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METHOD OF PROTECTING CYLINDER LINER TRANSFER OPENINGS FROM  
CASTING MATERIAL DURING INJECTION DIE-CASTING OF CYLINDERS  
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**FIG. 1**

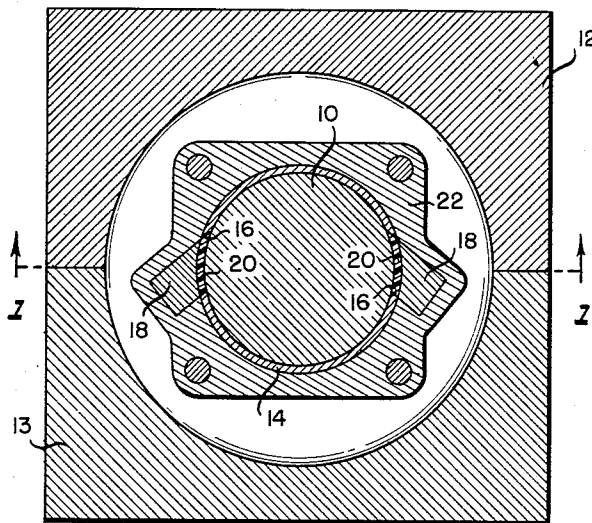
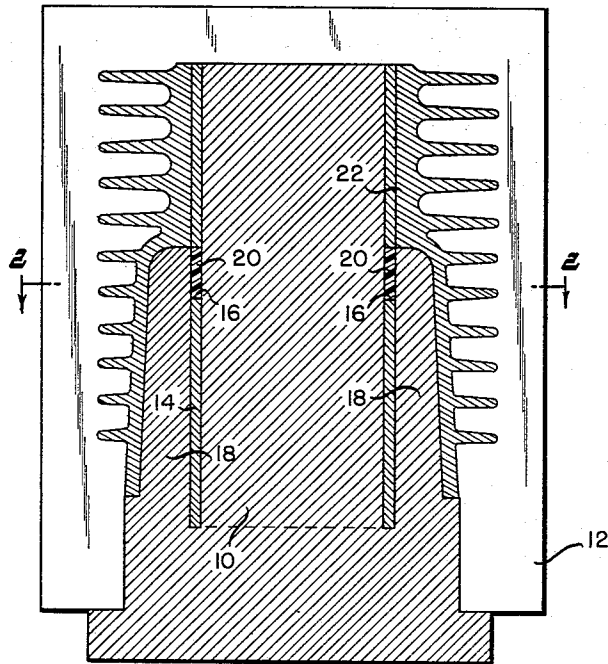


**FIG. 2**

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## METHOD OF PROTECTING CYLINDER LINER TRANSFER OPENINGS FROM CASTING MATERIAL DURING INJECTION DIE-CASTING OF CYLINDERS

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This invention relates to a method of protecting cylinder liner transfer ports from the casting material used in the die-casting method of forming cylinders around a preformed liner, the cylinders being used for internal combustion engines, particularly two-stroke engines.

There are known methods of injection die-casting a cylinder over a preformed cylinder liner, for use in two-stroke internal combustion engines, in which transfer passages lead from the base of the cylinder up to transfer ports in the wall of the cylinder liner. In at least one previously known die-casting method the cores used to form the transfer passages in the cylinder casting have upper ends shaped to exactly cover pre-formed transfer ports in the cylinder liner, the arrangement being intended to prevent entrance of the casting material into and around the edges of the cylinder liner transfer ports. In following that known method, the cores used to form the transfer passages must comply exactly with the shape of the cylinder liner transfer ports, thus dictating manufacture of the cylinder liner to very close tolerances, particularly within the region of the transfer ports. It has been found that even when the cylinder liner manufacture and the core formation are held to close tolerances, entrance of casting material past the core and into the transfer ports cannot be completely prevented due to the extremely high pressure, approximately 4500 p.s.i., used during the injection casting process. Under these high pressures the casting material is capable of penetrating the most minute gaps and openings. Other known methods use multiple port movable cores to shift into the liner openings, but even so, the extremely close tolerances between cores and liner make the cost excessive.

Accordingly, the primary object of the present invention resides in improving the process of injection die-casting of cylinders around cylinder liners by the novel procedure of prefilling the cylinder liner transfer ports or other openings with a filling material substantially inert to the material of the liner, resistant to pressure of the injection process and easily removable upon completion of the casting operation.

Further novel features and other objects of this invention will become apparent from the following detailed description, discussion and the appended claims taken in conjunction with the accompanying drawings, showing a preferred manner of carrying out this invention:

FIGURE 1 is a vertical section through the die and cylinder liner assembly illustrating the manner in which the present invention is utilized in an injection die-casting process; and

FIGURE 2 is a section view taken on lines 2-2 of FIGURE 1 to illustrate the relationship of the transfer passages, their molding cores and the filled transfer openings of the cylinder liner.

To illustrate the improved die-casting process, representative components used in injection die-casting of a two-stroke cycle internal combustion engine cylinder around a ported liner are shown in FIGURES 1 and 2. The drawings illustrate that stage of the process where injection die-casting has been completed and the die-cast cylinder and liner are still within the mold forms.

The casting mold is made in three parts: a lower part 10 which includes the interior core formations, and the two upper parts 12 and 13 forming a split exterior casting form. The mold can be firmly secured by clamps or other normal means (not shown) to withstand the very high injection casting pressures of approximately 4500 pounds per square inch.

Before assembling the mold to receive casting material, a cylinder liner 14 having transfer ports 16 is slipped over the vertical core of the lower mold part 10. The liner 14, if desired, can itself be a pre-cast component. Included on lower mold part 10 are transfer passage cores 18 which are disposed vertically up and adjacent the exterior side of cylinder liner 14, fitting over the cylinder liner transfer ports 16. Transfer ports 16 in the cylinder liner 14 have been completely prefilled with a special material 20 prior to the cylinder liner 14 being slipped over the core of lower part 10. The exterior die parts 12 and 13 are then placed over the assembled lower part 10 and cylinder liner 14 after which injection die-casting of cylinder material is accomplished to form cylinder 22 on and around the liner 14.

Transfer passage core parts 18 together with the cylinder liner transfer port 16 result in inlet and outlet transfer channels through the cylinder 22 to the interior of the liner 14. After completion of the injection molding operation the exterior mold parts 12 and 13 are separated, enabling the finished unit of a cylinder 22 with its internal liner 14 to be drawn off the lower mold part 10: after which the transfer port filling material 20 is easily knocked out of the liner ports 16. The presence of the port filling material 20 assures that no die-casting flash material or excess injection material is present at the edges of and/or within the cylinder liner transfer ports 16.

The importance of this invention resides in the fact that such flashes and projections of casting material which previously often resulted at the joiner of the inlet and outlet transfer passages and the cylinder liner transfer ports are now eliminated. Any such projections in the path of fluid flow constitute serious interference with desired proper flow characteristics through the transfer passage and into the cylinder liner and from the cylinder liner out through the other transfer passage. Interference with proper flow effects the operating characteristics efficiency of the internal combustion engine. Using previously known methods of casting, it was very difficult, if not practically impossible, to avoid such unwanted projections around the edges of the cylinder liner transfer openings.

It is realized that the objectionable projections and flashes at the edges of the transfer openings in the cylinder liner can be removed by additional work steps, such as grinding, or they could be avoided by utilizing a rather complex mold which would include additional core parts to fill the transfer port in the cylinder liner. However, there is considerable complexity when such additional core parts are used because they must be capable of being drawn into the interior of the vertical core inside the cylinder liner. Besides being expensive and complicated, such a production method requires very close tolerances of the mold, mold components and, more particularly, a close working tolerance between mold core and shape of the transfer ports of the liner in order to enable precise engagement of the movable cores which must shift into and exactly fill the liner port openings. In order to assure success of such a process, there are additional aspects which must be considered and which increase the unfeasible, economic factors which make such previously known process, unacceptable. One such factor is that the openings in the liner, when die cores must move into the openings, cannot be formed in their final shape during the step of casting the liner but, because of requisite tol-

erances, must be subjected to further mechanical treatment, such as grinding, to assure a close proper fit of the movable core in the port.

Exact grinding and peripheral shape of the transfer ports is in fact not really necessary to assure proper functioning of the engine. Hence, in accord with applicant's invention, liners having transfer ports may be produced by inexpensive methods, the tolerances of the port shapes being dictated only by the necessary functioning in the engines for which they are made, in other words, the transfer ports need no longer be formed to close tolerances previously required not by the engine operation but by the necessary close fit with extraneous mold parts used for injection casting of the cylinder around the liner.

Transfer ports with inclinations and intersections can be produced with no problems according to this method.

With the present method the cylinder liners can be made by an injection casting process and the cast surface can remain untreated insofar as the transfer ports are concerned. Introduction of casting material into and around the edges of the transfer openings during injection casting is effectively completely avoided by the placing of an insert of expendable filling material to completely fill the liner transfer ports prior to the injection casting of material into the mold.

The three-part injection mold for die-casting the cylinder around the liner, in accord with the present invention, may be developed in the simplest manner; it does not require pre-made movable internal core parts for the liner transfer ports, nor does it require transfer passage cores which must exactly cover the transfer passages.

Referring again to the drawings, the filling material 20 which is placed in the cylinder liner transfer ports 16 should be some material inert relative to the metal cylinder and liner, i.e., a material which will not alloy with the casting or liner material and it must also be capable of withstanding high pressures while still retaining its shape. It may be gypsum or some ceramic material or the like which can be utilized in a plastic condition and molded into shape within the ports 16.

It is also envisaged to use a filling body correspondingly preformed, for example, consisting of the prementioned materials or the like which can be inserted in the manner of a preformed plug into the transfer ports and readily removed after the injection casting process is completed. Material of the aforementioned constituency will neither alloy with the cylinder liner nor with the casting material used to make the cylinder around the liner.

The filling material can be readily and easily removed by light tapes or blows upon completion of the injection casting of the cylinder and liner.

In accord with the aforescribed invention, there is provided an inexpensive process for die-casting a cylinder on a cylinder liner, the combination including transfer passages and transfer ports, the relationship between the passages and ports being such to provide the optimum cross-sectional area with regard to the flow of combustion fluid enabling proper flow characteristics in the finished engine with the smallest possible flow resistance to cause undesired and troublesome whirls and non-turbulent dead spots. Transfer ports with inclinations and sharp edge intersections can easily be produced according to this method.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restric-

tive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. A method of die-casting a cylinder around a cylinder liner, the liner having at least one opening through the wall thereof and wherein the cast cylinder will include at least one passageway leading to the opening in the liner, the steps comprising: positioning a tubular metal liner having an opening in the wall thereof snugly upon a core portion of a die mold form with a surface of the core portion providing complementary surface contour continuity with the inner surface of the liner, engaging the inner peripheral edge of the liner opening and extending across the liner opening; completely filling the opening in said cylinder liner with a plug of material which is pressure resistant and will not alloy with the material of the liner or the casting material, the plug being in intimate engagement with the edges of the opening and having substantially the same thickness and contour of the liner; disposing the liner so a transfer passage core portion of the mold form is positioned along the exterior side of said liner snugly overlying and engaging said filling material in said liner opening and terminates adjacent at least a part of the periphery of the opening; disposing an exterior die mold surrounding said liner and core portions; and die-casting a cylinder surrounding said liner by means of a high pressure injection casting process.

2. A method of die-casting a cast metallic structure surrounding a metallic insert, the metallic insert having at least one opening through a part thereof and wherein the die-cast additional structure will include at least one passageway leading to the opening in the insert, the steps comprising: positioning the metallic insert with at least its part having the opening therethrough, disposed snugly against a rigid portion of a die-mold form so that the rigid portion of the die-mold form provides complementary surface continuity with the surface of the metallic insert around one end of the opening, engages the peripheral edge of the one end of the opening and extends across and thereby provides a rigid backing surface over one end of said opening; completely filling the opening in the metallic insert with a plug of material which is pressure resistant and will not alloy with the material of the liner or with the casting material, the material plug being in intimate engagement with the edges of the opening and having substantially the same thickness and contour continuity of the metallic insert adjacent its opening; the positioning of the insert resulting in a passage core portion of the die-mold form being disposed adjacent the other end of the insert opening with a terminal portion of the passage core snugly overlying and engaging the entire end surface of said filling material in the metallic insert opening; disposing an exterior die-mold surrounding said metallic insert and mold form portions; and die-casting additional structure surrounding said metallic insert by means of a high pressure injection casting process.

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