Dec. 4, 1962 R. S. FORSYTHE 3,066,400

METHOD OF REPAIRING METAL CASTINGS

Filed Feb. 18, 1959

FIG. 1

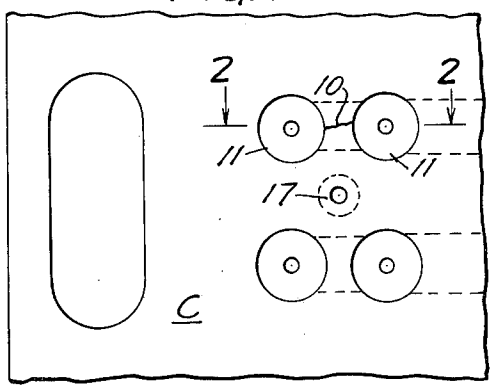


FIG. 2

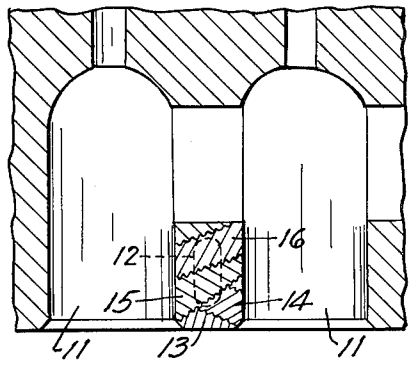


FIG. 3

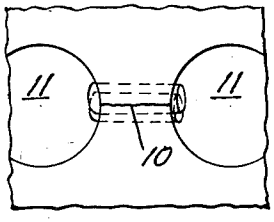


FIG. 4

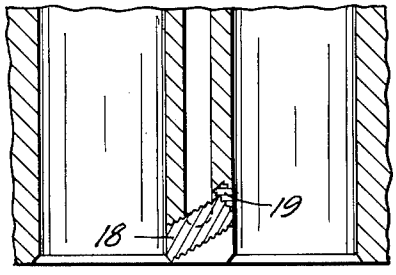


FIG. 7

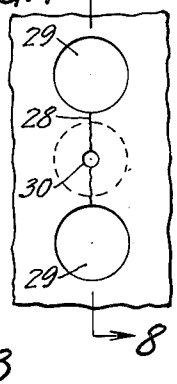


FIG. 5

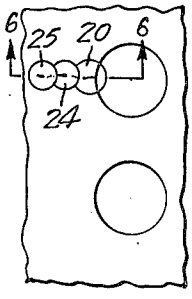


FIG. 6

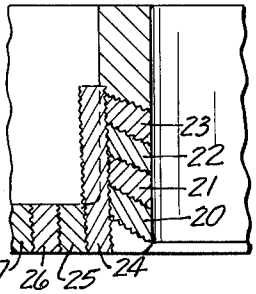


FIG. 8

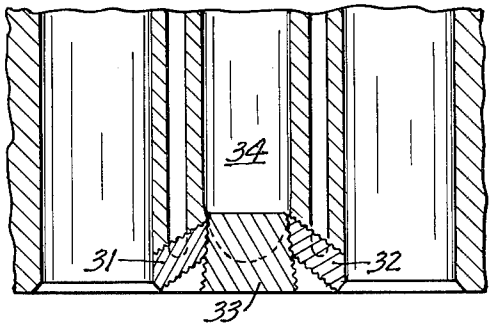


FIG. 9

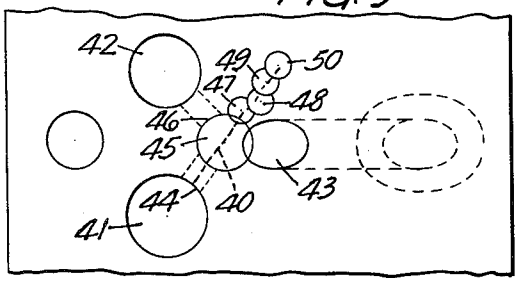
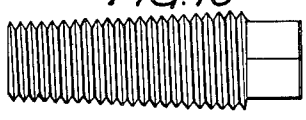


FIG. 10



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METHOD OF REPAIRING METAL CASTINGS

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17 Claims. (Cl. 29—402)

This invention relates to an improved method for repairing metal castings, and in particular to metal castings used in internal combustion engines wherein cooling fluids are employed which interfere with the operation and usefulness of the engine when permitted to escape through cracks which may develop in such metal castings.

An object of this invention is to provide a method for effectively repairing cracked metal castings by sealing the crack without employing heat, which warps or distorts the casting and creates residual strains and stresses in the casting which may later develop into cracks during use, and without the use of sealing compounds which tend to clog the cooling system and cause the engine to run hot and develop additional cracks during use.

Another object is a method of sealing or cutting off cracks in metal castings with new metal in such a manner as to prevent the passage or seepage of fluid through said cracks and prevent further expansion of the crack during use of the casting following repairing thereof.

Still another object is a method of repairing metal casting by means of tapered threaded members which remove the expansion from the crack and fill the crack with new metal to cause sealing thereof and are inserted in such manner as to resist loosening thereof under the strains and vibrations normally encountered in the use of internal combustion engines.

A more specific object is a method of repairing cracked metal castings wherein one or more tapered threaded members are inserted into the crack in such a manner as to take the expansion out of the crack, fill the crack with sufficient new metal to seal the leak, and cut off the crack to prevent its extending further into the casting.

These and other objects and advantages of my invention will more fully appear from the following description made in connection with the accompanying drawings, wherein like reference characters refer to the same or similar parts throughout the several views, and in which:

FIG. 1 is a bottom plan view of a cracked diesel cylinder head for a diesel type internal combustion engine;

FIG. 2 is an enlarged sectional view of a portion of FIG. 1 taken on the line 2—2 thereof;

FIG. 3 is a partial plan view of FIG. 2;

FIG. 4 is a sectional view of another type of cracked casting in which the crack extends between openings in the casting and method of repairing same;

FIG. 5 is a bottom plan view of a casting wherein the crack is associated with one opening only and method of repairing same;

FIG. 6 is a sectional view of a portion of FIG. 5 taken on the line 6—6 thereof;

FIG. 7 is a top plan view of still another type casting in which the crack extends between two valve ports and through the fuel injector hole;

FIG. 8 is a sectional view of FIG. 7 taken on the line 8—8 thereof showing a method of repairing the crack shown in FIG. 7;

FIG. 9 is a bottom plan view of still another cracked casting and method of repairing same; and

FIG. 10 is a detail view of a plug used in this invention to repair the casting.

The types of metal castings and the crack which may occur in them are too numerous to be included herein individually. However, the drawings suffice to illustrate some of the more common types of failures occurring in metal castings, particularly those relating to diesel engines, and the method of repairing them according to my invention. However, it should be clearly understood that the drawings serve only to illustrate and not to limit. Although the methods of repair shown by the drawings differ somewhat in application, they all embody three basic objectives of my invention, namely (1) taking the expansion out of the crack; (2) filling the crack with sufficient new metal to seal the leak; and (3) cutting off the crack and preventing further extension thereof into the casting.

To accomplish these objectives and the repair contemplated by my invention, I insert one or more threaded tapered plugs of the type illustrated in FIG. 10 into the cracks in the manner hereinafter to be described. If these plugs are carefully installed by the methods of my invention, a satisfactory and successful repair can be accomplished without the use of heat, sealing compounds or devices other than those tapered threaded plugs. Although the method of repair of my invention is applicable to many types of metal castings, it is particularly directed to the repair of metal castings employed in internal combustion engines having interior passageways containing a cooling fluid, usually water, wherein the crack or failures are associated with one or more openings in the casting, such as valve ports, piston chambers, injector holes and the like, and extend through the casting to the water chambers thereby permitting harmful leaking of fluid to occur.

To adequately repair the crack, substantially all of the expansion or play must be taken out of the crack, the crack must be filled with enough new metal to seal the crack and prevent further leaking, and the origin of the crack must be cut off or blocked to prevent further extension thereof into the casting when the casting is placed in use after repairing thereof.

According to my invention, one or more tapered threaded plugs are inserted directly into the crack generally longitudinally thereof in suitable drilled and tapped holes originating in the wall of the opening associated with the crack in such fashion that the plug engages or overlaps both sides of the crack for its entire length, and fills the entire length of the crack with a continuous mass of new metal to prevent the fluid from leaking through to the face of the casting. The taper of the plug enables the plug to expand the crack and remove all expansion or play therefrom. The plug also overlaps the crack origin or base so as to engage the sound metal adjacent the crack origin and cut off the crack, thereby preventing further extension thereof. Because of the nature of these castings and the difficulty of drilling into a crack from an opening therein such as a valve port at the angle necessary to accomplish this type of repair, it is usually necessary to supplement the initially inserted plug with one or more additional tapered threaded plugs which overlap or engage at least a portion of the previously inserted plug or plugs in the casting to form a fluid tight seal therebetween and lock the plugs in place to prevent subsequent loosening thereof. To accomplish the soundest and strongest repair possible, the plugs are so installed as to engage a maximum amount of metal in the casting consistent with accomplishing the three major objectives of repair of my invention. To complete the repair, it is sometimes necessary to insert one or more plugs into the cracks substantially vertically or transversely of the length thereof. However, where possible, it is preferable to install the plugs longitudinally of the crack, as this not only reduces the number of plugs which must be installed to accomplish the repair, but also better takes the expansion out of the crack and leaves the plugs tightly installed since the greater the number of threaded plugs inserted, the

greater the risk of loosening the plugs previously installed in the crack. The plugs employed are, of course, metallic and are of a metal having thermo-expansion characteristics closely resembling the metal of the casting being repaired. In each type of repair it is obvious that the portion of the plug projecting from any working surface of the casting must be cut off and finished to conform to the desired configuration of the casting.

In some instances, hereinafter to be described, the repair may be effected by combining a plug inserted vertically into the depth of the crack with one or more plugs installed longitudinally of the crack through one or more openings associated therewith, in which the vertical and longitudinal plugs intersect and overlap each other at least in part. In such a repair, it is usually preferable to insert the longitudinal or diagonal plugs first, and cut them off in part with the vertical plug, in order that the vertical plug may engage as much metal as possible to effect maximum strength of repair, for, in internal combustion engines, the deck surface and the vertical plugs inserted therein are subjected to more severe strains than the walls of the openings such as the valve ports therein. With these basic principles in mind, reference is now made to the drawings for further explanation and understanding of my invention.

FIGS. 1, 2 and 3 illustrate the method according to my invention of repairing a crack 10 occurring between valve ports 11 and extending through the casting C to the water chamber 12, the particular illustration being that found on diesel type heads such as those made by Cummins and General Motors, where the water chamber 12 consists of an elongate narrow and closed passageway extending substantially the length of the casting between the valve port and has a relatively thinly cast base or deck 13, the water chamber being enclosed interiorly by the casting to permit the existence of an opening between the exhaust ports which permits the exhaust gases to be exhausted from one side only of the engine.

To accomplish the repair contemplated by my invention, I employ one or more elongated tapered threaded screw or plug members, as best illustrated in FIG. 10, which are inserted in suitably tapped holes made in the casting. To repair the crack 10 of FIGS. 1, 2 and 3 by the method of my invention, a tapered threaded plug 14 is inserted diagonally into the casting into the crack longitudinally thereof in an appropriately tapped hole from one valve port to another with the plug being in approximately the same plane as the crack with ⅓ to ½ of the cross sectional area of the plug overlapping the crack and filling the crack with new metal through its entire length between the valve ports and effectively sealing off the fluid in the cooling chamber from the outside surface or face 13 of the deck. Since the crack 10 usually extends some distance into one or both of the valve ports, it becomes necessary to seal off not only the outside surface but also the valve ports from fluid leaking through the crack from the cooling chamber. To achieve an effective seal in a minimum of time according to my invention, the easiest method would be to insert a single plug which would overlap both sides of the crack for its entire length to effectively seal the crack and at the same time extend beyond the origin or base of the crack into the sound metal of the casting so as to cut off the crack and further extension thereof. However, due to the small nature of the openings such as the valve ports and the nature of the drilling and tapping equipment necessary in the operation of my invention, it is virtually impossible to originate any substantially horizontally tapped hole any substantial distance into the opening which could accomplish all of the objectives of my repair by use of a single plug since the plug must be inserted diagonally with the angle of inclination approaching the vertical the further into the opening the hole originates. Therefore, the first diagonal plug frequently does not catch or cut off all of the crack so as to prevent leakage into the ports. Therefore, to catch and seal the remaining unsealed portion of the crack, one or more additional plugs such as 15 and 16 are necessary to complete the repair. The second plug 15 may be inserted from the opposite port as the first plug, overlapping both sides of the crack by ½ to ⅓ its diameter as best shown in FIG. 3, being of the same plane as the crack and intersecting and interlocking with at least a portion of the first plug and cutting off and sealing additional ports of the crack extending into the walls of the valve ports.

As an alternative, an equally effective method is to insert the second plug from the same side as the first plug but starting it further into the crack while permitting it to lap and engage the first plug for substantially its entire length. Whether the plugs are inserted from the same or opposite sides will depend in large part on how far the crack extends into each of the openings or ports. If two plugs are not sufficient to effectively seal and cut off the crack, additional diagonal plugs may be inserted further into the port, or a third plug 16 may be inserted diagonally from the opposing or inner side which is possible in this particular type of casting, so as to overlap and engage the lower leading ends of the first two plugs and complete the sealing and cut off operation.

In most instances, the size of the casting and plug and the angle of insertion are such as to carry the plug into and through the water chamber. In such instances, this is usually not only the unavoidable result, but is usually a desirable one, since it cuts off and seals the crack at a source adjacent the water chamber, where it is smaller and easier to repair then at the longer outer periphery thereof. However, in such instances where the plugs enter the water chamber, care must be taken to avoid more than ½ the cross sectional area of the plug being in water. This provides a water tight seal and prevents the casting from expanding away from the plug when heated during use to break the seal and cause leaking again. The purpose of the taper is to take all of the expansion out of the crack. If this is not done, the crack will expand when heated in use after the repair, loosening the plug and reopening the crack. It should be noted that according to the method of my invention, it is not necessary that the entire fissure created by the crack be filled with new metal. It is sufficient if enough new metal is added to seal the leak and upon completion of the repair, it is quite common to have exterior portions of the crack still open and exposed. When enough plugs have been inserted to take all of the expansion out of the crack, to seal the leak, and the origin or base of the crack has been lapped or cut off to prevent further expansion thereof, the portion of the plug extending into the valve ports are cut off and the ports are rebored to desired dimensions. Sometimes the plugs extending into the water chamber are such as to obstruct the flow of water therethrough, which is not desirable, as it causes the engines to run hot and promotes the formation of additional cracks. In such instances, the water chamber is rebored in whole or in part to remove enough of the plugs in the chamber to permit free passage of fluid therethrough. The addition of the plugs not only repairs the crack, but also builds up the deck area and reinforces it to increase the resistance to subsequent strains and stresses. By inserting the plugs longitudinally of the crack, the repair is not only effected with a minimum number of plugs, but the plugs engage a maximum amount of casting, which insures a stronger and more enduring repair.

In this type of head shown in FIG. 1, it has been found preferable to insert the first plug 14 on the side of the crack furtherest away from the injector port 17.

Where the crack is of the surface variety and does not extend deeply into the casting, one plug such as 18 may suffice to complete the repair as best shown in FIG. 4 and an additional plug 19 may be inserted diagonally from one of the ports to cut off the leading end of the first plug to lock the plug in place and/or cut off the

crack if it should have extended somewhat beyond the reach of the first plug.

FIGS. 5 and 6 illustrate the preferred form of repairing a crack which does not extend between and into two adjacent openings or ports, but rather extends across the deck and into one port only, and does not create the problem of sealing two vertical cracks in the port nor does it enable plugs to be inserted diagonally from either side of the crack. In this instance, the order and method of inserting the plugs is very important if optimum results are to be achieved by the repair. In this situation, a plug 20 is first inserted diagonally from the valve seat so as to catch that portion of the crack in the corner of the water chamber. Additional plugs such as 21, 22 and 23 are then successively inserted diagonally into the crack from the openings, each successive plug overlapping and cutting off a portion of the previous plug until the entire length of the crack extending into the port has been filled and the base thereof has been cut off. A vertical plug 24 is then inserted from the deck surface so as to also catch the corner of the water chamber and cut off the leading end of the previously diagonally inserted plug, the first diagonal plug 20 and the first vertical plug 24 combining to seal the crack around the corner of the water chamber. Additional plugs such as 25, 26 and 27 are then successively and overlappingly inserted into the crack from the deck until that portion of the crack extending along the deck surface has been sealed and cut off. Although the first vertical plug might suffice to seal the vertical portion of the crack extending into the valve port, it usually does not engage sufficient metal to take all of the expansion out of the crack, and does not engage enough metal to prevent subsequent expansion during use. The diagonal plugs 20 to 23 are necessary not only to take up the expansion, but are also necessary to cut off the base of the crack and prevent further extension thereof into the casting. It is preferable to insert the diagonal plugs first, in order that the first vertical plug will not be cut off in part, as would be the case if the vertical plugs were inserted ahead of the diagonal plug and forms a stronger repair. The deck portion of the casting is subjected to a more severe strain during use then are the walls of the port, and it is preferable to have the vertical plugs engaging as much metal as possible to prevent loosening thereof during use.

FIGS. 7 and 8 illustrate the method of repairing still another common type of failure, wherein the crack 28 extends between two adjacent openings or valve ports 29 and through the injector port 30 as well. For maximum efficiency, the deck surface surrounding the injector port must be finished to rather close tolerances to permit accurate adjustment of the injector. In use, this area becomes somewhat uneven or irregular and this is intensified by any cracks which may occur. Therefore, to repair this type of failure, plugs 31 and 32 are inserted diagonally into the crack from each valve port in the manner previously described to seal the crack and cut it off. If more diagonal plugs are needed to complete the repair, they may be added. A substantial portion of the deck surface between the ports including the injector port 30 is drilled and tapped, and a large tapered plug 33 is inserted vertically therein so as to extend into the injector chamber 34 and intersect and cut off a portion of the diagonal plugs 31 and 32 to form a secure engagement therewith. The head of the injector chamber is then reshaped to desired dimensions and the injector port is rebored in the plug to the desired size.

FIG. 9 illustrates a type of failure peculiar to International type diesel heads, wherein a crack 40 commonly occurs in a somewhat triangular area defined by the valve ports 41 and 42 and the inclined injector port 43 wherein the crack usually extends from one of the valve ports such as 41 along the deck surface between the other valve port 42 and the injector port 43. In this particular head, the injector is attached to the head in such fashion as to create a strain on the casting and tends to expand such a crack. A series of small interlaced plugs is usually not sufficient to take all of the expansion out of the crack and resist the strain caused by the injector. Therefore, a diagonal plug 44 is inserted from one valve port 41 into the crack and a large vertical plug 45 sufficient to take all of the expansion out of the crack is inserted so as to intersect and cut off a portion of the first diagonal plug 44. A plug 46 is then inserted diagonally from the other port to intersect the large vertical plug 45 and lock it in place. Small vertical plugs 47, 48, 49 and 50 are then laced along the remainder of the crack to seal and cut it off.

Thus, from the foregoing description, the advantages of my invention are readily apparent. By inserting tapered threaded plugs directly into the crack the expansion or play is removed therefrom to prevent the plugs loosening during subsequent use. By overlapping and engaging the plugs with one another an uninterrupted body of new metal is provided in the crack between the water chamber and the exterior surfaces of the casting so as to provide a fluid tight seal therebetween and by overlapping the base or origin of the crack with one or more of the plugs, the crack is cut off and is prevented from further extending into the casting. By inserting the plugs directly into the crack so as to extend substantially the entire length thereof, the number of plugs which must be employed to accomplish the repair is substantially reduced and the risk of loosening previously inserted plugs is substantially lessened. Finally, by first installing the diagonal plugs and then cutting them off with one or more vertical plugs, the vertical plugs which receive the major portion of the strain during use engage a maximum amount of metal to provide a secure strong repair, and prevent loosening of the vertical plugs during use.

It will, of course, be understood that various changes may be made in the form, details, arrangement and proportions of the various parts without departing from the scope of my invention.

What I claim is:

1. In metal castings such as the heads of internal combustion engines having adjacent openings such as valve ports extending into the interior of the casting from the casting surface, a method of repairing a crack which extends between said adjacent openings, said method comprising inserting at least two elongate metallic tapered threaded members into the crack generally longitudinally thereof through suitably drilled and tapped holes originating in said openings interiorly of the casting surface, at least one of said members originating in one of said openings and at least one other member originating in said adjacent opening, said members removing the expansion from the crack and threadedly engaging at least a portion of one another, said engaged members providing a continuous mass of new metal in the crack effecting a fluid tight seal, said members also overlapping and threadedly engaging the sound metal adjacent the base of the crack, thereby cutting off the crack and preventing further extension thereof into the casting.

2. In metal castings such as the heads of internal combustion engines having an interiorly disposed fluid chamber and adjacent openings such as valve ports and the like extending into the casting from the surface thereof, a method of repairing a crack extending between said adjacent openings said method comprising inserting at least two metallic threaded tapered members into the crack generally longitudinally thereof and diagonal to the face of the casting, at least one of said members originating in one of said adjacent openings, said members penetrating the fluid chamber and engaging opposite sides thereof and overlapping and engaging the sound metal at the base of the crack to prevent further extension thereof into the sound metal, said members engaging at least a portion of one another and cooperating to take

the expansion out of the crack and provide a continuous mass of metal in the crack effecting a fluid tight seal.

3. In a cast metal head for an internal combustion engine having an injector port disposed between the adjacent valve ports, which injector port communicates with an injector chamber interiorly of the casting, and fluid chambers enclosed within the casting and disposed between the injector chamber and each of the adjacent valve ports, the method of repairing a crack extending between the valve ports and through the injector port comprising inserting tapered members into the injector chamber at such an angle as to provide a fluid tight seal, boring a substantial portion of the face of the casting lying between the valve ports, including the injector port, and tapping the hole provided, said tapped hole extending from the face of the casting to the injector chamber, inserting a threaded tapered member vertically into said tapped hole, said member extending into the injector chamber and engaging at least a portion of the members originating in the valve ports, recontouring the injector chamber to the desired dimensions, and reboring the injector port in said vertically inserted tapered threaded member.

4. In metal castings such as the heads of internal combustion engines having adjacent ports extending inwardly from the face of said casting and fluid cooling chambers disposed interiorly of said casting and intermediate said ports, a method of repairing a crack extending inwardly from the face of said casting and communicating with said ports and said chamber, said method comprising inserting a tapered threaded plug into said crack from one end thereof located adjacent one of said ports and generally longitudinally of said crack to engage and overlap the entire length of that portion of the crack in direct communication with said chamber to seal same, said plug removing the expansion from said crack and overlapping and engaging the sound metal adjacent the base of said crack to prevent further extension thereof into the sound metal of the casting.

5. In metal castings such as the heads of internal combustion engines having adjacent ports extending inwardly from the face of said casting and fluid cooling chambers disposed interiorly of said casting and intermediate said ports, a method of repairing a crack extending inwardly from the face of said casting and communicating with said port and said chamber, said method comprising inserting tapered threaded plugs into said crack from opposite ends thereof adjacent the ports and generally longitudinally of said crack, and threadedly engaging both sides of said crack to remove the expansion therefrom and seal said crack, said plugs overlapping and threadedly engaging each other and overlapping the joint between the base of the crack and the sound metal to prevent further expansion of said crack.

6. The method set forth in claim 5, wherein the plugs engage the entire length of that portion of the crack located in the chamber wall to completely seal the same and prevent escape of fluid therefrom.

7. In metal castings such as the heads of internal combustion engines having an opening extending inwardly into said casting from the face thereof and a fluid cooling chamber disposed interiorly of said casting adjacent said opening, a method of repairing a crack extending inwardly from the face of said casting and communicating with said opening and said chamber, said method comprising inserting first tapered threaded plug means into said crack generally longitudinally thereof and into said chamber from said opening, and inserting second tapered threaded plug means into said crack and chamber from the face of said casting, said first and second plug means overlapping both sides of the crack and the sound metal adjacent the base of said crack and thereby removing the expansion from said crack and preventing further extension thereof into the sound metal of the casting, said first and second plug means also overlapping and threadedly engaging each other and cooperating with each other to seal said crack and prevent passage of fluid therethrough from said chamber.

8. The method set forth in claim 7 wherein said first plug means are installed before said second plug means whereby in installing said second plug means said first plug means are cut off and threadedly engaged by said second plug means.

9. The method set forth in claim 7 wherein said casting has a second opening located adjacent said crack but not in communication therewith, and wherein third threaded tapered plug means are inserted into said casting from said second opening said third plug means being disposed diagonally to the face of the casting and extending towards said second plug means, whereby said second and third plug means intersect and are threadedly engaged.

10. In metal castings such as the heads of internal combustion engines having adjacent openings extending inwardly from the face of said casting and a cooling fluid chamber disposed interiorly of said casting and intermediate said openings, a method of repairing a crack extending inwardly from the face of said casting and communicating with said ports and said chamber, said method comprising inserting first tapered threaded plug means into said crack from each of said openings in such fashion that said plug means from opposite ends of said crack extend generally towards one another and into said chamber, and inserting second threaded tapered plug means into said crack and chamber from the face of said casting, said first and second plug means intersecting and being threadedly engaged and cooperating to seal said crack and prevent passage of fluid therethrough from said chamber, said plug means also engaging the sides of and removing the expansion from said crack and overlapping the sound metal of the base of the crack to prevent said crack from extending further into the sound metal.

11. In metal castings such as the heads of internal combustion engines having adjacent ports extending inwardly from the face of said casting and fluid cooling chambers disposed interiorly of said casting and intermediate said ports, a method of repairing a crack extending inwardly from the face of said casting and communicating with said ports and said chamber, said method comprising inserting tapered threaded plug means into said crack generally longitudinally thereof from said openings whereby said plug means engage both sides of said crack and remove the expansion therefrom, seals the crack, and overlaps the sound metal at the base of the crack to prevent further extension of the crack into the sound metal.

12. In metal castings such as the heads of internal combustion engines having a plurality of openings adjacent to one another, a method of repairing a crack in said casting originating in one of said openings and extending into the general area intermediate to and defined by said openings, said method comprising inserting tapered threaded plug members into said casting from said openings including the opening where the crack originates, said plug means in said last named opening extending into said crack and generally longitudinally thereof so as to overlap both sides thereof, and inserting second threaded tapered plug means into said casting from the face thereof in said area whereby said second plug means intersects, cuts off and threadedly engages said first named plug means, said plug means cooperating to seal said crack, remove the expansion therefrom and overlap the sound metal at the base of the crack to prevent further extension thereof.

13. In metal castings such as the heads of internal combustion engines having an opening extending inwardly from the face of said casting and a fluid cooling chamber disposed interiorly of said casting adjacent to and separated from said opening by said casting, a method of repairing a crack extending inwardly from the face of said casting and communicating with said opening and said chamber, said method comprising inserting tapered

threaded plug means into said crack generally longitudinally thereof from said opening and into said chamber whereby said plug means overlap both sides of said crack and the sound metal adjacent the base of said crack and thereby removing the expansion from said crack and preventing further extension thereof into the sound metal of the casting, and sealing said crack to prevent the escape of fluid from said chamber therethrough.

14. In metal castings such as the heads of internal combustion engines having an opening extending into said casting from the face thereof and a fluid cooling chamber disposed beneath the face of said casting adjacent said opening, a method of repairing a crack extending inwardly from the face of said casting and communicating with said chamber and opening, said method comprising inserting tapered threaded plug members into said crack, at least some of said members being inserted into said crack from said opening generally longitudinally thereof so as to overlap the sound metal adjacent the base of the crack and prevent its further extension into the casting, said plug members also being threadedly engaged with each other whereby through said threaded engagement the plug members form a continuous body of new material in the crack which provides a fluid tight seal and prevents the escape of fluid therethrough.

15. In metal castings such as the heads of internal combustion engines having adjacent openings extending inwardly from the face of said casting and a cooling fluid chamber disposed interiorly of said casting and intermediate said openings, a method of repairing a crack extending inwardly from the face of said casting and communicating with said ports and said chamber, said method comprising inserting first tapered threaded plug means into said crack from each of said openings in such fashion that said plug means from opposite ends of said crack extend generally towards one another and into said chamber, and inserting second threaded tapered plug means into said crack and chamber from the face of said casting, said first and second plug means intersecting and being threadedly engaged and cooperating to seal said crack and prevent passage of fluid therethrough from said chamber, said plug means also engaging the sides of and removing the expansion from said crack and overlapping the sound metal of the base of the crack to prevent said crack from extending further into the sound metal, and wherein said second plug means is installed after said first plug means whereby said second plug means intersects, cuts off, and threadedly engages said first plug means.

16. In metal castings such as the heads of internal combustion engines having adjacent ports extending inwardly from the face of said casting and a fluid cooling chamber disposed interiorly of said casting and intermediate said ports, a method of repairing a crack extending inwardly from the face of said casting and extending between and communicating with said ports, said method comprising inserting a single large tapered threaded plug into said crack from the face of said casting, said plug spanning the major portion of the length of said crack, and inserting tapered threaded plugs which are smaller than said first named plugs into the crack generally longitudinally thereof from each of said openings whereby said smaller plugs are threadedly engaged with said first named plug, said first and second named plugs overlapping both sides of the crack and the sound metal adjacent the base of said crack and thereby removing the expansion from said crack and preventing further extension thereof into the sound metal of the casting, said plugs also cooperating with each other to seal said crack and prevent passage of fluid therethrough from said chamber.

17. In metal castings such as the heads of internal combustion engines having an opening extending inwardly from the face of said casting and a fluid cooling chamber disposed interiorly of said casting adjacent to and separated from said opening by said casting, a method of repairing a crack in said casting extending inwardly from the face thereof towards said chamber, said method comprising inserting a single large tapered threaded plug into said crack from the face of the casting whereby said plug overlaps both sides of said crack and the sound metal adjacent the base of the crack, thereby removing the expansion from the crack and preventing further extension thereof into the sound metal of the casting and inserting at least one smaller tapered threaded plug into said casting from said opening whereby said smaller plug is disposed diagonally to the face of said casting and intersects said first named plug whereby said first and second named plugs are threadedly engaged with each other, said plugs forming a fluid tight seal with said casting and preventing escape of fluid from said chamber through said crack.

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