Nov. 6, 1934. W. H. EMRICK 1,980,156

METHOD OF AND MEANS FOR MAKING OR SEPARATING AN EXPANSION FIT

Filed Nov. 24, 1931 2 Sheets-Sheet 1

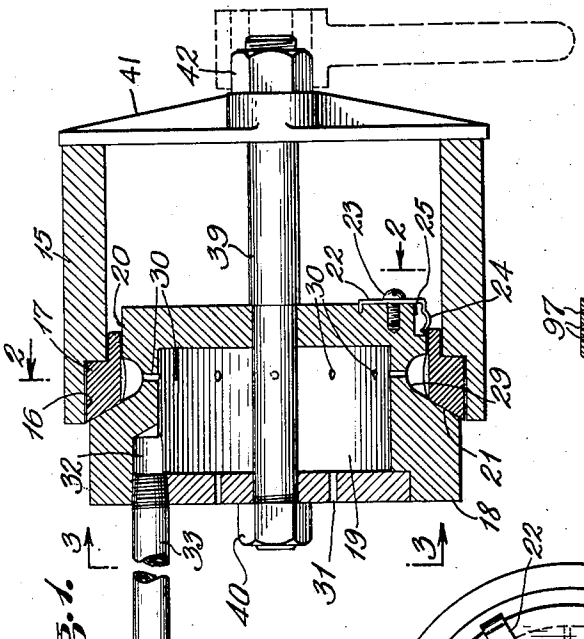


Fig. 1.

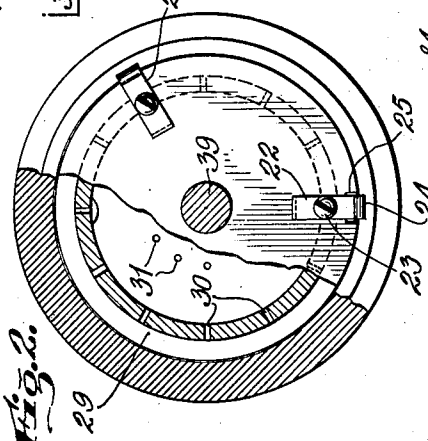


Fig. 2.

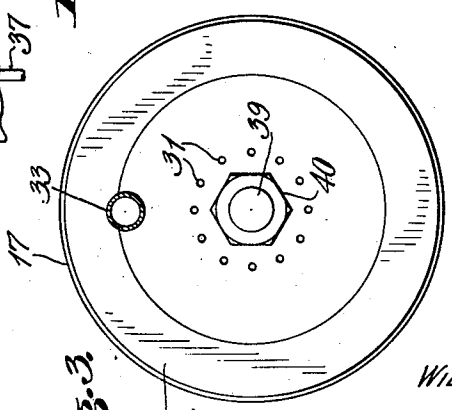


Fig. 3.

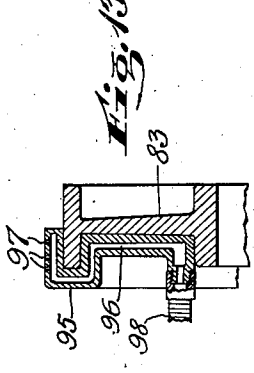


Fig. 13.

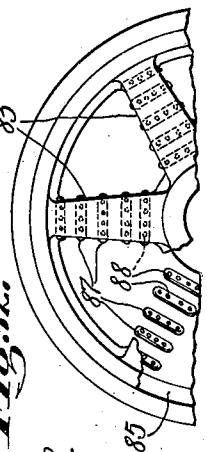


Fig. 12.

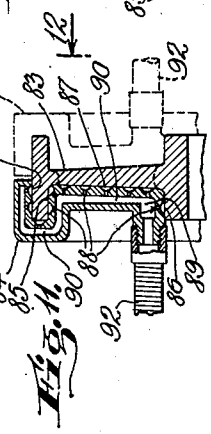


Fig. 14.

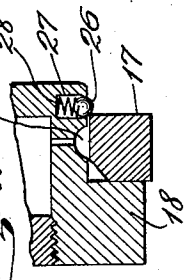


Fig. 4.

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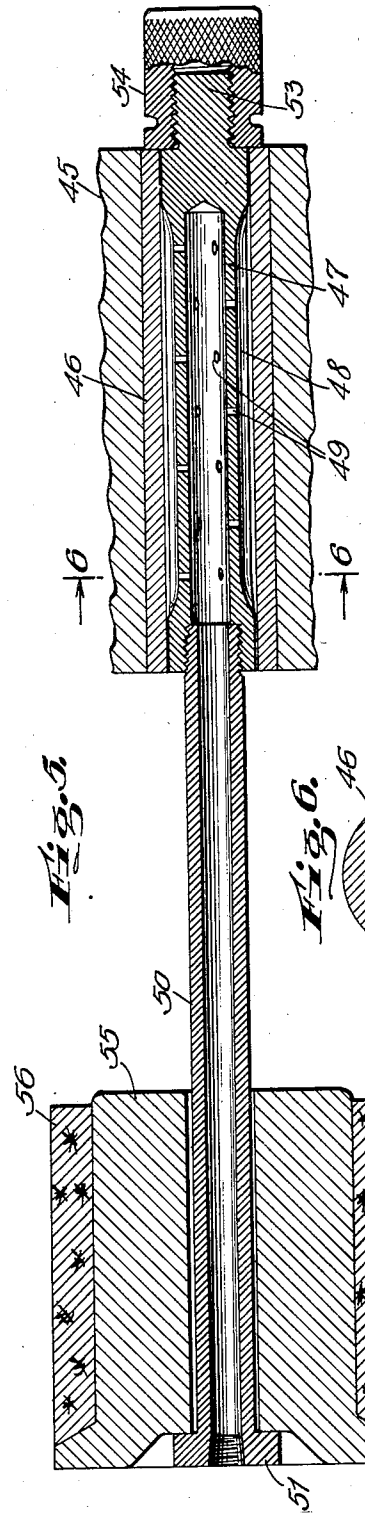


Fig. 5.

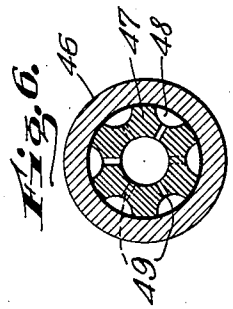


Fig. 6.

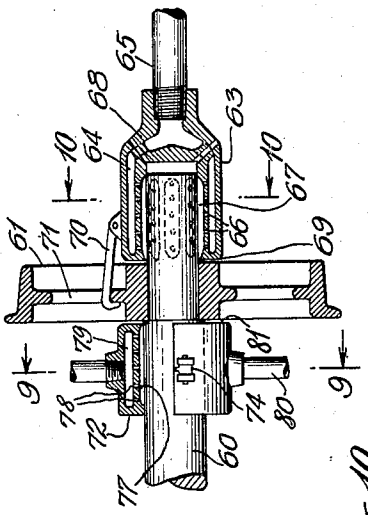


Fig. 8.

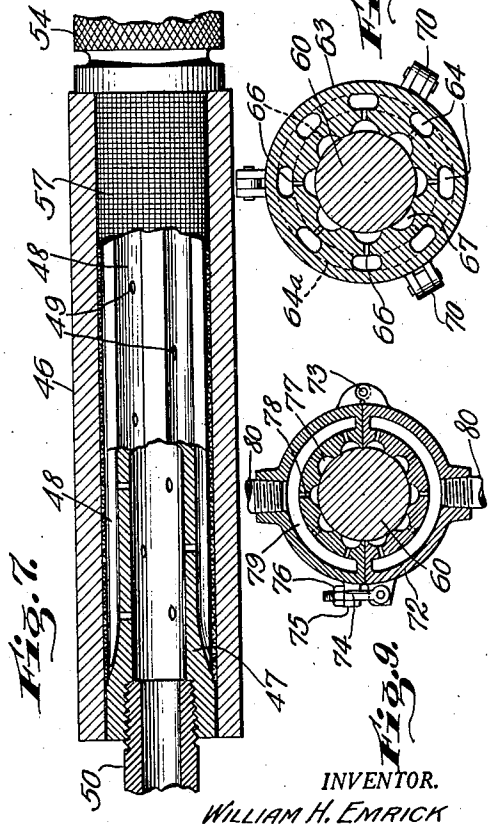


Fig. 7.

Fig. 10.

Fig. 9.

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UNITED STATES PATENT OFFICE

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METHOD OF AND MEANS FOR MAKING OR SEPARATING AN EXPANSION FIT

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Application November 24, 1931, Serial No. 577,011

31 Claims. (Cl. 62—1)

My invention relates to methods of and means for seating members in tight fitting sockets or holes and/or removing the same therefrom.

In one of its aspects my invention relates to "expansion fitting" as distinguished from "shrink fitting". In shrink fitting, as commonly practiced, the inner member (the part which is to be fitted into an encircling seat) is machined slightly larger in diameter than said seat. Then the outer member (the part containing the seat) is expanded by heat sufficiently to permit of inserting the inner member therein, so that when the outer member cools it will shrink upon the inner member and fit very tightly thereon.

While this method of producing shrink fits is widely practiced situations often arise in which it is inconvenient or impracticable to subject the outer member to the requisite heating. When the outer member is massive it may be difficult or inefficient to heat the same for the purpose of introducing a small bushing therein. Also the heating may warp the part or set up injurious internal stresses therein.

Occasionally, parts that have been joined by shrink fitting or have rusted fast, are separated by heating the outer member so that it will release its hold on the inner member, but this cannot readily be done, particularly if the outer member is much more massive than the inner member, because while the outer member is being expanded by heat much of the heat will also penetrate the inner member and there will not be a sufficient difference of expansion in the two parts to loosen the hold of the outer member on the inner member. Sometimes this differential expansion is accentuated by applying water or ice to the inner member to carry off the heat conducted thereinto from the outer member and thus prevent it from expandi..g. But this expedient is bothersome and cannot be employed in many cases.

My invention has for an object to overcome the difficulties and disadvantages above enumerated by dispensing with the application of heat not only in fitting one member into another but also in separating members that have been tightly fitted or rusted together.

In general my improved method provides for contracting the inner member by abstracting heat therefrom or refrigerating the same well below its normal temperature, and then after inserting it into its seat permitting it to expand by absorption of heat from its surroundings or from the atmosphere thereby effecting a tight fit of the member in its seat. To separate parts that are tightly fitted one within the other I apply a refrigerating agent to the inner member to shrink the same and loosen the joint between the two members.

It is an object of my invention to provide a method of and means for concentrating a refrigerating effect at any desired point and producing such a rapid chill of the member treated as to contract said member before the chilling effect is communicated to any considerable extent to the outer member.

A specific object of my invention is to use as the refrigerating agent a highly expansible fluid maintained as a liquid under pressure so that the fluid can be conveyed by its own pressure to the point of application with little if any, expansion and consequently little absorption of heat, and then to liberate the fluid at the desired point so that by its rapid expansion it will absorb a large volume of heat and will cause instant chilling and contraction of the object with which it contacts.

Another object of my invention is to provide means for protecting the outer member from contact with the expanding gas adjacent the seat in which the inner member is fitted.

While my invention is not limited to any particular refrigerating agent, I prefer to use liquefied carbon dioxide. This refrigerant offers the advantages of being non-corrosive, non-poisonous, and non-inflammable. The boiling point of carbon dioxide at normal atmospheric pressure is about 110 degrees below zero Fahrenheit so that when the pressure on the liquid is released it instantly flashes into gas, producing by its expansion a very low temperature which is adequate for practically all purposes to which expansion fitting is likely to be applied.

Another object of the invention is to provide means for producing uniform cooling of the object to be contracted so as not to set up any undue stresses therein.

Another object of the invention is to provide a tool or apparatus with which the object to be shrunk may be very conveniently refrigerated. Said tool may also be of such form as to provide a convenient means for introducing the object into its seat and forcing it home therein.

Another object of the invention is to provide a tool of the general character described above which also has means for driving the object out of its seat. This is of advantage because often an object such as a bushing becomes peened over at its ends by wear, so that even when it is shrunk

it requires some force to drive it out of its bearing.

Other objects and advantages of my invention will appear in the following description of my improved method and of certain tools and apparatus for carrying out the same and thereafter the novelty and scope of the invention will be pointed out in the claims.

In the accompanying drawings;

Figure 1 is a view in longitudinal section showing how a bushing is introduced into a seat therefor;

Fig. 2 is a view in transverse section of the bushing and a shrinking tool on which it is mounted, the section being taken substantially on the irregular line 2—2 of Fig. 1;

Fig. 3 is a view in transverse section of the same taken on the line 3—3 of Fig. 1;

Fig. 4 is a detail view in section of a slight modification of the tool shown in Fig. 1;

Fig. 5 is a view in longitudinal section of a somewhat different form of tool adapted particularly for long liners, sleeve members and the like;

Fig. 6 is a view in section of the tool shown in Fig. 5, with the liner thereon, the section being taken on the line 6—6 of Fig. 5;

Fig. 7 is a fragmental view partly in section of a modified form of tool similar to that shown in Fig. 5;

Fig. 8 is a view in longitudinal section of apparatus for removing a car wheel from an axle;

Fig. 9 is a view in transverse section taken on the line 9—9 of Fig. 8, the car wheel being omitted;

Fig. 10 is a view in transverse section taken on the line 10—10 of Fig. 8;

Fig. 11 is a fragmental view in section of a shrinking apparatus or tool applied to one face of a wheel for contracting the same prior to applying a tire thereon, a corresponding apparatus on the opposite face being indicated by broken lines;

Fig. 12 is a fragmental side elevation looking in the direction of the arrow 12 in Fig. 11; and

Fig. 13 is view similar to Fig. 11, but showing a modified form of shrinking apparatus.

In Fig. 1, I show a hollow cylidrical member 15 formed interiorly with a seat 16 adapted to receive a bushing 17. The drawings show the bushing already contracted and inserted in the seat.

The tool for shrinking the bushing comprises a cylindrical head 18 which is hollow and provides an internal expansion chamber 19. The head 18 is formed with a portion 20 of reduced external diameter adapted to enter the bushing. Between the portion 20 and the main body of the head there is a shoulder 21 which provides an abutment for the outer end of the bushing. A number of keepers are provided for holding the bushing on the tool head. These keepers, as shown in Figs. 1 and 2, may consist of leaf springs 22, secured to the inner face of the tool head by means of screws 23 and having resilient ends 24 bent backward so that they normally project from the cylindrical face of the portion 20 but may be depressed into recesses 25 formed in said face. The particular form of keeper, however, is not essential and may be varied as occasion demands. Thus an alternative form is shown in Fig. 4 consisting of balls 26 which are seated in sockets 27 and are pressed outwardly by springs 28. At their outer ends the sockets are slightly peened over so as to retain the balls therein.

In the cylindrical face of the reduced portion 20 an annular groove 29 is formed and a series of ports 30 open from the expansion chamber into this groove. Also a number of discharge ports 31 are provided in the rear wall of the head 18, the purpose of which will be explained hereinafter.

The tool head is provided with an inlet port 32 into which a nozzle pipe 33 is screwed. This nozzle pipe is connected by a flexible pipe 34 to the discharge end 35 of a bottle 36 containing liquid carbon dioxide. Since there is always a certain amount of gas in such a container a discharge tube 37 is provided therein which extends to a point near the bottom of the bottle, so as to draw liquid rather than gas from the container. A valve handle 38 is provided to control the feed of carbon dioxide to the tool head.

A shouldered rod 39 passes through the tool head and is clamped thereto by means of a nut 40. This rod serves as a handle for the tool and also as a means for forcing the bushing home, as will be explained presently.

The operation of the tool is as follows: We shall assume first, that it is desired to produce an expansion fit of the bushing 17 in the seat 16. The bushing at normal temperature is machined slightly larger in diameter than the seat or the relative diameters may be such as to provide a fit of the desired tightness at the temperature to which the parts will be normally subjected. The bushing is first placed upon the reduced portion 20 of the tool head and is retained thereon by means of the keepers springs 23. The bushing is of somewhat larger internal diameter than the external diameter of the portion 20, but the keepers serve to hold the bushing substantially concentric with the tool head providing a slight annular gap between the bushing of the port 20 and the tool head. The operator may hold the tool by means of the handle 39, and then the valve handle 38 is turned to introduce carbon dioxide into the tool head. There is little expansion of the liquid carbon dioxide as it flows through the tube to the tool head, but as it enters the chamber 19 it expands almost instantly into a gas chilling the tool head. This rapid expansion continues because the gas is permitted to escape through the discharge ports 31 and also the ports 30. The gas issuing from the latter ports plays in jets upon the bushing, fills the annular groove 29 and discharges through the clearance between the bushing and the part 20 of the tool head. Some of the gas enters between the end of the bushing and the shoulder 21 and would blow the bushing off the tool were it not for the keepers. However, most of the gas escapes by way of the ports 31 which should be properly proportioned to insure the requisite venting of the expansion chamber, so as not to fill the latter with snow or solidified carbon dioxide and also not to waste the carbon dioxide, but to insure sufficient back pressure to cause a certain proportion of the frigid gas to pass out of the ports 30. The bushing is chilled very quickly by contact with the refrigerated head and by the gas jets playing upon it and is thereby contracted sufficiently to permit of inserting it into the seat 16. The valve handle 38 is preferably turned to cut off the supply of refrigerant just before the bushing is inserted in its seat.

In order to force the bushing into place if it should still fit the seat rather snugly, and to hold it firmly in ints seat while it is expanding, the handle 39 is passed through a cross-bar 41 which bears upon the member 15 and the tool head is drawn inward by means of a nut 42 threaded on the outer end of the handle and bearing against the cross-bar. A few turns of a wrench (indi-

cated by broken lines at 43) will serve to draw the bushing very tightly into place. The bushing then absorbs heat from the member 15 and also from the surrounding atmosphere and is thereby expanded in the seat 16. The tool may be removed as soon as the seat grips the bushing and before the latter has been fully restored to normal temperature.

The operation of removing a bushing from a tight seat is as follows: The tool head is inserted in the bushing and the carbon dioxide is applied for a few seconds to chill the bushing and permit it to shrink away from its seat. After which, the bushing may be easily withdrawn with the tool, the keepers serving to retain the bushing on the tool as it is being extracted from its seat. While the bushing is being shrunk away from its seat the discharging gas should be kept as much as possible from impinging against the member 15. Consequently the ports 31 through which most of the gas discharges, are located in the rear or outer wall of the expansion chamber and the gas is directed away from the member 15.

The tool shown in Fig. 5 is particularly adapted for the insertion of long liners or bushings into sockets or bores. This tool also involves a somewhat different principle of operation. In the tool described above a large part of the expansion takes place within the tool head, whereas in the tool shown in Fig. 5 most of the expansion of gas takes place as it issues from the tool and impinges against the surface to be cooled.

In Fig. 5, I show a member 45 formed with a bore into which a tubular bushing 46 is to be fitted or from which said bushing is to be removed as the case may be. The tool comprises a tubular head 47 which is closed at its outer end. The outer cylindrical surface of the tool head is formed with flutes 48 and ports 49 open from the bore of the tool head into these flutes. The inner end of the tool head is threaded upon one end of a pipe 50 and the opposite end of the pipe is formed with a collar or nut 51. The latter end of the pipe is internally threaded for connection to a nozzle pipe, such as the pipe 33 shown in Fig. 1, whereby carbon dioxide may be introduced from a suitable source of supply into the tool head.

The outer end of the tool head is formed with a threaded extension 53 to receive a nut 54 which overlaps the adjacent end of the bushing or liner 46. Mounted to slide freely on the pipe 50 is a weight or hammer 55 and this hammer is preferably provided with a grip 56 of cork or other insulation material.

In operation, when it is desired to introduce the liner 46 into the port 45, the nut 54 is removed and said liner is fitted upon the tool head. Then liquid carbon dioxide is admitted through the pipe 50 into the tool head. Since there is no expansion chamber in the tool head, the bore of said head being of substantially the same diameter as the bore of the tube 50 and of the tube that conducts the carbon dioxide into the tool head, and since the ports 49 are small, a substantial pressure will be maintained in the tool head. Initially there will be a back pressure of air in the tube to assist in maintaining the pressure on the carbon dioxide. Thus, there will be little expansion of the carbon dioxide and a large proportion of it will reach the ports 49 in liquid form. However, upon issuing from said ports into the flutes 48 the carbon dioxide will immediately expand into a gas and will rapidly cool the bushing.

In this case there is the equivalent of an expansion chamber outside the tool, said chamber being defined by the flutes 48 and the encompassing bushing 46. The latter does not fit tightly upon the tool head and the gas discharges through the clearance between the tool head and the bushing. The chilling of the bushing is effected almost entirely by the gas and only slightly by contact with the tool head.

As soon as the bushing has been shrunk sufficiently, it is introduced with the tool into the bore of a member 45, and then it is permitted to expand by absorption of heat until it fits tightly into said bore. If, for any reason, the bushing needs to be forced into the bore this can readily be done by hammering the weight 55 against the adjacent end of the tool head to drive the bushing with the tool into said bore. The tool becomes extremely cold and the grip 56 serves to protect the operator's hand from being blistered, while operating the hammer.

When removing the bushing from the bore the tool is inserted through the bushing and the nut 54 is screwed upon the extension 53. Then a charge of carbon dioxide is introduced into the bushing through the tool head, so as to cause contraction of the bushing. In the meantime, the hammer 55 may be operated against the collar 51 so as to drive the bushing out as soon as it has cooled sufficiently to loosen its fit in the bore.

One of the difficulties encountered in a tool of this sort is the fact that there is a tendency to produce greater cooling and shrinking of the bushing near the ends thereof than at the center. This is due to the expansion of the gas passing out of the flutes at either end of the tool heads. A uniform cooling and shrinking of the bushing may be effected by varying the size and distribution of the ports 49 so as to increase the gas expansion at the center of the tool and correspondingly increase the cooling effect.

Another way in which uniform cooling may be obtained is illustrated in Fig. 7. Here the tool illustrated is almost exactly like the tool shown in Fig. 5 and corresponding parts are indicated with the same reference numerals. The only difference is that a screen 57 is fitted over flutes in the tool head. The presence of this screen results in the formation of snow or solidified carbon dioxide. In operation the flutes become filled with snow almost instantly and this solidified carbon dioxide produces uniform refrigeration of the bushing 46. The cooling effect of the solidified carbon dioxide is not as rapid as that of the flowing gas but is uniformly distributed. For liners of certain size and composition it produces adequate shrinking.

In Fig. 8, I show an apparatus for removing a car wheel from an axle. Obviously, this same apparatus could be employed for removing any solid member from a hole or socket. The principle employed is the same as described above except that in this case the article to be cooled is not hollow and cannot be cooled from the inside. Hence the tool is made hollow so that it may encompass the object to be shrunk and may apply the refrigerating fluid upon the outside of the object. A car axle usually projects to a considerable extent beyond the face of the car wheel so as to enter a journal box on the outside of the wheel.

In Fig. 8 a car axle is shown at 60 and on this axle is a wheel 61. The tool for shrinking the car axle is formed with a socket head 63 which fits over the outer end of the car axle.

This socket head has either an annular expansion chamber, indicated by broken lines 64a in Fig. 10, or preferably separate channels 64 therein which communicate with a nozzle pipe 65 adapted to conduct the liquid carbon dioxide to the tool from a suitable source of supply. Ports 66 open from the channels 64 into flutes 67 formed in the face of the socket of the tool. Exhaust ports 68 are provided which lead from the inner end of the socket to the atmosphere.

In applying this tool to the car axle it is preferable to insert a washer 69 of asbestos or other insulation material between the end of the tool and the wheel 61 so that the chilling effect will not readily be communicated to the wheel. In order to hold the tool on the axle a number of hooks 70 are provided. These hooks are hinged to the tool head and may conveniently be passed through the openings 71 in the web of the wheel.

The operation of this tool will be readily understood. When the charge of refrigerant enters the tool head it will either expand in the chamber or channels 64, if the latter are made large enough to serve as expansion chambers. If the channels are too small for this purpose most of the expansion will take place when the refrigerant issues from the ports 66 into the flutes 67 and impinges against the axle 60. The gasified refrigerant then passes out of the tool by way of the ports 68, and such of the gas as passes along the axle toward the wheel is prevented from chilling the wheel by the washer 69. After the refrigerant has been applied for a sufficient period to chill the axle and release the fit of the wheel thereon the tool may be drawn off the axle carrying with it the wheel to which it is connected by the hooks 70.

If sufficient cooling cannot be obtained by the application of refrigerant to the outer end of the axle the refrigerant may also be applied to the axle on the opposite side of the wheel. To this end, I provide a double tool comprising a pair of semi-annular tool heads 72 which are hinged together at 73 (Fig. 9) so that they may be swung open and pass about the axle, after which they are closed upon the axle. A latch bolt 74 hinged to one of the tool heads is adapted to enter between a pair of lugs 75 on the other tool head. A nut 76 on the bolt is then tightened to lock the two semi-annular heads in closed position.

Each tool head is formed on its inner face with flutes 77 into which open ports 78 from an inner chamber 79. The latter is connected to a suitable source of liquid carbon dioxide by means of a pipe 80. In this case also there may be a large expansion of refrigerant in the chamber 79 if said chamber is of sufficient capacity, but if the cross-sectional area of the chamber is not substantially larger than that of the bore of the pipe 80 the expansion of the refrigerant will take place against the axle rather than in the chamber 79. A washer 81 of suitable insulation material is preferably fitted between the wheel and the tool heads.

The tools shown in Fig. 8 may be found useful not only for the particular purpose illustrated, but also for removing pins, shafts and other solid objects from sockets or bores in which they are tightly fitted and also for introducing them into such bores in contracted condition so that on expansion they will make a very tight fit.

The construction shown in Fig. 11 illustrates another adaptation of my invention. In this case, the object to be cooled is a wheel 83 upon which a tire (not shown) is to be fitted. For this purpose the tool is made in two parts. In other words, it comprises two heads 84 of substantially disc form which fit against opposite faces of the wheel. In the drawings only one of these tool heads is shown, in full, the other which is of like form and indicated in broken lines, is applied to the opposite face of the wheel. The tool head 84 is formed with an annular groove 85 to receive the felly of the wheel and is also shaped near its center to fit about the hub of the wheel. The tool is formed with flutes 86 and 87 in the working face thereof. The flutes 86 are annular and lie against the felly and hub of the wheel. The flutes 87 however are just long enough to span the spokes of the wheel and project slightly from opposite sides of said spokes, as shown in Fig. 12.

From the flutes, ports 88 open into interconnecting channels 89, 90 and 91, formed within the tool head. The channel 89 which is annular encircles the hub of the wheel and the channel 90 which is also annular but U-shaped in cross-section embraces the felly. The channels 91 radiate from channel 89 to channel 90 and are located to register with the spokes of the wheel. Carbon dioxide is led into the channel 89 through a supply pipe 92.

In operation two of the tool heads are placed on the wheel respectively at opposite sides thereof so as to enclose the wheel. Then the refrigerant is introduced into each tool head and is permitted to expand in the channels 89, 90 and 91. The refrigerant which issues as a gas from the ports 88 into the flutes 87 will discharge past the spokes. A certain amount of clearance is provided in the socket 85 so that there will be a leakage of gas from the flutes 86 which bear against the felly of the wheel and the hub of the wheel, respectively. This will result in very rapid cooling of the entire wheel. There is preferably a slight annular clearance between the two tool heads 84, as indicated at 93, in Fig. 11, to provide for the escape of gas impinging upon the felly of the wheel.

Obviously, the position and size of the ports 88 may be so chosen as to insure a uniform shrinking of a wheel. Obviously, too, the channels 89, 90 and 91 may be made of such cross-section as to prevent any material expansion of the refrigerant until it issues from the ports 88. However, since this tool is not to be used for removing the tire from the wheel rapid cooling of the wheel is not essential, and the cooling of the wheel might be effected entirely by contact of the wheel with the tool heads without permitting the gas to impinge upon the wheel. In other words, since it is essential to have uniform shrinking of the wheel and the time element is not a factor, the tool head 95 could be formed as shown in Fig. 13. This tool head is similar in form to that shown in Fig. 11 but it has no flutes 86 and 87 and no ports 88 on the inner face of the tool. The tool head is hollow and is not provided with separate radiating channels. Instead there is a single expansion chamber 96 provided with a number of discharge ports 97.

In use the carbon dioxide is led into the chamber 96 through a pipe 98 and expands therein. As a result the tool head is chilled and by conduction the wheel 83 is also chilled and shrunk.

As stated above my invention is not limited to the use of carbon dioxide since other well-known refrigerants may be used such, for instance, as ethane, propane, etc. I prefer to use a refrigerant which is liquefied under pressure, employing the pressure to force the liquid to the point of application so that the expansion and

consequent refrigeration will be confined largely to said point. However, it is within the scope of my invention to use a refrigerant in the form of a compressed gas instead of a liquid, permitting it to expand at the point of application. It is also within the scope of my invention to use a liquid refrigerant such, for instance, as liquid air, and to spray the liquid upon the object to be shrunk. The tools shown in Figs. 5 and 8 could be used to direct jets of liquid air against the object to be shrunk. I have found, however, that because of the extremely low temperature of liquid air objects thus shrunk become very brittle and must be handled very carefully to prevent fracture.

It will be understood that the various embodiments described above are to be taken as illustrative and not limitative of my invention and that various modifications and changes may be made in details of construction, arrangement of parts and the mode of operation, without departing from the spirit and scope of my invention.

I claim:

1. A method of separating a part from a tight encircling seat, which consists in conducting a highly expansible refrigerant fluid under pressure to the part, permitting the refrigerant to expand against the part so as to chill and shrink the same, and withdrawing the part from the seat.

2. A method of removing from an outer member a hollow inner member tightly fitted therein, which consists in introducing into said hollow member a highly expansible refrigerant liquefied under pressure, expanding the refrigerant into a gas within said hollow member to abstract heat therefrom and shrink said hollow member, directing the discharge of the expanding gas away from the outer member, and withdrawing the hollow member from the outer member.

3. A method of removing an inner member from an outer member in which it is tightly fitted, which consists in applying a highly expansible refrigerant liquefied under pressure to the vicinity of the inner member, permitting the refrigerant to expand into a gas, directing the gas against the inner member to abstract heat therefrom and shrink the same, thermally protecting the outer member from the refrigerant gas, and separating the two members after the inner member has been shrunk.

4. A method of separating an inner member from an outer member in which it is tightly fitted, which consists in applying a highly expansible refrigerant liquefied under pressure to the vicinity of the inner member, permitting the refrigerant to expand into a gas against the inner member to abstract heat therefrom and shrink the same, discharging the refrigerant gas away from the outer member, and withdrawing one member from the other.

5. A tool for chill shrinking an object, comprising a head adapted to fit the object, said head having a chamber therein and ports opening from the chamber toward said object, and means for connecting the chamber to a supply of fluid refrigerant.

6. A tool for shrinking a hollow member, said tool comprising a head adapted to be inserted in said member, means for retaining the member on the head, said head being formed with a chamber and with ports leading from the chamber to said member, and means for connecting the chamber to a source of fluid refrigerant.

7. A tool for shrinking a hollow member, said tool comprising a head adapted to be inserted in said member, spring keepers on the head adapted to retain the member in concentric relation to the head but slightly spaced therefrom, the head being formed with a chamber and with ports opening therefrom toward the member, and means for connecting the chamber to a source of fluid refrigerant.

8. A tool for shrinking a hollow member, said tool comprising a head adapted to be inserted in a member, spring keepers on the head adapted to retain the member in concentric relation to the head but slightly spaced therefrom, the head being formed with a chamber and with ports opening therefrom toward the member, and means for connecting the chamber to a source of fluid refrigerant, the head being also formed with ports leading from the chamber away from said member.

9. A tool for shrinking a hollow member, said tool comprising a hollow head adapted to be inserted in said member, the head being formed with a groove adapted to be encompassed by said member and with ports leading from the interior of the head into said grooves, and means for connecting the hollow head to a source of liquid refrigerant.

10. A tool for shrinking a hollow member, said tool comprising a head formed with an expansion chamber and adapted to be inserted into the hollow member, means for conducting a fluid refrigerant under pressure into said chamber, the head being formed with ports opening out of said chamber and adapted to direct the refrigerant in jets against said member.

11. A tool for shrinking a hollow member, said tool comprising a head formed with an expansion chamber and adapted to be inserted in the hollow member, and means for conducting a fluid refrigerant under pressure into said expansion chamber, the head being formed with ports opening out of said chamber and adapted to direct the refrigerant in jets against said member and also with discharge ports directed away from said chamber.

12. A tool for shrinking a hollow member, said tool comprising a hollow head formed with an expansion chamber and adapted to be inserted in the hollow member, and means for conducting a compressed fluid refrigerant into said expansion chamber, the head being formed with a groove in its outer surface and with ports opening out of said chamber into said groove, said ports being adapted to direct the refrigerant in jets against said member.

13. A tool for shrinking a hollow member, said tool comprising a hollow head formed with an expansion chamber and adapted to be inserted in the hollow member, and means for conducting a fluid refrigerant into said expansion chamber, the head being formed with a groove in its outer surface and with ports opening out of said chamber into said groove, said ports being adapted to direct the refrigerant in jets against said member, and the head being also formed with discharge ports leading from said chamber away from said member.

14. A tool for inserting a hollow member into an opening in another member, said opening being of smaller cross-sectional area than that of the hollow member, said tool comprising a head adapted to be inserted in said hollow member, said head being formed with a passage therein and with ports radiating from the passage toward

said hollow member, means for connecting the passage to a supply of fluid refrigerant, whereby the hollow member will be shrunk by the refrigerant issuing from the ports, and means for forcing the outer member into said opening.

15. A tool for inserting a hollow member into an opening in another member, said opening being of smaller cross-sectional area than that of the hollow member, said tool comprising a head adapted to be inserted in said hollow member, said head being formed with a passage therein and with ports radiating from the passage toward said hollow member, means for connecting the passage to a supply of fluid refrigerant whereby the hollow member will be shrunk by the refrigerant, the head having a shoulder at one end adapted to bear against the hollow member, a threaded handle projecting from the opposite end of the head, a yoke adapted to bear against the outer member and formed with an opening through which said handle projects, and a nut adapted to be screwed on the handle against the yoke to draw the hollow member into the opening.

16. A tool for shrinking a sleeve-like member, said tool comprising a tubular head adapted to be be inserted into said member, the head being formed with flutes in its exterior surface and with ports leading from the bore of the head into said flutes, said head being closed at one end, and means at the opposite end of the head for connecting said bore to a source of fluid refrigerant.

17. A tool for shrinking a sleeve-like member, said tool comprising a tubular head adapted to be inserted into said member, the head being formed with flutes on its exterior surface and with ports leading from the bore of the head into said flutes, said bore being closed at one end, and means at the opposite end of the head for connecting said bore to a source of fluid refrigerant, the ports near the center of the head being of larger diameter than that of the ports near the ends thereof.

18. A tool for shrinking a sleeve-like member, said tool comprising a tubular head adapted to be inserted into said member, the head being formed with flutes in its exterior surface and with ports leading from the bore of the head into said flutes, said bore being closed at one end, and means at the opposite end of the head for connecting said bore to a source of fluid refrigerant, said ports being of variable size and distribution to provide uniform cooling of the hollow member.

19. A tool for shrinking a sleeve-like member, said tool comprising a tubular head adapted to be inserted into said member, the head being formed with flutes on its exterior surface and with ports leading from the bore of the head into said flutes, means for connecting the bore at one end of the head to a source of fluid refrigerant, the bore at the opposite end of the head being closed, and a keeper adapted to be applied to the latter end of the head, said keeper overlapping the hollow member.

20. A tool for shrinking a sleeve-like member, said tool comprising a tubular head adapted to be inserted into said member, the head being formed with flutes on its exterior surface and with ports leading from the bore of the head into said flutes, said head being threaded at one end, a nut adapted to be screwed thereon to overlap the adjacent end of the hollow member, an extension at the opposite end of the head, a hammer reciprocable on the extension, the latter being formed at its outer end with a collar, the bore being closed at one end, and means for connecting the opposite end of the bore to a source of fluid refrigerant.

21. A tool for shrinking a sleeve-like member, said tool comprising a tubular head adapted to be inserted into said member, the head being formed with flutes on its exterior surface and with ports leading from the bore of the head into said flutes, said head being threaded at one end, a nut adapted to be screwed thereon to overlap the adjacent end of the hollow member, a tubular extension at the opposite end of the head, a hammer reciprocable on said tubular extension, the latter being formed at its outer end with a collar, the bore being closed at one end, means for connecting the opposite end of the bore to a source of fluid refrigerant, and a grip of thermal insulation material on said hammer.

22. A tool for shrinking a member, said tool comprising a socket head adapted to receive said member, said head being formed interiorly with channels, and means for connecting said channels to a source of fluid refrigerant, said head being formed with ports opening from the channels into the socket so as to direct the refrigerant in jets against said member.

23. A tool for shrinking a member, said tool comprising a socket head adapted to receive said member, said head being formed interiorly with channels, and means for connecting said channels to a source of fluid refrigerant, said head being formed with grooves in the surface of the socket and with ports leading from the channels into said grooves.

24. A tool for shrinking a member, said tool comprising a socket head adapted to receive said member, said head being formed interiorly with channels, and means for connecting said channels to a source of fluid refrigerant, said head being formed with flutes in the surface of the socket and with ports leading from the channels into said flutes, said head being provided also with discharge ports leading from the socket away from said member.

25. A tool for shrinking a member, said tool comprising a socket head adapted to receive said member, said head being formed interiorly with channels, means for connecting said channels to a source of fluid refrigerant, said head being formed with flutes in the surface of the socket and with ports leading from the channels into said flutes, and keepers carried by said head.

26. Means for removing an inner member from a tight fitting seat in an outer member, said inner member projecting from the outer member, said means comprising a socket head adapted to receive the projecting end of the inner member, said head being formed with channels therein and with ports leading from the channels into the socket, a tube connecting the channels to a source of fluid refrigerant, and hooks on the tool head adapted to be attached to the outer member.

27. Means for removing a wheel from an axle on which it is tightly fitted, said axle projecting from one face of the wheel, said means comprising a socket head adapted to receive the projecting end of the axle, hooks carried by the head and adapted to be secured to the wheel, a washer of thermal insulation material placed between the socket head and the wheel, said socket head being formed with channels therein and with ports opening from the channels into the socket, and means for connecting said channel to a source of fluid refrigerant.

28. A tool for shrinking a member, said tool comprising a head having a surface conforming

substantially to the member, said head being formed with channels and with discharge ports leading therefrom through said surface, and means for connecting the channels to a source of fluid refrigerant.

29. A tool for shrinking a member, said tool comprising a head having a surface conforming substantially to the surface of the member said surface being formed with grooves, the head being further formed with channels therein and with ports leading from the channels into said grooves, and means for connecting said channels to a source of fluid refrigerant.

30. Means for shrinking a member, said means comprising a pair of heads, each formed with a recess to receive a part of said member, means for securing said heads together about the member, each head being formed with a channel and with ports leading from the channel into the recess, each recess being formed with grooves into which the ports open, and means for connecting the channel of each head to a source of fluid refrigerant.

31. A method of chill shrinking an object which consists in conducting to the vicinity of the object a current of highly expansible refrigerant liquefied under pressure, permitting the refrigerant to expand into a gas against the object to chill and shrink the same, and simultaneously using the chilling effect of the expanded gas to precool said current.

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