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No More Valve Grinding!

by Joseph Geschelin

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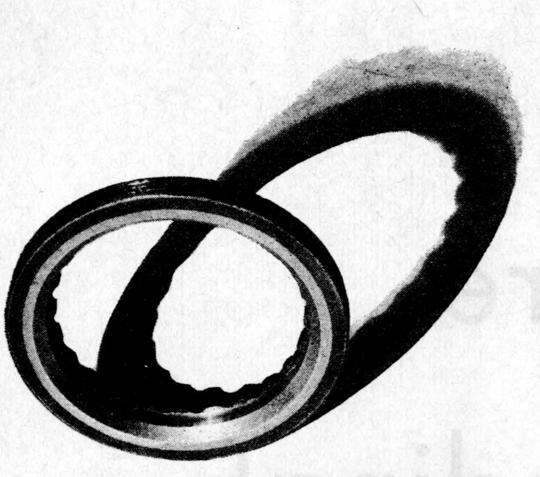

Courtesy Haynes-Stellite Co.

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No More Valve Grinding!

Elimination of this common service job and of other troubles too is aim of valve seat insert developments summarized here.

JUST when a large group of commercial engine builders were wrinkling their brows over the desirability of inserted valve seats—BANG, along comes Chrysler with inserted exhaust valve seats on the whole family including the economically-priced Plymouth. And in the same breath we learn that Willys has followed suit on both the four and six.

Why all the excitement? Apparently it's a case of history repeating itself. Once again an idea born of the hard knocks of service bids fair to find its place as a new engineering principle. We say this advisedly considering that aircraft engines and the few passenger car jobs using aluminum blocks have incorporated inserted valve seats for many years. But their problem is entirely different. Such engines couldn't operate without hard inserts, while engines with cast iron blocks can.

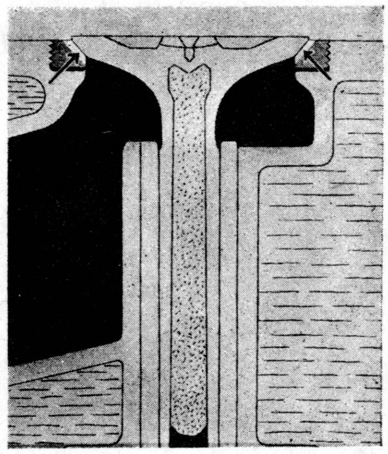


Fig. 2 — Bi-metal Stellited insert, screwed-in construction. Light portion adjacent to the valve is Stellite

Some of the larger fleet operators and service stations have used inserted valve seats for several years. This resulted logically from the necessity of servicing valve seats which were burned, pitted, or pounded out, on heavy duty equipment. In this type of service, valve seats had to be serviced frequently, and considerable metal had to be removed periodically, so that the very life of an expensive cylinder block was dependent upon the amount of metal below and around the valve seat.

For a time, some jobs were serviced by welding new metal into the worn seat. Perhaps this procedure still is necessary on certain old engines which do not permit the counterboring necessary for the ring. At any

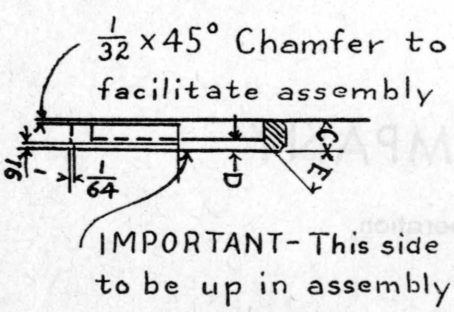


Fig. 1—Typical Buda insert of special alloy cast iron

TABLE I

NAME	Valve Insert	Material	Method of Application	Press Fit
Buda	Fig. 1	Spec. Alloy Iron	Pressed and rolled-in	0.006-0.007 in.
Haynes-Stellite	Fig. 2	Bi-metal	Screwed-in	
White Motor	Fig. 3	Bi-metal	Screwed-in	
Hercules	Fig. 4	Cast iron	Pressed and Rolled-in	
Waukesha	Fig. 5	Spec. Alloy Iron	Pressed	0.008-0.010 in.
Lycoming	Fig. 6	High tungsten steel	Pressed and Rolled-in	
Allis-Chalmers	Fig. 7	High speed tool steel	Pressed	0.003-0.007 in.
Autocar	Fig. 8	High speed tool steel	Pressed and Rolled-in	0.007 in.
Sheepbridge-Stokes	Fig. 9	Centrifugal cast iron	Spec. Press Fit	1½-2½-ton pressure

Grinding!

rate, the service field worked out its own salvation quite satisfactorily. We know of one large fleet operator in Philadelphia who used inserted exhaust valve seats made of a special grade of cast iron, more than five years ago. We are told by one of our friends in the service field that Yellow Cab of Chicago used inserted valve seats as far back as 1919.

In view of the possibility of a general adoption of inserted valve seats, we have gathered together a good deal of valuable information from various sources in the hope that it may be of service to engineers who are working on the problem.

A census of those who have adopted inserted valve seats includes the names of some of the outstanding organizations in the industry as will be evident from the list given in table I. To these, we may add Mack, General Motors Truck, and several others who are not yet ready to release the information; also Chrysler and Willys with high-speed steel inserts on both the four and six.

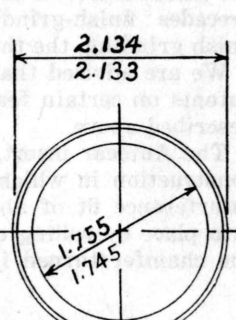
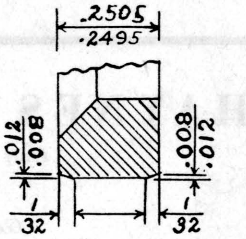


Fig. 4—Hercules insert of cast iron



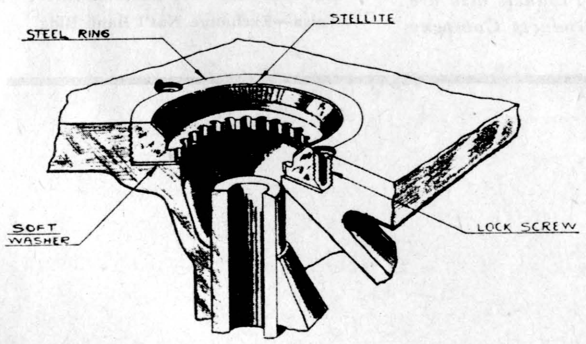


Fig. 3—White Co., insert of bi-metal construction, screwed into threaded seat. It is screwed down on a soft metal washer set in the base of the counterbore. Threads are painted with a bonding material for heat transfer and locking

Correspondence indicates that there is a group of industrial engine builders who are awaiting the results of experimental tests before adopting the new construction. These and others are watching the outcome of experimental work by users who have taken the initiative and put in the valve seats on their own engines.

It is obvious from recent correspondence that many engineers are convinced of the desirability of employing inserted valve seats but prefer to rest their decision upon the verdict of service experience. For service alone will bring out the weakness or soundness of optional materials and methods of application.

According to a recent study by Haynes Stellite, the inserted valve seat is a necessity on the current crop of engines because higher compression ratios, faster speeds, and more constant running at full load, all contribute to shortening the useful life of seats machined in a cast iron block. Moreover, the exhaust valve is subjected to high temperatures at which a deposit of an extremely hard substance is formed on the valve seat and valve. As the seat wears away or is pounded in, and the valve sinks deeper into the block, the clearance between the valve stem and plunger is diminished. When this clearance is completely taken up leaks occur and the engine may lose compression attended by rapid erosion.

The logical answer is to use some abrasion—and heat-resisting material which resists these conditions more successfully than the material used for the block or head casting.

According to Haynes Stellite, there are three major requirements of a valve seat material:

1. It must have approximately the same coefficient of expansion as the cylinder block material.

2. It must resist abrasion and softening at elevated temperatures.

3. It must resist the formation of deposits of foreign substances.

E. I. Williams, of P. R. Mallory, gives the following six criteria for an acceptable valve seat in a paper he

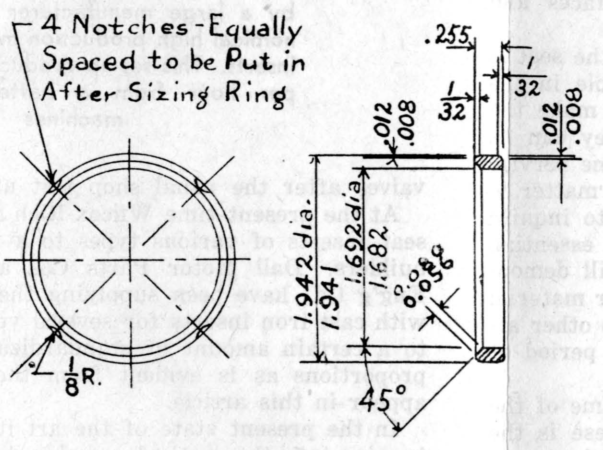


Fig. 5—Typical Lycoming insert of high tungsten steel. Note the four notches around the periphery to assure locking when the insert is rolled in place

read June 2, 1932, before the Automotive Engine Rebuilders' Association:

"1. It must stand up to its particular duty. With light passenger cars, we don't have much trouble with valve seats as a rule, and the cheapest kind of seat is, therefore, perfectly satisfactory. On the other hand, we have the very heavy duty, hot engines running at high speed, pulling trailers over mountains, and there we feel that the very best material that you can get is the cheapest in the end.

"2. The coefficient of expansion must be taken into consideration. The cast iron, of course, has approximately the same expansion as the block; the steels and alloys have not.

"3. High thermal conductivity to help cool the valve head. This is a very important item. Note the expense valve manufacturers have gone to to help accomplish this.

"4. Action on the valve. A material might make a perfect seat in itself but tend to injure the valve proper.

"5. Ease of installation and serviceing.

"6. The material should be cheap for the job it has to do."

A wide range of materials has been used for valve seat inserts starting with plain cast iron at one end and embracing Stellite and Elkonite at the other. In between there is the gamut of combinations some of which are noted in table 1. These include alloy cast irons, cold rolled steel, high speed steel, high tungsten steel, and various proprietary brands. Obviously, the choice of material has to be made carefully on the basis of service requirements and the criteria mentioned above, together with a consideration of the costs involved since the material will govern to some extent the method of application.

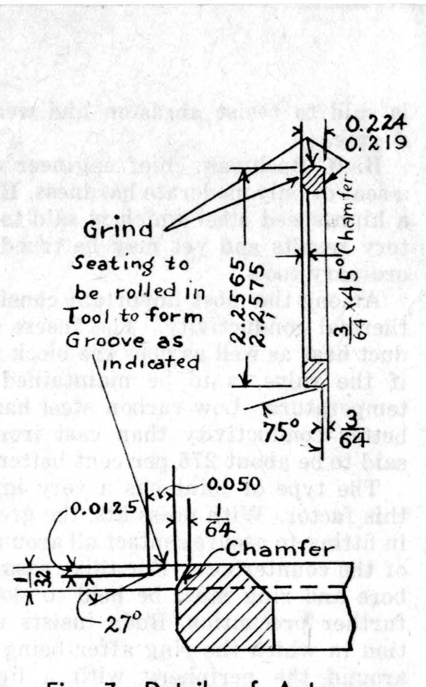


Fig. 7—Details of Autocar method of rolling in the high speed tool steel insert

Broadly, there are two general methods of installing valve seats. One which has wide acceptance consists in pressing in with a force fit and spinning over the block material so as to hold the ring in place. The other method, chiefly used in fitting the bi-metal inserts made by Wilcox-Rich is to thread into the block and anchor by means of set screws.

Inserted valve seats bring up a number of technical points which must be thoroughly investigated before any specific method is adopted in regular production. In the first place there is the moot question, quite disturbing to metallurgists, as to the relation between hardness and wear resistance. Bi-metal, Stellited seats made by Wilcox-Rich rely upon extreme hardness. Haynes Stellite in a recent survey finds White heavy duty engines have run 75,000 to 100,000 miles without needing regrinding or refinishing of the valves.

On the other hand, Elkonite, according to Mr. Williams, has entirely different properties. Although it is "soft" enough to be readily machinable in the field, it

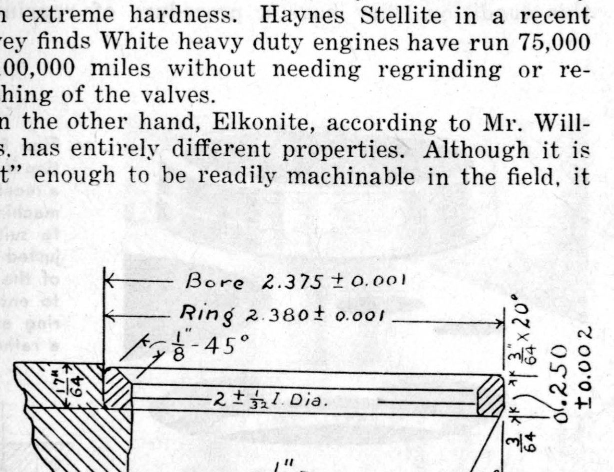


Fig. 6—Allis-Chalmers makes the insert of high speed tool steel and rolls in place for locking

is said to resist abrasion and wear to a remarkable degree.

B. B. Bachman, chief engineer of Autocar, prefers a seat of only moderate hardness. His company is using a high speed steel which is said to give very satisfactory results and yet may be trued up in service with ordinary tools.

Among the most important considerations is that of thermal conductivity. The insert material must conduct heat as well as does the block material, and better if the valve is to be maintained at reasonably low temperature. Low carbon steel has about 20 per cent better conductivity than cast iron while Elkonite is said to be about 275 per cent better.

The type of joint has a very important bearing on this factor. With press fits, the greatest care is needed in fitting to assure contact all around and at the bottom of the counterbore. For this reason, both the counterbore and ring must be held to close tolerances. As a further precaution, Buda insists upon a final inspection in which the ring after being rolled in, is tapped around the periphery with a light hammer. It is claimed that this checks the joint with great precision.

In a similar fashion, great care is needed in fitting threaded inserts to assure good conductivity. The White seat which is Stellite-faced and screwed in, is painted with a special solution to assist in a bonding action at the thread. This bonding material fills the clearance space between the threaded surfaces and thus aids in heat transfer.

Finally, there is the question of whether the seat is to be considered as permanent or replaceable in the field. Ostensibly, the current practice is to make the seats replaceable and it is claimed that they can be readily removed if necessary. However, some service men claim that it would be a rather difficult matter to carry this out in practice. This leads one to inquire whether the replacement feature is indeed essential. It is quite likely that service experience will demonstrate that a well-designed seat of the proper material will last as long as the block and require no other attention than that of truing-up after a long period of service.

Enough service data exists to establish some of the possible difficulties in the field. One of these is the possibility of trouble when using a pressed-in insert having a coefficient of expansion sensibly different from that of cast iron. One engine builder in the heavy-duty field reports that warping has developed in several cases with their high speed steel insert. To correct this condition, they have a procedure of regrinding valves after the usual shop test under heavy loads.

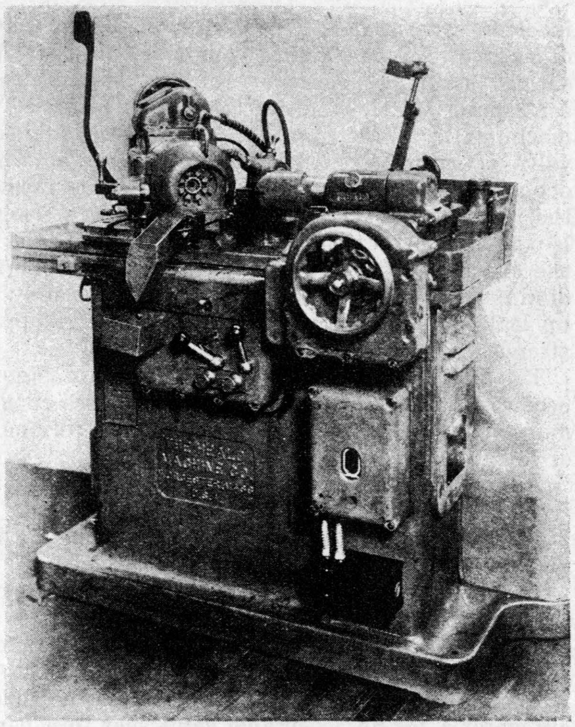


Fig. 9—Heald Sizematic grinder used by a large manufacturer for the economical high production manufacture of inserts. This set-up produces 450 pieces per hour from a battery of three machines

At the present time Wilcox-Rich is supplying valve seat inserts of various types to a number of engine builders. Dall Motor Parts Co., and Cedar Rapids Eng'g Co., have been supplying the replacement field with cast iron inserts for several years. This has led to a certain amount of standardization of sizes and proportions as is evident from the drawings which appear in this article.

In the present state of the art it is of interest to inquire into the methods employed in machining the inserts and fitting them in the cylinder block. Accordingly, the following section gives some high spots of the procedure in a number of well-known plants. This outline should prove to be of mutual interest.

European practice offers an interesting contrast. Consider the Centrilock construction described in *The Automobile Engineer* (Eng.) December, 1932. This is a centrifugally cast insert of cast iron made by Sheepbridge Stokes Centrifugal Casting Co., Ltd., (Eng.) and so designed, fig. 8, that it is locked positively in a recess formed at the bottom of the counterbore. The insert has two external diameters, the larger of which is compressed to pass through the small bore of the seat and then expands into the recess. This seat is put in to stay.

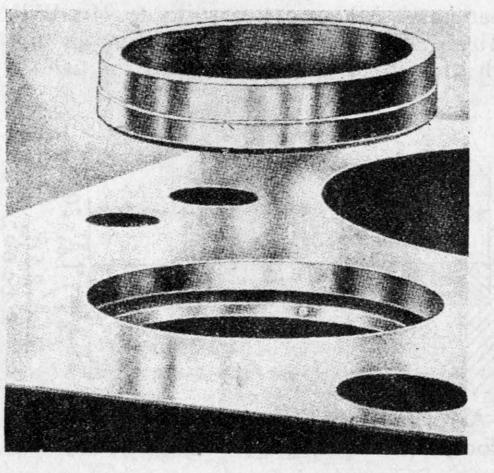
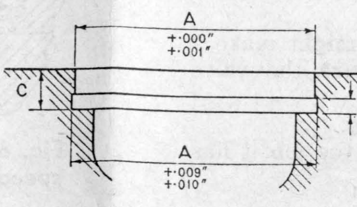


Fig. 8—Centrilock (Eng.) construction is unique. The seat is bored with a recess at lower end, the insert being machined with two external diameters to suit. Interference fits are so adjusted as to permit the large diameter of the insert to compress sufficiently to enter the smaller bore. Then the ring expands into the recess, making a rather effective but permanent lock



Buda inserts, fig. 1, are of special alloy iron, cast in hollow bars which are turned, bored and parted in much the same fashion as the old method of making piston rings. Before finishing, the rings are heat-treated to relieve strains and initial grain growth. Finally, they are ground flat on both sides, and cylindrically-ground on a centerless grinder.

Considerable development has featured the valve insert design finally adopted by White. As shown in fig. 3, it is a Stellite-faced bi-metal insert which is screwed into a threaded seat. Before the insert is set into place, a soft iron washer is laid on the bottom of the counterbore to serve as an elastic foundation. As mentioned earlier, the threads are painted with a bonding material which serves for locking and heat transference as well. As an added precaution, two small dowels are screwed into the head to prevent turning. After locking in place, the insert is finish-ground with a special high speed grinding wheel.

In production, the White seat is rough-turned from bar stock and then faced with Stellite puddled on from rod stock by an oxy-acetylene flame. Specially developed electrically controlled fixtures are employed in the process. Excess Stellite is removed by disc grinding, followed by rough grinding all surfaces and diameters before broaching. Broaching the serrations and sizing the inside diameter of the valve seat to close tolerances precedes finish-grinding and screw cutting. After finish grinding, the thread is milled to assure accuracy.

We are advised that The White Co. has applied for patents on certain features of valve seat construction described above.

The Autocar insert, fig. 7, is typical of the press fit construction in which the ring is pressed in with an interference fit of about 0.007 in. and is then locked into place by rolling or spinning the block metal over the chamfer turned in the insert. This procedure is followed whether the insert is of steel or cast iron except in a few cases where the spinning operation is not used.

According to Haynes Stellite, the General Motors Truck Company uses a combination of two methods for securing the valve seat insert. This company uses a threaded Stellite-facer seat similar to that used by White. However, the insert thread designed for an interference fit in its seat and at assembly it is shrunk to normal size by treating with Dry Ice.

The use of hard materials for valve seats has created a demand for special tools both in production and service. One of the outstanding developments is the Hall-Toledo high speed eccentric grinder which has been adopted by a number of automobile manufacturers. The wheel runs at 8500 rpm. and finishes the four exhaust seats of an eight cylinder engine in about 80 seconds. A small edition of this grinder has been placed on the market for service station use.

Another production machine to make its appearance in this field is the Heald grinder, fig. 9, which grinds the conical seat. Roundness and concentricity with the outside diameter are held to close limits in order to reduce the time required for lapping at assembly. A battery of three No. 81 Heald Sizematics with special workheads are grinding the valve seat insert at the rate of 450 pieces per hour in the plant of a well-known parts manufacturer.

The foregoing simply touches the high spots of this important development in engine design. The present intensive program of experimental work on the part of engine builders, users, and the manufacturers of valve seats and valves, should help to bring about a speedy crystallization of design practice, which will be of real benefit not only to those who have participated in this movement but also those who are ready to get into the swim.

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