When the force of fuel pressure at the inlet 23 exerted on the valve element 22 becomes larger with a difference beyond the urging force of the spring 29 than the force of fuel pressure exerted at the outlet 24 on the valve element 22, the valve element 22 is pushed back toward the outlet 24 (downwards in the drawing) irrespective of the urging force of the spring 29, so that the valve element seat portion 27 and the body seat portion 26 become separated from each other, creating a gap, and fuel flows from the inlet 23 to the outlet 24 through the gap.

[0063] When the force of fuel pressure at the inlet 23 exerted on the valve element 22 becomes smaller than the sum of the force of fuel pressure at the outlet 24 exerted on the valve element 22 and the urging force of the spring 29, the valve element 22 moves toward the inlet 23 (upwards in the drawing), so that the valve element seat portion 27 and the body seat portion 26 come into contact with each other to cut off the fuel flow path. At this instant the valve element 22 collides with the body 21, thus leading to wear of the seat portions in the conventional structure. But in this embodiment there is adopted the following measure against the wear.

[0064] The body seat portion 26 and the valve element seat portion 27 are formed of a nitrided alloy steel and the compound layer and the first layer in the diffusion layer are removed from their surfaces. The material, how to manufacture, microscopic structure, properties and modified examples of the both seat portions are the same as in the fuel injection device for a diesel engine of the previous embodiment described above, the above descriptions related to them are used as reference.

[0065] In the conventional counterpart, there have been used, for example, a carburized material of SCM420 for the body of the valve unit and SUJ2 for the valve element, thus resulting in wear of each seat portion. However, according to the construction of this embodiment, it is possible to reduce wear of each seat portion and prolong the product life.

Claims

1. A fuel injection device for a diesel engine wherein a needle valve (2) is moved in the inside of a nozzle body (1) to which fuel is supplied, thereby opening or closing seat portions (6,11) through which the nozzle body (1) and the needle valve (2) come into contact with each other to control the injection of fuel from a nozzle hole (8), the nozzle hole being opened to the nozzle body (1),
wherein a portion serving as the seat portion (6) of the nozzle body (1) and a portion serving as the seat portion (11) of the needle valve (2) are formed by a nitrided alloy steel, and the surfaces of the nozzle body (1) and of the seat portion (6) are provided by a nitriding treatment with a nitrided layer,
comprising an outer compound layer and an inner diffusion layer lying just under the compound layer and consisting of a first outer layer relatively high in nitrogen content and a second inner layer being tough and low in nitrogen content, and
wherein the compound layer and the first layer of the diffusion layer are removed from the surface of at least a portion of the seat portion (6) so that the second inner layer of the diffusion layer is exposed on the portion of the seat portion (6).

2. The fuel injection device for a diesel engine according to claim 1, wherein the compound layer and the first layer of the diffusion layer are in addition removed from the surface of the portion serving as the seat portion (11) of the needle valve (2).

3. The fuel injection device for a diesel engine according to claim 1 or 2, wherein the second layer of the diffusion layer exposed on the portion serving as the seat portion (6) of the nozzle body (1) has a smoothness of at least less than Ra 0.4 in terms of surface roughness attained by grinding.

4. A method for manufacturing a fuel injection device for a diesel engine wherein a needle valve (2) is moved in the inside of a nozzle body (1) to which fuel is supplied, thereby opening or closing seat portions (6,11) through which the nozzle body and the needle valve come into contact with each other to control injection of fuel from a nozzle hole (8), the nozzle hole being opened to the nozzle body (1), the method comprising the steps of:

   forming the nozzle body (1) and the needle valve (2) with an alloy steel;
   nitriding a whole surface of the nozzle body (1) and a whole surface of the needle valve (2),
   grinding a surface of a portion serving as the seat portion (6) of the nozzle body (1) and a surface of a portion serving as the seat portion (11) of the needle valve (2) to remove compound lay-

er and a first layer relatively high in in nitrogen content of a diffusion layer lying just under the compound layer from each of the surfaces; and then assembling the nozzle body and the needle valve.

5. The method for manufacturing a fuel injection device for a diesel engine according to claim 4, further comprising the steps of specularly grinding a section of an alloy steel of the same material as the material of the nozzle body (1) and the needle valve (2) and similarly nitrided, etching the section with 10% or more of alcohol nitrate, thereafter observing the section through a microscope to recognize a boundary between the first layer and a second layer being tough and low nitrogen content of the diffusion layer, and determining a grinding quantity necessary for grinding the surfaces of the portions serving as the seat portions (6,11) of the nozzle body (1) and the needle valve (2) to remove the compound layer and the first layer of the diffusion layer.

6. A valve unit for a fuel injection device for a diesel engine having a valve element (2), the valve element being moved in the inside of a body (1) to which fuel is supplied from an inlet of the body, thereby opening or closing seat portions (6,11) through which the body and the valve element come into contact with each other to let the fuel flow out from an outlet (8) of the body,
wherein a portion serving as the seat portion (6) of the body (1) and a portion serving as the seat portion (11) of the valve element (2) are formed by a nitrided alloy steel, and the surfaces of the body and of the valve element together with their seat portions are provided by a nitriding treatment with a nitrided layer, comprising an outer compound layer and an inner diffusion layer lying just under the compound layer and consisting of a first outer layer relatively high in nitrogen content and a second inner layer being tough and low in nitrogen content, and wherein the compound layer and the first layer of the diffusion layer are removed from a surface of each of the portions serving as the seat portions of the body and the valve element, so that the second inner layer of the diffusion layer is exposed on these portions.

7. The valve unit according to claim 6, comprising:

a body (1) having an inlet (5) for the flow of fuel into the body and an outlet (8) for the flow of fuel out of the body, with a body seat portion (6) formed in the inlet;
a valve element (2) accommodated movably in the inside of the body (1) and having a valve element seat portion (11) adapted to abut the body seat portion (6) to close the inlet; and
urging means disposed in the inside of the body, the urging means exerting a predetermined urging force on the valve element seat portion (11) of the valve element (2) to bring the valve element seat portion into abutment against the body seat portion (6), thereby closing the inlet,
wherein when a force based on fuel pressure in the inlet and acting on the valve element becomes larger beyond the urging force than a force based on fuel pressure in the outlet (8) and acting on the valve element (2), the valve element seat portion (11) and the body seat portion (6) move away from each other and the fuel flows from the inlet (5) to the outlet (8), and
when the force based on the fuel pressure in the inlet and acting on the valve element (2) becomes smaller than the sum of the force based on the fuel pressure in the outlet and acting on the valve element and the urging force, the valve element seat portion (11) and the body seat portion (6) come into contact with each other to shut off the fuel flow path,
the body seat portion (6) and the valve element seat portion (11) being formed of a nitrided alloy steel, with a compound layer and a first layer in a diffusion layer removed from a surface of each of the body seat portion and the valve element seat portion.

Patentansprüche

1. Brennstoff-Einspritzeinrichtung für einen Dieselmotor, bei welchem ein Nadelventil (2) in dem Inneren eines Düsenkörpers (1) bewegt wird, dem Brennstoff zugeführt wird, wobei dabei Sitzabschnitte (6, 11) geöffnet oder geschlossen werden, durch welche der Düsenkörper (1) und das Nadelventil (2) in Kontakt miteinander treten, um das Einspritzen von Brennstoff von einem Düsenloch (8) zu steuern, wobei das Düsenloch zu dem Düsenkörper (1) mündet, wobei ein Abschnitt, der als der Sitzabschnitt (6) des Düsenkörpers (1) dient, und ein Abschnitt, der als der Sitzabschnitt (11) des Nadelventils (2) dient, durch einen nitrierten Legierungsstahl gebildet wird, und wobei die Oberflächen des Düsenkörpers (1) und des Sitzabschnitts (6) durch eine Nitrierbehandlung mit einer nitrierten Schicht versehen sind,
umfassend eine äußere Verbundschicht und eine innere Diffusionsschicht, welche unmittelbar unter der Verbundschicht liegt und aus einer ersten äußeren Schicht mit relativ hohem Stickstoffanteil und einer zweiten inneren Schicht, die fest ist und einen niedrigen Stickstoffanteil aufweist, gebildet ist, und
wobei die Verbundschicht und die erste Schicht der Diffusionsschicht von der Oberfläche von zumindest einem Abschnitt des Sitzabschnitts (6) entfernt werden, so dass die zweite innere Schicht der Diffusionsschicht auf dem Abschnitt des Sitzabschnitts (6)

exponiert wird

2. Brennstoff-Einspritzeinrichtung für einen Dieselmotor nach Anspruch 1, wobei die Verbundschicht und die erste Schicht der Diffusionsschicht zusätzlich von der Oberfläche des Abschnitts entfernt werden, welcher als der Sitzabschnitt (11) des Nadelventils (2) dient.

3. Brennstoff-Einspritzeinrichtung für einen Dieselmotor nach Anspruch 1 oder 2, wobei die zweite Schicht der Diffusionsschicht, die auf den Abschnitt, der als der Sitzabschnitt (6) des Düsenkörpers (1) dient, exponiert wird, eine Ebenheit von zumindest weniger als Ra 0,4 im Sinne einer durch Schleifen erhaltenen Oberflächenrauhigkeit aufweist

4. Verfahren zur Herstellung einer Brennstoff-Einspritzeinrichtung für einen Dieselmotor, wobei ein Nadelventil (2) in dem Inneren eines Düsenkörpers (1) bewegt wird, welchem Brennstoff zugeführt wird, wobei dabei Sitzabschnitte (6, 11) geöffnet oder geschlossen werden, durch welche der Düsenkörper und das Nadelventil in Kontakt miteinander treten, um Einspritzen des Brennstoffs aus einem Düsenloch (8) zu steuern, wobei das Düsenloch zu dem Düsenkörper (1) mündet, wobei das Verfahren die Schritte umfasst:

Ausbilden des Düsenkörpers (1) und des Nadelventils (2) mit einem Legierungsstahl;
Nitrieren einer gesamten Oberfläche des Düsenkörpers (1) und einer gesamten Oberfläche des Nadelventils (2),
Schleifen einer Oberfläche eines Abschnitts, welcher als der Sitzabschnitt (6) des Düsenkörpers (1) dient, und einer Oberfläche eines Abschnitts, welcher als der Sitzabschnitt (11) des Nadelventils (2) dient, um eine Verbundschicht und eine erste Schicht mit relativ hohem Stickstoffanteil einer Diffusionsschicht, welche unmittelbar unter der Verbundschicht liegt, von jeder der Oberflächen zu entfernen; und
anschließendes Zusammenbauen des Düsenkörpers und des Nadelventils

5. Verfahren zur Herstellung einer Brennstoff-Einspritzeinrichtung für einen Dieselmotor nach Anspruch 4, ferner umfassend die Schritte des Spiegel-Schleifens eines Abschnitts eines Legierungsstahl von dem gleichen Material wie dem Material des Düsenkörpers (1) und des Nadelventils (2) und der ähnlich nitriert ist, Ätzen des Abschnitts mit 10 % oder mehr von Alkoholnitrat, anschließendes Beobachten eines Abschnitts durch ein Mikroskop, um eine Grenze zwischen der ersten Schicht und einer zweiten Schicht, die fest und niedrig im Stickstoffgehalt ist, der Diffusionsschicht zu erkennen, und Bestimmen einer Schleifquantität, die zum Schleifen der Oberflächen der Abschnitte nötig ist, welche als die Sitzabschnitte (6, 11) des Düsenkörpers (1) und des Nadelventils (2) dienen, um die Verbundschicht und die erste Schicht der Diffusionsschicht zu entfernen

6. Ventileinheit für eine Brennstoff-Einspritzeinrichtung für einen Dieselmotor mit einem Ventilelement (2), wobei das Ventilelement in dem Inneren des Körpers (1) bewegt wird, welchem aus einem Einlass des Körpers Brennstoff zugeführt wird, wobei dabei Sitzabschnitte (6, 11) geöffnet oder geschlossen werden, durch welche der Körper und das Ventilelement in Kontakt miteinander treten, um den Brennstoff aus dem Auslass (8) des Körpers heraus fließen zu lassen,
wobei ein Abschnitt, welcher als der Sitzabschnitt (6) des Körpers (1) dient und ein Abschnitt, welcher als der Sitzabschnitt (11) des Ventilelements (2) dient, durch einen nitrierten Legierungsstahl ausgebildet sind, und die Oberflächen des Körpers und das Ventilelement zusammen mit deren Sitzabschnitten durch eine Nitrierbehandlung mit einer nitrierten Schicht versehen sind,
umfassend eine äußere Verbundschicht und eine innere Diffusionsschicht, welche unmittelbar unter der Verbundschicht liegt, und aus einer ersten Schicht mit relativ hohem Stickstoffanteil und einer zweiten Schicht, welche fest ist und einen relativ niedrigen Stickstoffanteil enthält, gebildet ist, und wobei die Verbundschicht und die erste Schicht der Diffusionsschicht von einer Oberfläche von jedem von den Abschnitten, welche als die Sitzabschnitte des Körpers und des Ventilelements dienen, entfernt werden, so dass eine zweite innere Schicht der Diffusionsschicht auf diesen Abschnitten exponiert wird

7. Ventileinheit nach Anspruch 6, umfassend:

einen Körper (1) mit einem Einlass (5) zum Strömen von Brennstoff in den Körper hinein und einem Auslass (8) zum Strömen von Brennstoff aus dem Körper heraus, wobei ein Körper-Sitzabschnitt (6) in dem Einlass ausgebildet ist;
ein Ventilelement (2), welches beweglich in dem Inneren des Körpers (1) untergebracht ist und einen Ventilelement-Sitzabschnitt (11) aufweist, der zum Anlegen des Körper-Sitzabschnitts (6) zum Schließen des Einlasses geeignet ist;
und
eine Drängungseinrichtung, die in dem Inneren des Körpers angeordnet ist, wobei die Drängungseinrichtung eine vorbestimmte Drängungskraft auf den Ventilelement-Sitzabschnitt (11) des Ventilelements (2) ausübt, um den Ventilelement-Sitzabschnitt in Anlage gegen den Körper-Sitzabschnitt (6) zu bringen, wodurch

der Einlass geschlossen wird,
wobei dann, wenn eine Kraft, die auf Brennstoffdruck in dem Einlass basiert und auf das Ventilelement wirkt, über die Drängungskraft hinaus größer als eine Kraft wird, die auf Brennstoffdruck in dem Auslass (8) basiert und auf das Ventilelement (2) wirkt, der Ventilelement-Sitzabschnitt (11) und der Körper-Sitzabschnitt (6) sich voneinander weg bewegen und der Brennstoff von dem Einlass (5) zu dem Auslass (8) strömt, und
wenn die Kraft, welche auf dem Brennstoffdruck in dem Einlass basiert und auf das Ventilelement (2) wirkt, kleiner als die Summe der Kraft, welche auf dem Brennstoffdruck in dem Auslass basiert und auf das Ventilelement wirkt und der Drängungskraft, der Ventilelement-Sitzabschnitt (11) und der Körper-Sitzabschnitt (6) in Kontakt miteinander treten, um den Brennstoffströmungspfad abzuschließen,
wobei der Körper-Sitzabschnitt (6) und der Ventilelement-Sitzabschnitt (11) aus einem nitrierten Legierungsstahl ausgebildet sind, mit einer Verbundschicht und einer ersten Schicht in einer Diffusionsschicht, die von einer Oberfläche von jedem von dem Körper-Sitzabschnitt und dem Ventilelement-Sitzabschnitt entfernt ist.

Revendications

1. Dispositif d'injection de carburant pour un moteur diesel, dans lequel une soupape à pointeau (2) est déplacée dans l'intérieur d'un corps de buse (1) auquel du carburant est fourni, ainsi ouvrant ou fermant des parties formant siège (6,11) à travers lesquelles le corps de buse (1) et la soupape à pointeau (2) entrent en contact l'un avec l'autre pour commander l'injection de carburant d'un trou de buse (8), le trou de buse étant ouvert au corps de buse (1),
dans lequel une partie qui sert comme partie formant siège (6) du corps de buse (1) et une partie qui sert comme partie formant siège (11) de la soupape à pointeau (2) sont formées par un acier allié nitruré, et les surfaces du corps de buse (1) et de la partie formant siège (6) sont fournies avec une couche nitrurée par un traitement de nitruration,
comprenant une couche de combinaison extérieure et une couche de diffusion intérieure qui est juste en dessous de la couche de combinaison et se compose d'une première couche extérieure, qui est relativement forte en azote, et une deuxième couche intérieure, qui est dure et faible en azote, et
dans lequel la couche de combinaison et la première couche de la couche de diffusion sont enlevées de la surface d'au moins une partie de la partie formant siège (6), de manière à exposer la deuxième couche intérieure de la couche de diffusion sur la partie de la partie formant siège (6).

2. Dispositif d'injection de carburant pour un moteur diesel selon la revendication 1, dans lequel la couche de combinaison et la première couche de la couche de diffusion sont en outre enlevées de la surface de la partie qui sert comme partie formant siège (11) de la soupape à pointeau (2)

3. Dispositif d'injection de carburant pour un moteur diesel selon la revendication 1 ou 2, dans lequel la deuxième couche de la couche de diffusion qui est exposée sur la partie qui sert comme partie formant siège (6) du corps de buse (1) est lisse d'au minimum moins de Ra 0 4 en termes de rugosité de surface qui est atteint par le meulage.

4. Procédé de fabrication d'un dispositif d'injection de carburant pour un moteur diesel, dans lequel une soupape à pointeau (2) est déplacée dans l'intérieur d'un corps de buse (1) auquel du carburant est fourni, ainsi ouvrant ou fermant des parties formant siège (6, 11) à travers lesquelles le corps de buse et la soupape à pointeau entrent en contact l'un avec l'autre pour commander l'injection de carburant d'un trou de buse (8), le trou de buse étant ouvert au corps de buse (1), le procédé comprenant les étapes suivantes:

former le corps de buse (1) et la soupape à pointeau (2) d'un acier allié;
nitrurer une surface entière du corps de buse (1) et une surface entière de la soupape à pointeau (2),
meuler une surface d'une partie qui sert comme la partie formant siège (6) du corps de buse (1) et une surface d'une partie qui sert comme la partie formant siège (11) de la soupape à pointeau (2) pour enlever une couche de combinaison et une première couche, qui est relativement forte en azote, d'une couche de diffusion qui est juste en dessous de la couche de combinaison, de chacune des surfaces; et
puis assembler le corps de buse et la soupape à pointeau

5. Procédé de fabrication d'un dispositif d'injection de carburant pour un moteur diesel selon la revendication 4, comprenant de plus les étapes suivantes:

le meulage spéculaire d'une section d'un acier allié du même matériau que le matériau du corps de buse (1) et de la soupape à pointeau (2) et nitrurée de manière similaire,
la gravure de la section avec au moins 10% de nitrate d'alcool,
ensuite l'observation de la section à travers un microscope pour reconnaître une limite entre la

première couche et une deuxième couche, qui est dur et faible en azote, de la couche de diffusion, et

la détermination d'une quantité de meulage nécessaire à meuler les surfaces des parties qui servent comme les parties de siège (6, 11) du corps de buse (1) et de la soupape à pointeau (2) pour enlever la couche de combinaison et la première couche de la couche de diffusion,

6. Unité de soupape pour un dispositif d'injection de carburant pour un moteur diesel, ayant un élément de soupape (2), l'élément de soupape étant déplacé dans l'intérieur d'un corps (1) auquel de carburant est fourni d'une arrivée du corps, ainsi ouvrant ou fermant des parties formant siège (6, 11) à travers lesquelles le corps de buse et l'élément de soupape entrent en contact l'un avec l'autre pour permettre au carburant de couler d'une sortie (8) du corps,

dans laquelle une partie qui sert comme partie de siège (6) du corps (1) et une partie qui sert comme partie de siège (11) de l'élément de soupape (2) sont formées par un acier allié nitruré, et les surfaces du corps et de l'élément de soupape ainsi que leurs parties de siège sont fournies avec une couche nitrurée par un traitement de nitruration, comprenant une couche de combinaison extérieure et une couche de diffusion intérieure qui est juste en dessous de la couche de combinaison et se compose d'une première couche extérieure, qui est relativement forte en azote, et une deuxième couche intérieure, qui est dure et faible en azote, et

dans laquelle la couche de combinaison et la première couche de la couche de diffusion sont enlevées d'une surface de chacune des parties qui servent comme parties formant siège du corps et de l'élément de soupape, de manière à exposer la deuxième couche intérieure de la couche de diffusion sur celles parties.

7. L'unité de soupape selon la revendication 6, comprenant:

un corps (1) ayant une arrivée (5) pour l'écoulement de carburant à l'intérieur du corps et une sortie (8) pour l'écoulement de carburant à l'extérieur du corps, avec une partie formant siège (6) du corps qui est formée dans l'arrivée;

un élément de soupape (2) logé de manière déplaçable dans l'intérieur du corps (1) et ayant une partie formant siège (11) de l'élément de soupape qui est adaptée pour être contiguë à la partie formant siège (6) du corps pour fermer l'arrivée; et

dispositif d'entraînement disposé à l'intérieur du corps, le dispositif d'entraînement exerçant une force d'entraînement prédéterminée sur la partie formant siège (11) de l'élément de soupape (2) de l'élément de soupape pour rendre la partie formant siège de l'élément de soupape contiguë à la partie formant siège (6) du corps, ainsi fermant l'arrivée,

dans laquelle, quand une force basée sur la pression de carburant dans l'arrivée et chargeant l'élément de soupape devient plus grande au-delà de la force d'entraînement qu'une force basée sur la pression de carburant dans la sortie (8) et chargeant l'élément de soupape (2), la partie formant siège (11) de l'élément de soupape et la partie formant siège (6) du corps s'éloignent l'une de l'autre et le carburant coule de l'arrivée (5) à la sortie (8), et

quand la force basée sur la pression de carburant dans l'arrivée et chargeant l'élément de soupape (2) devient plus petite que la somme de la force qui est basé sur la pression de carburant dans la sortie et qui charge l'élément de soupape et la force d'entraînement, la partie formant siège (11) de l'élément de soupape et la partie formant siège (6) du corps entrent en contact l'une avec l'autre pour bloquer le passage d'écoulement du carburant,

la partie formant siège (6) du corps et la partie formant siège (11) de l'élément de soupape étant formées d'un acier allié nitruré avec une couche de combinaison et une première couche dans une couche de diffusion enlevée d'une surface de chacune de la partie formant siège du corps et la partie formant siège de l'élément de soupape.

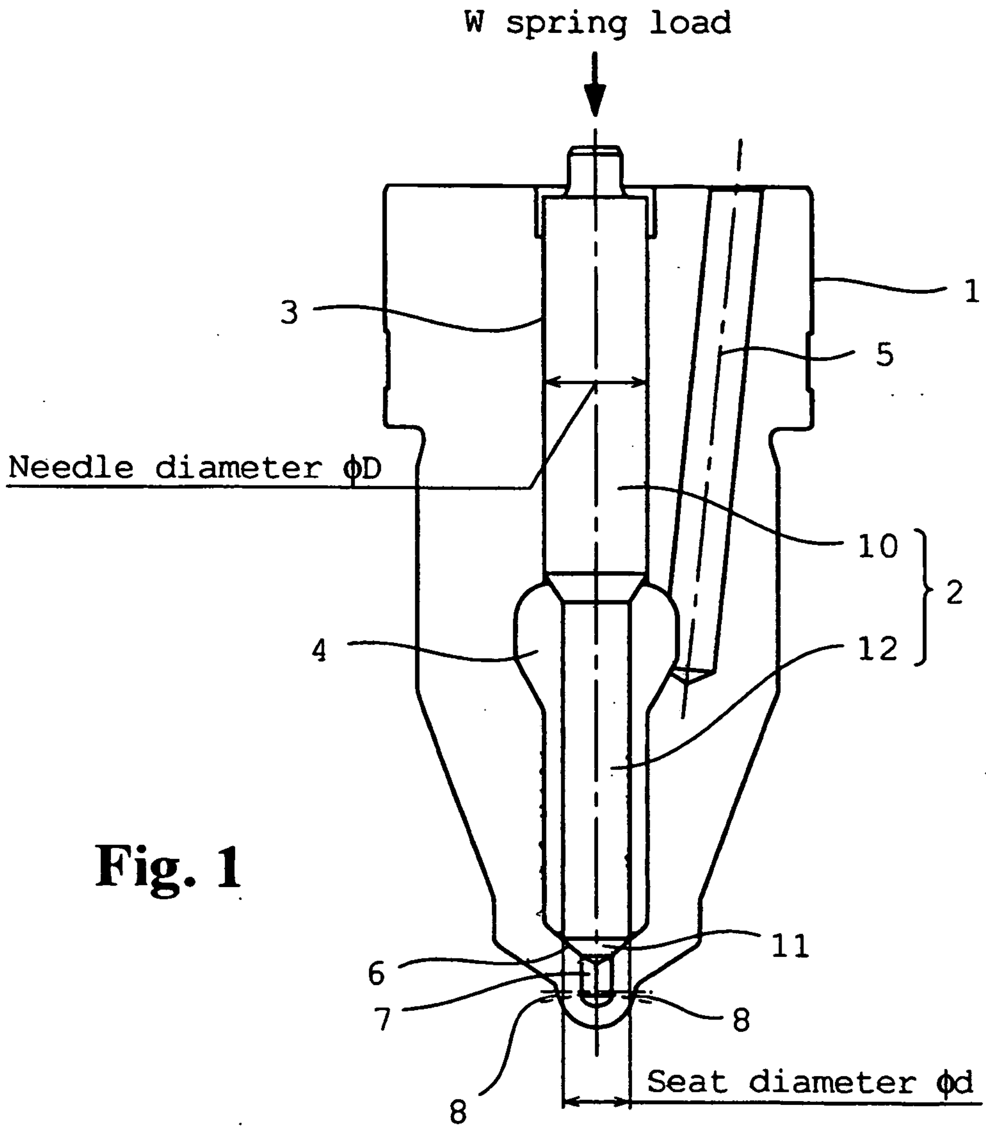

W spring load
1
3
5
Needle diameter ϕD
10
2
12
4
11
6
7
8
8
Seat diameter ϕd

Fig. 1

Fig. 2A

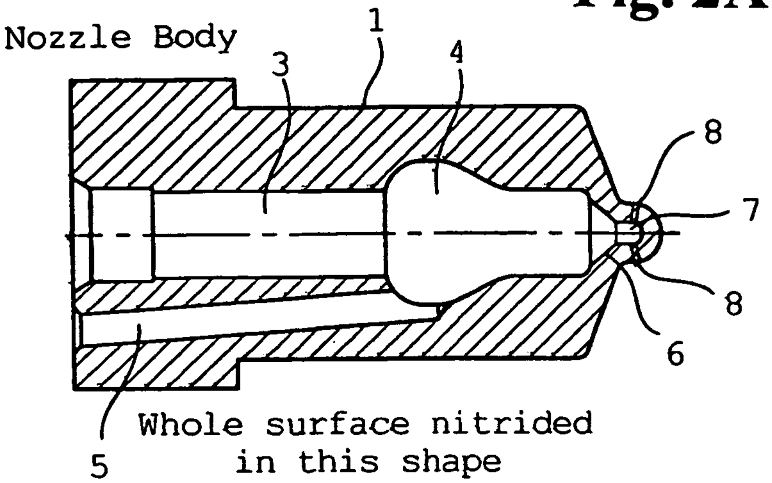

Nozzle Body
1
3
4
8
7
8
6
5
Whole surface nitrided
in this shape

Fig. 2B

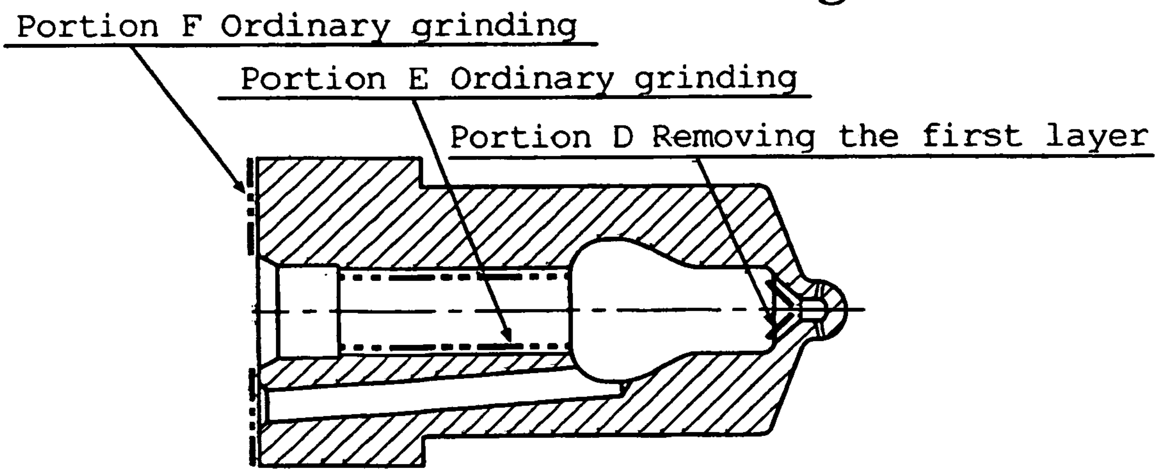
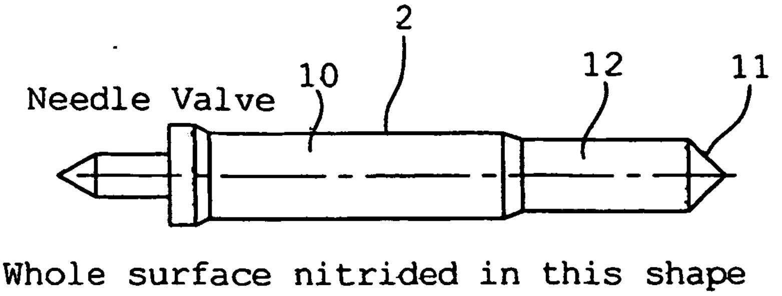

Portion F Ordinary grinding
Portion E Ordinary grinding
Portion D Removing the first layer

Fig. 3A


2
10
12
11
Needle Valve
Whole surface nitrided in this shape

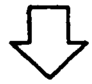
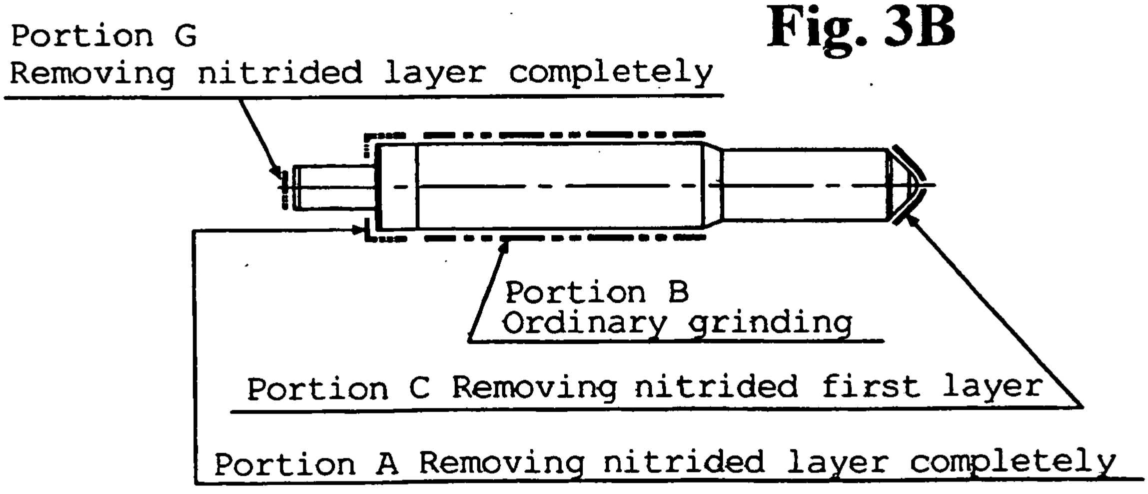


Fig. 3B


Portion G
Removing nitrided layer completely
Portion B
Ordinary grinding
Portion C Removing nitrided first layer
Portion A Removing nitrided layer completely

SKD61 Nitrided Layer Form

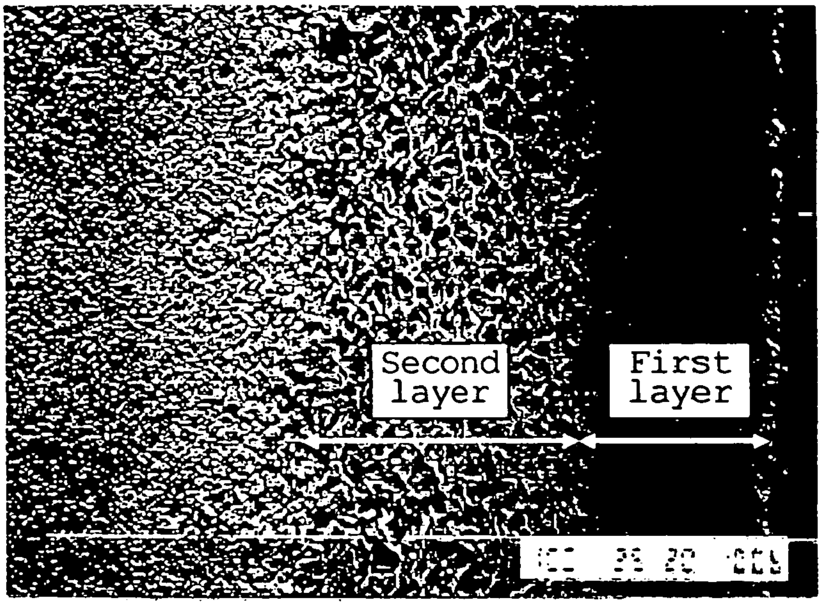


Fig. 4

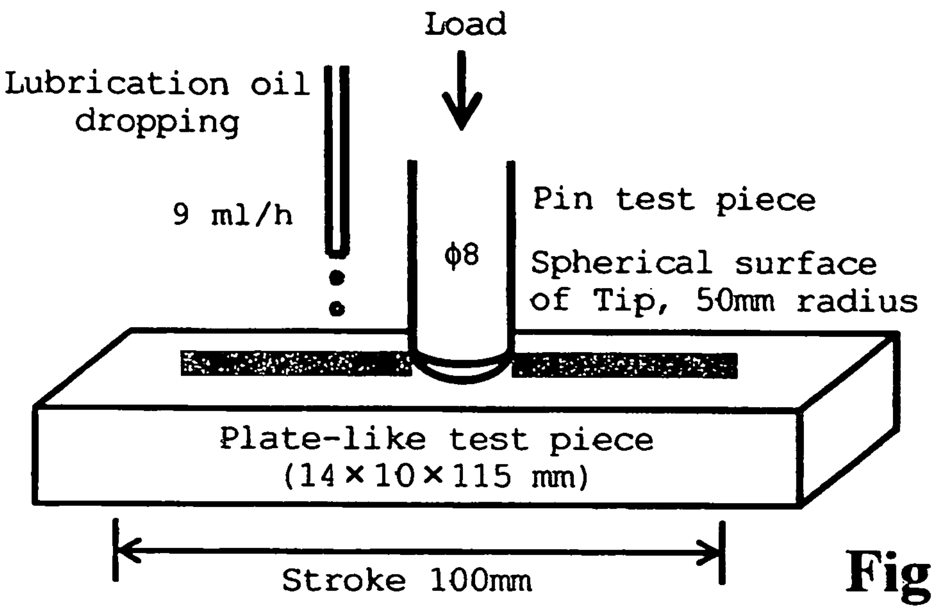

Load
Lubrication oil dropping
9 ml/h
Pin test piece
ϕ8
Spherical surface of Tip, 50mm radius
Plate-like test piece
(14×10×115 mm)
Stroke 100mm

Fig. 5

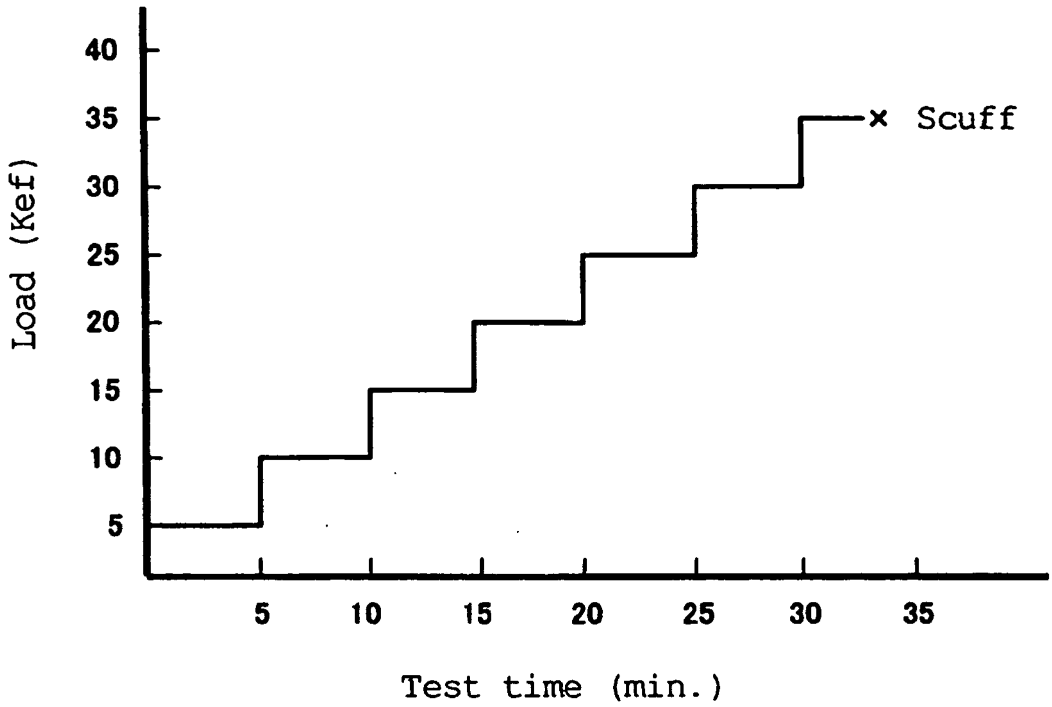


Fig. 6 Seizure Test Outline

Fig. 7

Sliding Speed Varying Test

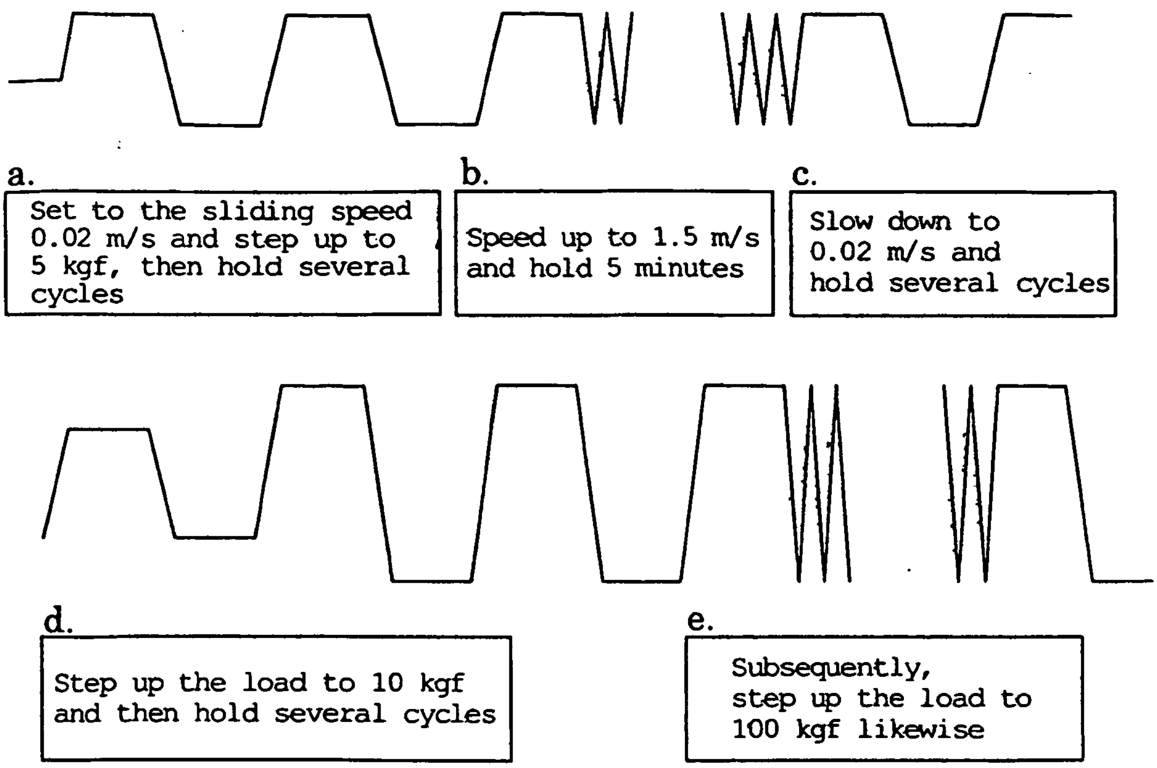
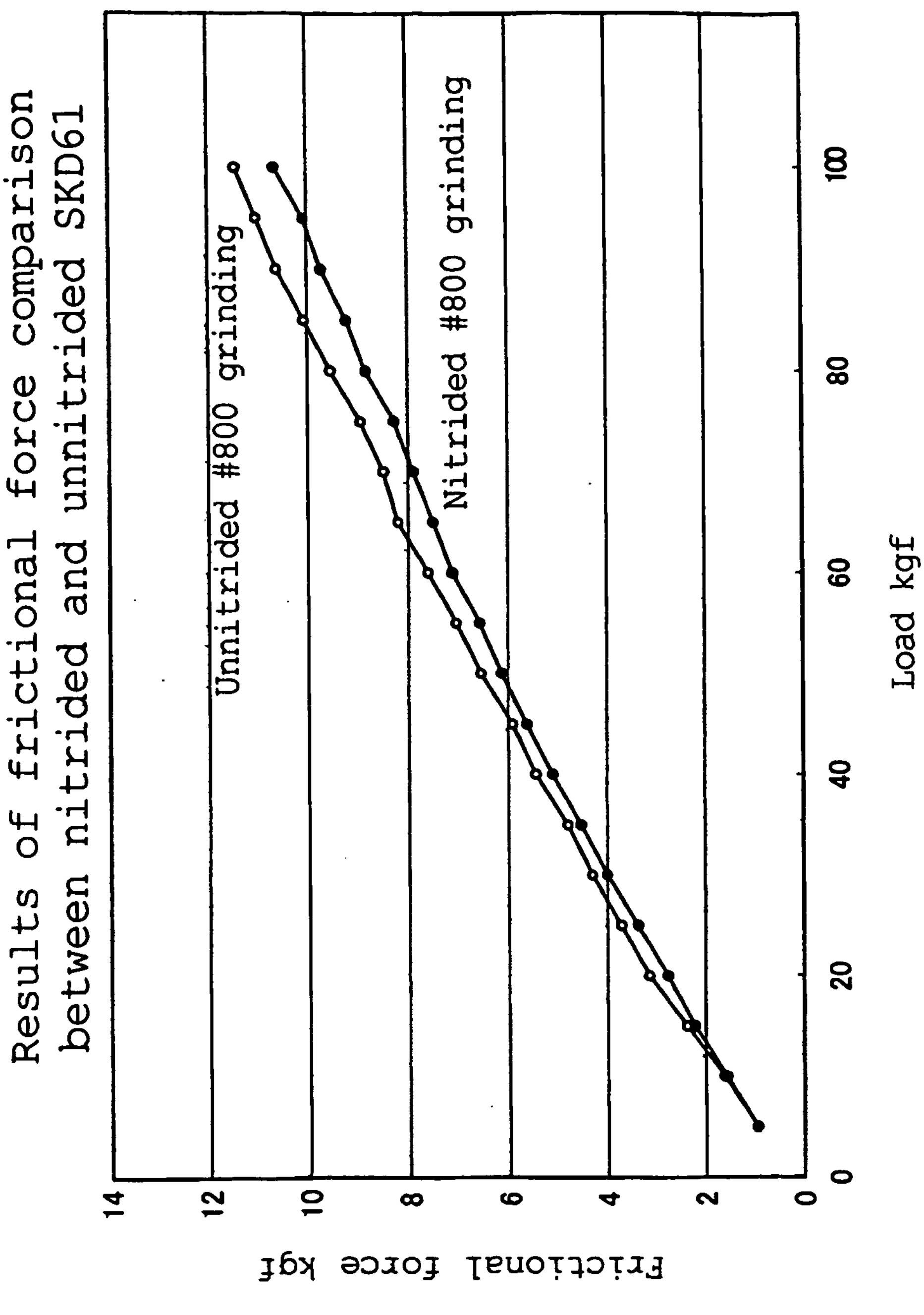


Fig. 8


Results of frictional force comparison
between nitrided and unnitrided SKD61
Unnitrided #800 grinding
Nitrided #800 grinding
Frictional force kgf
Load kgf
0
2
4
6
8
10
12
14
0
20
40
60
80
100

Pin appearance [SKD61]

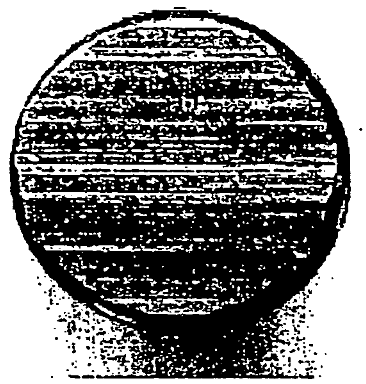


Fig. 9A

Plate TP appearance
[SKD61 nitrided]

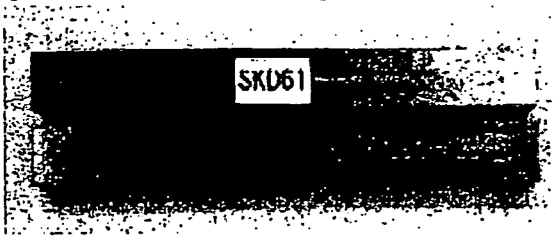


Fig. 9B

Pin appearance
[SKD61 nitrided]

A5

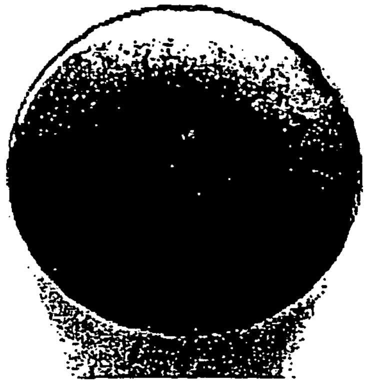


Fig. 10A

Plate TP appearance
[SKD61 nitrided #800 grinding]

A7

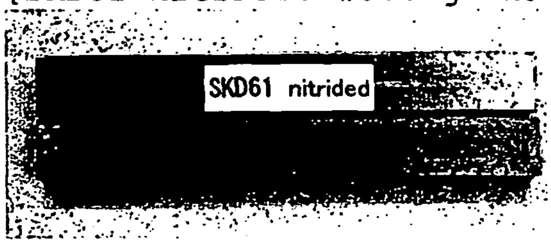


Fig. 10B

Pin appearance [SKD61]

A2

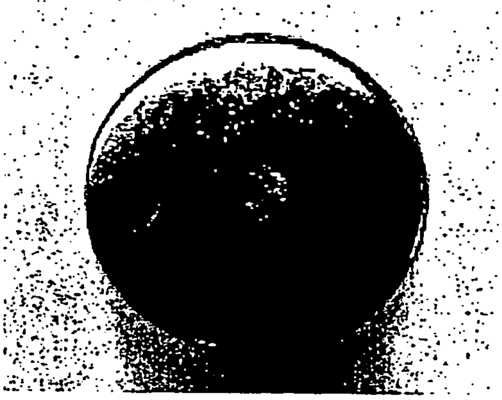


Fig. 11A

Plate TP appearance
[SKD61 nitrided #800 grinding]

A4

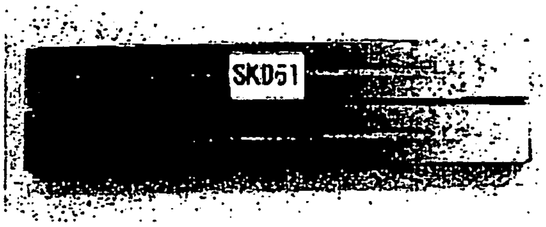
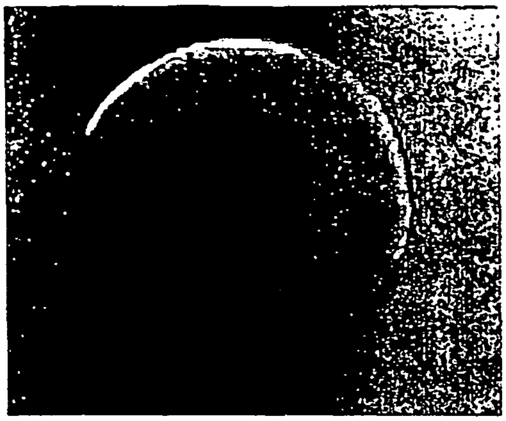


Fig. 11B

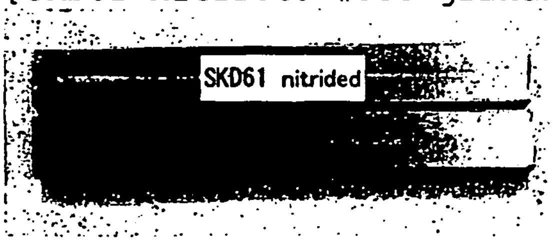
Pin appearance
[SKD61 nitrided]



A6

Fig. 12A

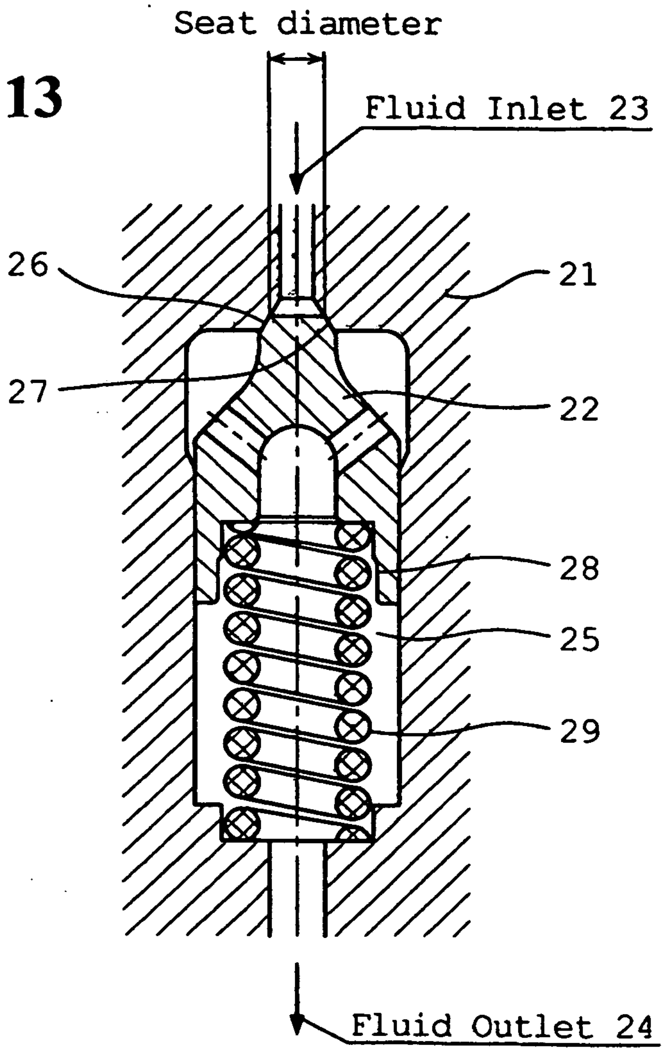
Plate TP appearance
[SKD61 nitrided #800 grinding]



A8

Fig. 12B

Fig. 13


Seat diameter
Fluid Inlet 23
26
21
27
22
28
25
29
Fluid Outlet 24

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20070069576 A **[0008]**