May 8, 1934. F. JEHLE 1,958,004

INTERNAL COMBUSTION ENGINE AND SIMILAR MACHINE

Filed April 20, 1931

Fig. 1.

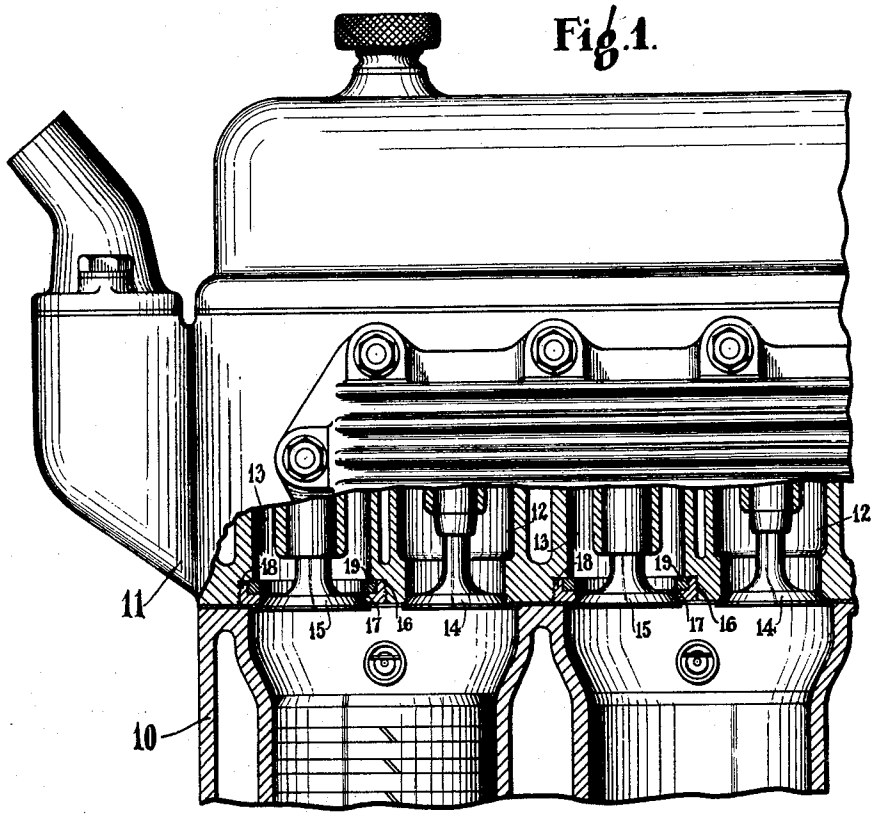


Fig. 2.

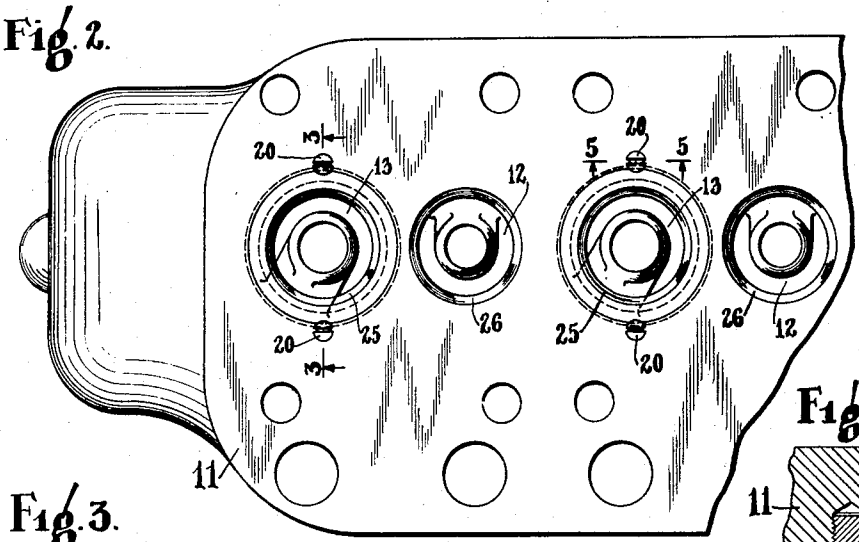


Fig. 3.

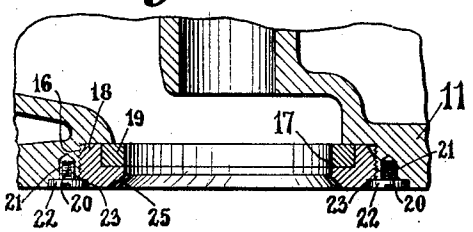


Fig. 4.

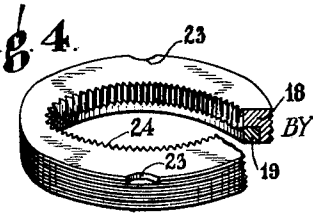
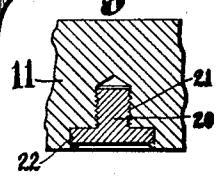


Fig. 5.



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INTERNAL COMBUSTION ENGINE AND SIMILAR MACHINE

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Application April 20, 1931, Serial No. 531,294

6 Claims. (Cl. 123—188)

This invention relates to internal combustion engines of the poppet valve type, and to similar machines in which the seats for the valves are heated to varying temperatures.

It is often necessary in the construction of machines of the type to which this invention pertains, in order to obtain certain qualities in the valve seats, to construct the valve seats of a different material having a greater coefficient of thermal expansion than that used in the construction of the associated parts of the machines. In those instances, in which the valve seat material has a substantially greater coefficient of thermal expansion than that of the material used in the construction of the associated parts of the machines, difficulty is encountered in securing the valve seats in place. The difficulty thus encountered arises from differential expansion of the valve seats and associated parts which, under the more simple methods of securing valve seats in place, acts either to produce a permanent deformation of the valve seats or associated parts, or to effect a rupture thereof.

I have discovered that the stresses imposed upon a valve seat and the associated parts of a machine by temperature change may be modified by shrinking the valve seat part over an inner part. By applying this discovery to the problem of affixing valve seats to parts having a substantially lower thermal expansion, I have found that in most instances where trouble occurs through deformation or rupture of the valve seat or associated parts, that such trouble may be overcome through the use of a properly designed composite valve seat unit comprising a valve seat part of the material sought to be used, and an inner part over which the valve seat part is shrunk, constructed of a selected material consonant with the purpose of such construction.

In the drawing;

Figure 1 is a fragmentary side elevation, partly in section of an engine equipped with valve seat units constructed in accordance with this invention.

Figure 2 is a fragmentary bottom plan view of the cylinder head of the engine shown in Figure 1.

Figure 3 is a fragmentary section taken on line 3—3 of Figure 2.

Figure 4 is a perspective view, partly in section, of an unfinished valve seat unit of the type shown in Figures 1, 2 and 3, and

Figure 5 is a fragmentary section taken on line 5—5 of Figure 2.

Referring to the drawing, the engine therein illustrated consists in general of a conventional assembly of conventional parts including a block 10 and a cylinder head 11. The cylinder head 11 is constructed of cast iron, and is formed with inlet and exhaust passages 12 and 13 controlled by inlet and exhaust valves 14 and 15 respectively. Screwed into a threaded seat 16 adjacent the interior end of each exhaust passage 13, there is a valve seat insert or unit 17 comprising an outer aluminum bronze valve seat part 18 shrunk upon an inner steel part 19. The inserts 17 have a tight threaded engagement with their seats 16, and are held against rotation by means of screws 20, which screws are turned into threaded bores 21 formed in the cylinder head 11, and are formed with enlarged heads 22 which fit within seats 23 formed conjointly in the inserts and cylinder head.

The aluminum bronze alloy used in the construction of the valve seat parts is particularly adapted for use in the valve seats of an internal combustion engine, but has a substantially greater coefficient of thermal expansion than that of cast-iron, and when employed in the form of an insert secured in place in a cast-iron part in a like or similar manner to the inserts 17, is deformed and loosened within its seat by its tendency to expand a greater amount than that permitted by expansion of its seat.

In the present construction, the parts 18 and 19 of the inserts 17 are so designed, that the difference in expansion of the assembled inserts and their seats in the cast-iron head is insufficient to stress the aluminum bronze parts beyond their elastic limit to thereby cause a deformation of such parts. Moreover, the parts 18 and 19 are so designed that they will not be stressed beyond their elastic limits, and thus be deformed, by the maximum tension set up in the valve seat parts.

A convenient and logical procedure which may be employed in the design of a unit as above described, in order to reduce the experimental work, is as follows:

1. Assume for the maximum tensile stress to be set up in the aluminum bronze part as high a value as can be safely used without stressing the aluminum bronze part beyond its elastic limit, and calculate the stress which will be imposed upon the aluminum bronze part by expansion of the unit against its seat under the best conditions of design. The computation of the stress imposed upon the aluminum bronze part may be

accomplished through solutions of the formula,

$$S=E_B\,T(C_B-C_C)-S_b,$$

in which:—

S=the stress imposed upon the aluminum bronze part.

E_B=the modulus of elasticity in tension of the aluminum bronze part.

T=the change in temperature to which the insert will be subjected in use.

C_B=the thermal coefficient of lineal expansion of the aluminum bronze part.

C_C=the lineal expansion of cast iron.

S_B=the assumed maximum tensile stress to be set up in the aluminum bronze part.

If the stress which will be imposed upon the aluminum bronze part by expansion of the unit against its seat is greater than the yield strength of the aluminum bronze part, it will be impossible to design an insert of the type contemplated in which the aluminum bronze part will not be deformed by differential expansion of the insert and its seat. It will be found, however, that the stress imposed upon the aluminum bronze part of an insert for an internal combustion engine of conventional size will be well within the elastic limit of aluminum bronze.

2. Assign to the parts of the unit cross-sectional dimensions such that

(*a*) The requirements of the available space are satisfied, and

(*b*) The area of the bronze part is made as small as is consonant with good design.

The latter condition, as will readily be understood from a thorough study of the problem of design, makes for the smallest interference fit of the parts.

3. Compute the elongation of the inner diameter of the aluminum bronze part under the tensional stress assumed under step 1. This may be accomplished by means of the formula,

$$e_B=\frac{S_B d^o_B}{E_B}$$

in which:—

e_B=the elongation of the diameter of the aluminum bronze part.

S_B=the assumed maximum stress to be set up in the aluminum bronze part.

d^o_B=the inner diameter of the aluminum bronze part in unassembled condition at the lowest temperature to which such part will be subjected in use. This value is taken to equal the sum of the diameter of the port opening plus twice the width of the steel part.

E_B=the modulus of elasticity in tension of the aluminum bronze part.

4. Compute the decrease in the diameter of the steel part which will be produced by the assumed maximum value of the tensional stress set up in the aluminum bronze part. This may be accomplished by the solution of the formula,

$$e_S=e_B\frac{A_B E_B}{A_S E_S}$$

in which:—

e_B=the elongation of the inner diameter of the aluminum bronze part computed under step 3.

e_S=the decrease in the diameter of the steel part.

A_B=the cross section of area of the aluminum bronze part.

E_B=the modulus of elasticity in tension of the aluminum bronze part.

A_S=the cross section of area of the steel part.

E_S=the modulus of elasticity in compression of the steel part.

5. Compute the outer diameter of the steel part in an unassembled condition at minimum temperature, that is, the lowest temperature to which the unit will be subjected in use. This is effected through solution of the formula,

$$d^o_S=d^o_B+(e_B+e_S)$$

in which:—

d^o_S=the aforesaid diameter of the steel part.

d^o_B=the inner diameter of the aluminum bronze part assumed under step 3.

e_B=the elongation of the inner diameter of the aluminum bronze part computed under step 3.

e_S=the decrease in the outer diameter of the steel part computed under step 4.

6. Compute the inner diameter of the aluminum bronze part and the outer diameter of the steel part in unassembled condition at the temperature at which such parts are to be machined into final form. This is effected by the solution of the formulæ,

$$d^t_B=d^o_B+d^o_B\,c_B{}^t \text{ and } d^t_S=d^o_S+d^o_S\,C_S{}^t$$

in which:—

d^t_B=the inner diameter of the unassembled aluminum bronze at the temperature at which such part is to be machined in final form.

d^o_B=the inner diameter of the aluminum bronze part assumed under step 3.

C_B=the thermal coefficient of lineal expansion of the aluminum bronze part.

t=the temperature change from minimum temperature to the temperature at which the parts are to be machined into final form.

d^t_S=the inner diameter of the unassembled steel part at the temperature at which such part is to be machined in final form.

d^o_S=the outer diameter of the steel part computed under step 5.

C_S=the thermal coefficient of lineal expansion of the steel part.

The units 17 are each initially constructed of a steel ring 19 and an aluminum bronze part of the form shown in Figure 4, the assembly of the two parts being effected by heating the aluminum bronze part to a temperature at which the steel part may be dropped into place. Following the assembly of the two parts of the units, the units are screwed into their seat 16 in the cylinder head by means of a special tool which engages the radial projections 24 of the aluminum bronze part. After the units have been set up tightly in their seats 16, the cylinder head and units are formed with the previously described seats 23 for the heads of the screws 20, following which the cylinder head is formed with the threaded bores 21 for the reception of the shanks of the screws 20. The screws 20 are then inserted into the bores 21 and turned into place, after which the metal of the head adjacent the screws is peened over into the grooves of the screws. Following the insertion of the screws 20, the projections 24 of the aluminum bronze part are machined away, and the seating surfaces 25 added.

The inlet valves 14 are provided with seats 26 formed in the cast iron cylinder head 11, but if desired may be provided with valve seat inserts similar to the inserts 17. Such construction, however, is not warranted in the present engine as the inlet valves and their seats are not subjected to sufficiently high temperatures as to materially lessen their resistance to

wear or to cause a material amount of scaling or pitting of such parts.

Although the foregoing description has been concerned with securing an aluminum bronze valve seat to a cast-iron part, it is to be understood that my invention is of a more general nature, and may be employed to secure valve seats of various materials to parts constructed of various materials.

It is further to be understood that my invention is not limited to valve seat units designed and constructed in the manner of the valve seat units herein described, but is broad enough to comprehend any valve seat unit in which one part is tensioned over another part in order to decrease the stresses imposed upon the parts of the unit, or the associated parts of the machine of which the unit forms a part.

It is further to be understood that my invention comprehends any method of securing a valve seat unit in place, in which the unit and the adjacent portion of the machine will be placed under stress through temperature change as a result of the unit having a different thermal expansion than that of the adjacent portion of the machine.

What I claim is:

1. A valve seat unit for an internal combustion engine or similar machine comprising an inner member, and a valve seat member shrunk upon said inner member.

2. A valve seat unit for an internal combustion engine or similar machine comprising a valve seat member, and a member having a smaller thermal expansion over which said valve seat member is tensioned.

3. A valve seat unit for an internal combustion engine or similar machine comprising a valve seat member of aluminum bronze, and a second member having a smaller thermal expansion over which said valve seat member is tensioned.

4. A valve seat unit for an internal combustion engine or similar machine comprising an inner steel member, and a valve seat member of aluminum bronze shrunk over said steel part.

5. A valve seat unit for an internal combustion engine or similar machine comprising an inner member, and a valve seat member tensioned upon said inner member.

6. A valve seat unit for use in an internal combustion engine in conjunction with a poppet valve for controlling a passage leading into a combustion chamber of an engine, designed for securement within a recess formed at the inner end of said passage in circumambient relation to said passage, said unit comprising an inner part and an outer part formed with a valve seat surface tensioned upon said inner part.

FERDINAND JEHLE.