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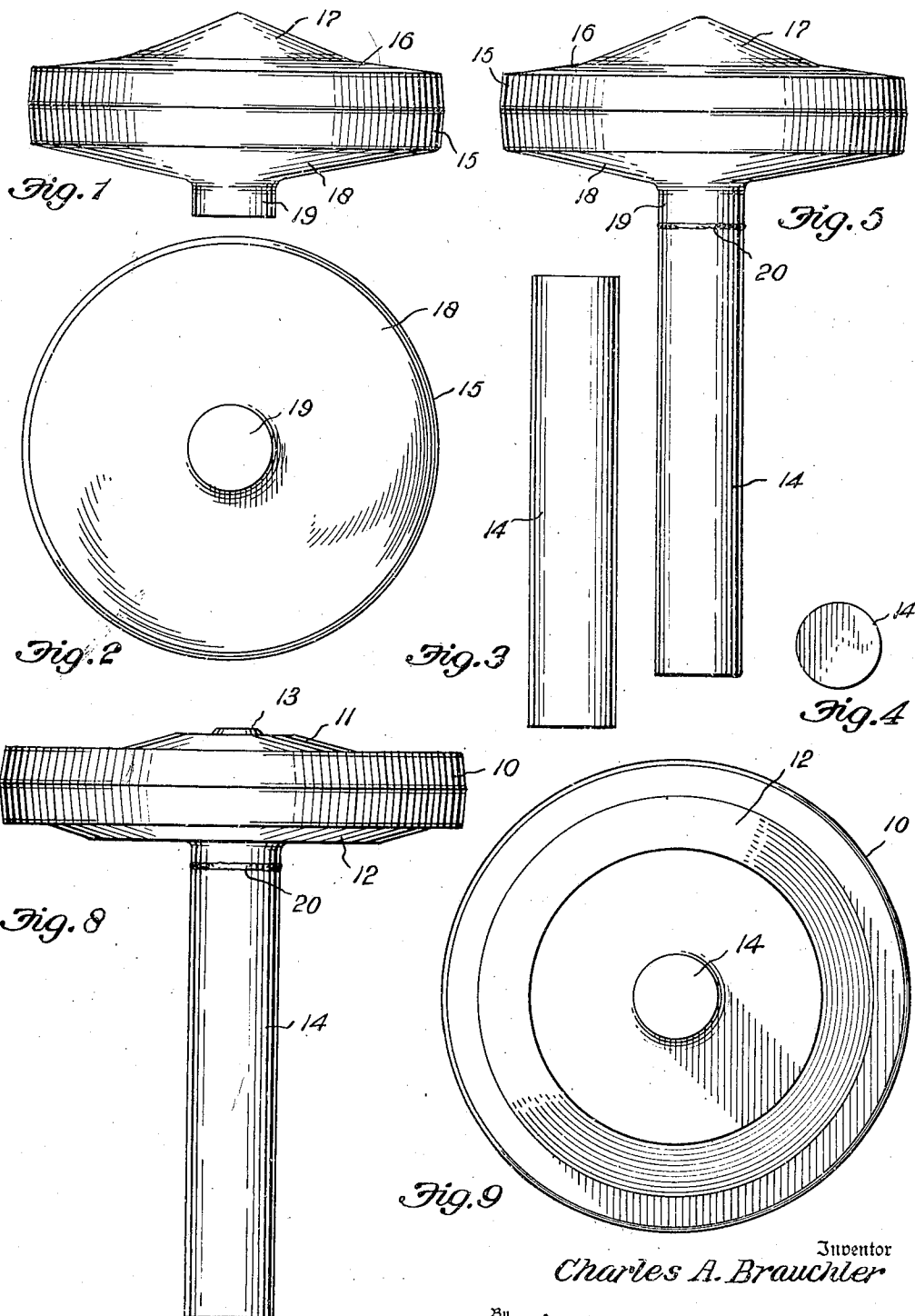
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2,487,304

METHOD OF MAKING TURBINE WHEEL FORGINGS

Filed April 17, 1945

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

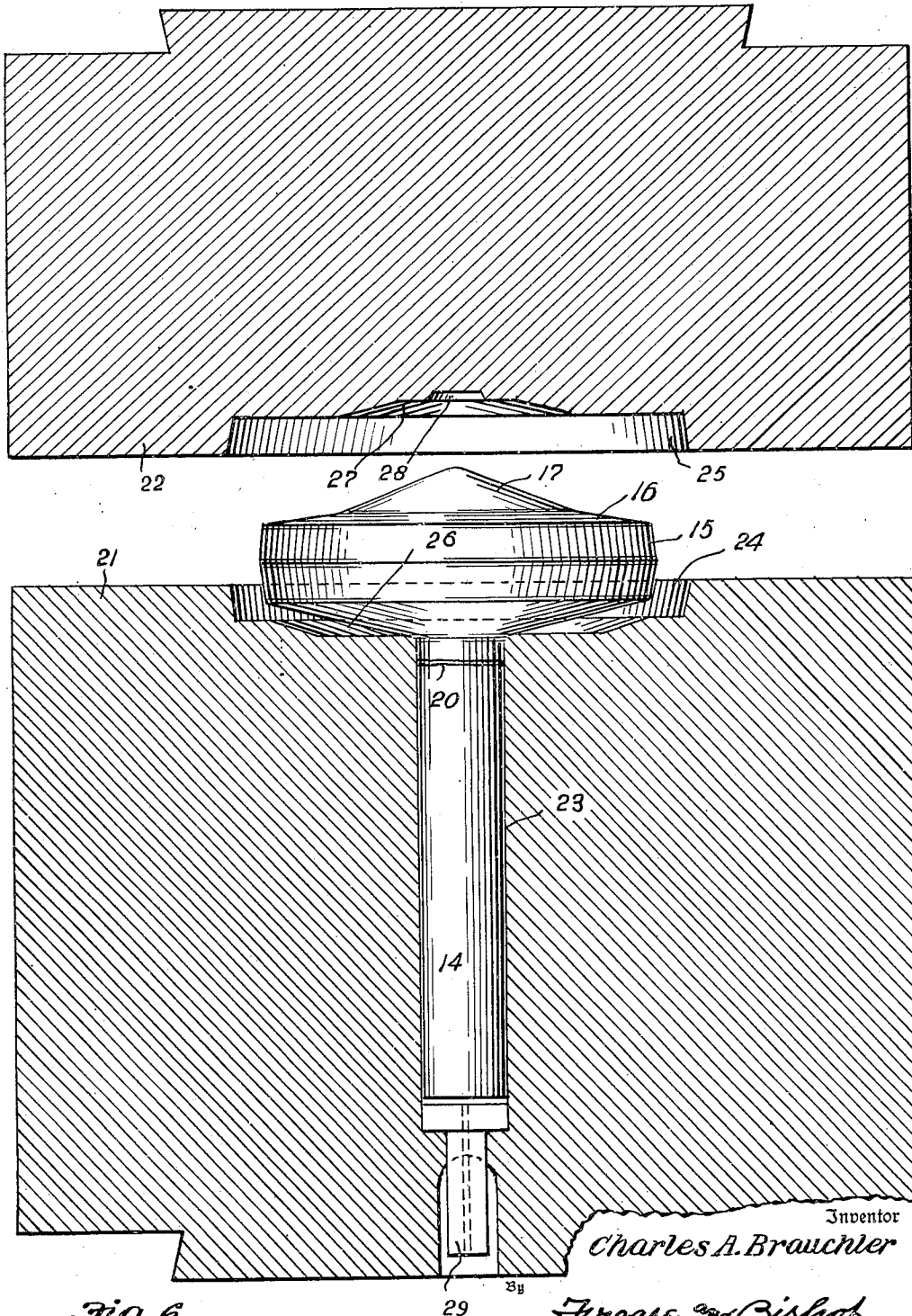


Fig. 6

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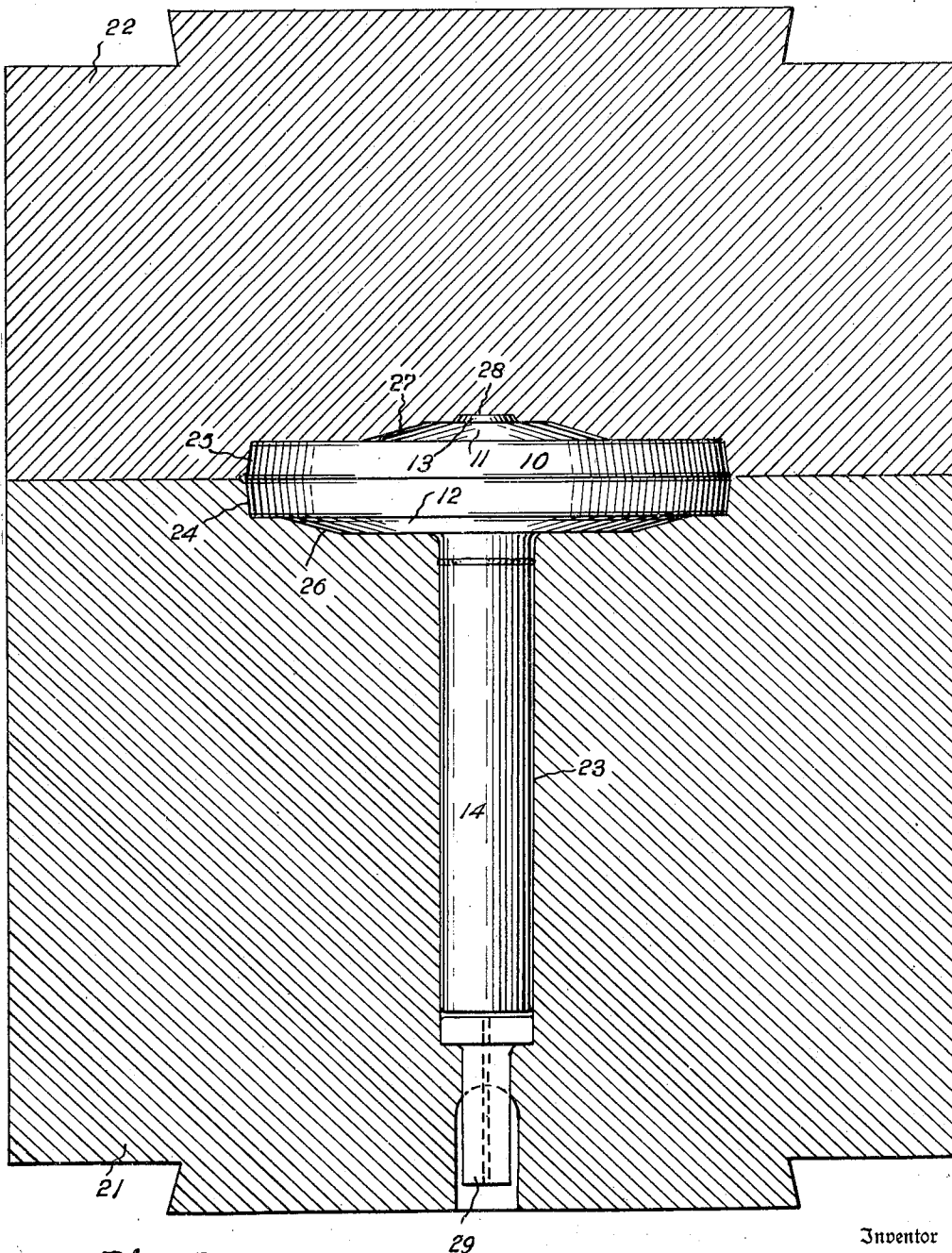


Fig. 7

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METHOD OF MAKING TURBINE WHEEL
FORGINGS

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13 Claims. (Cl. 148-12)

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The invention relates to the manufacture of forgings and the like comprising a part formed from a high heat resisting alloy and another part welded thereto and formed of a medium carbon alloy steel which requires heat treatment to harden, and more particularly to a turbine wheel in which the wheel itself is formed of a high heat resisting alloy incapable of being drawn to any extent and capable of hardening only by cold working, and the shaft of the wheel is formed of a medium carbon alloy steel which requires heat treatment to harden the same, the shaft being welded at one end to the wheel.

In the recent development of jet propelled planes for use by the armed forces such planes include a turbine wheel formed of a high heat resisting alloy which can stand high running temperatures and which can be hardened only by cold working.

Due to the physical properties of these high heat resisting alloys it is impossible to draw the same in the forging operation to form an integral shaft thereon and this necessitates the formation of a separate shaft of a different material which is attached to the high heat resisting alloy wheel itself by welding. This shaft is made of a medium carbon alloy steel which requires heat treatment to harden and it is also necessary that the weld be heat treated to relieve strains and stresses in the structure.

Under present practice the wheel itself is forged to finished shape from the high heat resisting alloy which as an example may be an alloy containing relatively large amounts of a combination of alloys taken from a group comprising chrome, nickel, molybdenum, titanium, columbium and cobalt, and a very small percent of carbon. Such heat resisting alloys can not be drawn so as to forge the shaft integrally upon the wheel and they can only be hardened by cold working.

For this reason it is necessary that the shaft be formed separately and then welded to the wheel. Under present practice these turbine wheels are made by hot forging the heat resisting alloy wheel at about 2000° F. to a certain shape, requiring about 200 hammer blows and then cold working at about 1250° F. to build up hardness in the wheel as it is forged to the final shape.

The shaft is formed of a medium carbon alloy steel containing .30 to .70 carbon and containing small amounts of one or more alloys such as molybdenum, manganese, chrome, nickel, aluminum and tungsten. Such medium carbon alloy steels require heat treatment to harden and must be capable of developing a certain Brinell hard-

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ness after quenching and tempering at the proper temperature. The quenching temperature depends upon the particular analysis selected and varies from about 1450° F. to 1800° F., and the tempering temperature will depend upon the hardness and physicals desired.

This shaft is then welded at one end to the wheel at a temperature exceeding 2000° F., which ruins the hardness in the wheel and puts in strains that can not be relieved. If the shaft is heat treated before it is welded to the wheel it is obvious that the higher temperature of the welding operation will also destroy the hardness in the shaft. On the other hand if the shaft is heat treated after welding to the wheel, this will only tend to further destroy the hardness of the wheel.

Such turbine wheels as are now being made in the above manner are not entirely satisfactory since they do not withstand high running temperatures for any considerable period of time which is probably due to the fact that the wheel and the shaft can not both be properly hardened.

The present invention contemplates a method of making such turbine wheels in a manner which obtains the maximum hardness in both the high heat resisting alloy wheel itself and the alloy steel shaft and relieves strains and stresses in the structure.

Another object of the invention is to make a turbine wheel forging by first hot forging the high heat resisting alloy head to a preliminary or partially completed shape, then welding the alloy steel shaft to this partially completed head, then heat treating the shaft and wheel with a quench and draw operation to whatever temperature may be required to bring out desired physicals in the shaft and to relieve all strains set up in the welding operation, and then cold working the wheel itself to the final finished form at a temperature below the draw temperature of the shaft so as not to destroy the physicals in the shaft.

More specifically it is an object of the invention to form a turbine wheel forging by first forging the high heat resisting alloy wheel to partially completed shape at a temperature of about 2000° F., then welding the medium carbon alloy steel shaft to the partially completed wheel at a temperature exceeding 2000° F., then heat treating the wheel and shaft, the tempering temperature of which is about 1300° F. and then cold working the partially completed wheel to final shape at a temperature below 1300° F.

The above and other objects which will be ap-

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parent from the drawings and following description, or which may be later referred to, may be attained by carrying out the improved method in the manner hereinafter described in detail and illustrated in the accompanying drawings, in which;

Figure 1 is a side elevation of the partially completed high heat resisting alloy turbine wheel forging;

Fig. 2 a bottom plan view of the same;

Fig. 3 is a side elevation of the alloy steel shaft;

Fig. 4 an end elevation of the same;

Fig. 5 a side elevation of the partially completed wheel forging shown in Figs. 1 and 2 with the shaft shown in Figs. 3 and 4 welded thereto;

Fig. 6 a sectional view through the cold working dies showing the partially completed wheel of Fig. 5 located therein;

Fig. 7 a view similar to Fig. 6 showing the turbine wheel forging therein after the cold working operation;

Fig. 8 a side elevation of the finished wheel and shaft forging; and

Fig. 9 an end elevation of the same.

The process to which the invention pertains is described and illustrated herein as carried out in the manufacture of a particular design of turbine wheel forging used in a type of jet propelled plane now being produced.

The particular design of turbine wheel referred to is illustrated in Fig. 8 and comprises generally the disc-like wheel 10, having the truncated conical portions 11 and 12 formed on opposite sides thereof, a small central boss 13 protruding from one side of the wheel and a shaft 14 being fixed to the other side thereof.

It has been found necessary to form the turbine wheel of a high heat resisting alloy which can stand high running temperatures, such alloys as are suitable for the purpose containing large amounts of various combinations of chrome, nickel, molybdenum, titanium, columbium or cobalt.

The physical properties of such high heat resisting alloys prohibit the drawing of the metal in the forging operation so as to form the shaft integrally upon the wheel, thus requiring that the shaft be formed separately of other material, preferably of medium carbon alloy steel, which is attached to the high heat resisting alloy wheel by welding. Furthermore, these high heat resisting alloys can not be hardened by a draw and quench operation but require cold working in order to develop hardness therein.

The difference in the physical properties of the two metals of which the wheel and shaft are made produces a problem in the manufacture of the wheel, and such turbine wheels as have been made under present practice do not give satisfactory results in that they can not stand high running temperatures for any considerable length of time.

It is present practice in the manufacture of these turbine wheels to hammer forge the high heat resisting alloy wheel 10 from a blank of high heat resisting alloy, hot forging the wheel at about 2000° F. and then cold working it at about 1250° F. to build up hardness in the wheel as it is forged to the final shape.

The shaft is formed of a medium carbon, alloy steel capable of developing a required Brinell hardness after quenching from the proper temperature and tempering at a temperature above 1250° F., the draw temperature of the alloy steel from which the shaft is made being preferably about 1300° F.

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This separate shaft, of medium carbon alloy steel, is then welded to the high heat resisting alloy wheel at a temperature exceeding 2000° F., ruining the hardness of the high heat resisting alloy wheel and putting in strains which can not be relieved.

Furthermore, if the medium carbon, alloy steel shaft is heat treated before the welding operation it is obvious that the high welding temperature will destroy the hardness in the shaft, while if the shaft is heat treated after the welding operation, this requires a temperature higher than the cold working temperature of the high heat resisting alloy wheel and only tends to further destroy the hardness thereof.

In carrying out the improved process to form a turbine wheel of this type, a blank or block of high heat resisting alloy is first hammer forged at a temperature of about 2000° F., to the preliminary shape shown in Figs. 1 and 2.

These high heat resisting alloys contain relatively large amounts of combinations of chrome, nickel, molybdenum, titanium, columbium or cobalt and a very small amount of carbon. As an example, a type of high heat resisting alloy which has been used for the purpose contains 16% chrome, 25% nickel, 6% molybdenum and about .08 to .12% of carbon.

The preliminary shape, shown in Figs. 1 and 2, comprises the disc portion 15, of considerably smaller diameter and somewhat greater thickness than the finished shape indicated at 10 in Fig. 8. A truncated conical portion 16 is formed on one side of the disc 15, terminating in the central conical portion 17, and a truncated conical portion 18 is formed on the other side of the disc, terminating in the cylindrical shaft boss 19.

The shaft 14 is separately formed of a medium carbon alloy steel which may contain any combination of small proportions of molybdenum, manganese, chrome, nickel, aluminum or tungsten and may contain from .30 to .70 carbon and which is capable of developing a required Brinell hardness after quenching and drawing at the proper temperature.

As an example, very satisfactory results may be obtained by forming the shaft from an alloy steel containing .38 to .45 carbon, .40 to .70 manganese, .040 maximum phosphorus, .050 maximum sulphur, .20 to .40 silicon, 1.40 to 1.80 chrome, .90 to 1.35 aluminum and .30 to .45 molybdenum. Such alloy steel is capable of developing a Brinell hardness of 229 minimum after quenching from the proper temperature and tempering at 1300° F. This particular analysis can be satisfactorily quenched in oil from a furnace temperature varying from 1700° F. to 1775° F.

The shaft boss 19 of the preliminary wheel shape may be rough machined, if necessary, and the shaft 14 is then welded thereto, as indicated at 20 in Fig. 5, at a temperature exceeding 2000° F.

The preliminary shape wheel forging with the shaft welded thereon, as shown in Fig. 5, is then heat treated to get the desired physical properties in the shaft. Where alloy steel of the above analysis is used this heat treatment consists in quenching at the proper temperature and tempering at about 1300° F. which will develop a Brinell hardness of approximately 229 minimum in the shaft.

It should be understood that while this heat treatment has brought out the desired physical qualities in the alloy steel shaft, and has relieved all strains set up in the welding operation,

it has not hardened the high heat resisting alloy wheel itself, since this material is capable of hardening only by cold working.

The preliminary shape of the wheel, with the heat treated shaft attached thereto, is then placed in the dies 21 and 22, as shown in Fig. 6, and cold worked by hammer forging in these dies at a temperature below the draw temperature of the shaft, so as not to ruin the hardness of the shaft. Where metals of the above analysis are used, and the shaft has been tempered at 1300° F., the cold working in these dies may be carried out at a temperature of about 1250° F.

In this cold working operation the high heat resisting alloy wheel only is forged to finished shape, the shaft 14 being merely held in the cylindrical portion 23 of the cavity of the die 21. The dies 21 and 22 have the cavities 24 and 25 respectively of the desired finished shape of the wheel, the cavity 24 having the truncated conical extension 26 and the cavity 25 having the truncated conical extension 27 terminating in the central recess 28.

In these dies the preliminary shape wheel forging is cold forged at the above mentioned temperature to the final shape, as shown in Fig. 7, the preliminary disc forging 15 being reduced in thickness and increased in diameter, forming the final shape of disc portion 10 which fills the cavities 24 and 25.

The conical portions 16 and 17 are deformed by the upper die and produce the truncated conical portion 11 and boss 13 of the finished wheel forging, filling the upper die recesses 27 and 28. The lower die may be provided with a conventional knock-out device 29 for removing the finished forging from the dies.

The finished forging, after being removed from the dies, should then be stress relieved, at a suitable temperature, below the critical temperature of the shaft, a temperature of about 1200° F., being suitable from the illustration above given where the shaft was tempered at 1300° F., although it should be understood that the temperature may vary where different materials or different physical properties are desired.

Although the invention has been illustrated and described in detail as applied to the making of a turbine wheel and shaft forging for jet propelled planes, it should be understood that the invention is not limited to the manufacture of this single item, nor is it limited to the use of metals of the particular analyses given, but is applicable to any case where a part is to be made of two separate portions of two different metals having the general characteristics above referred to.

It should further be understood that although the invention as disclosed refers to the hot forging of the high heat resisting alloy member to partially completed shape and then welding the shaft thereto, that it may be desirable in some cases to rough machine the partially completed hot forged high heat resisting alloy member between the hot forging operation and the welding operation, but this rough machining operation will not in any manner affect the novel process as described above and hereinafter claimed.

I claim:

1. The method of making a forging comprising one member of high heat resisting alloy capable of hardening only by cold working and one member of alloy steel capable of hardening by a quench and draw operation, which consists in hot forging

the high heat resisting alloy member to partially finished shape of greater thickness and less diameter than the finished shape, then welding the alloy steel member thereto, then hardening the alloy steel member by heat treating at the proper quenching temperature and tempering at a temperature to get the desired physical properties therein, and then cold forging the high heat resisting alloy member to finished shape at a temperature lower than the tempering temperature of the alloy steel member to get the desired physical properties therein.

2. The method of making a forging comprising one member of high heat resisting alloy capable of hardening only by cold working and one member of alloy steel capable of hardening by a quench and draw operation, which consists in hot forging the high heat resisting alloy member to partially finished shape of greater thickness and less diameter than the finished shape, then welding the alloy steel member thereto, then hardening the alloy steel member by heat treating at the proper quenching temperature and tempering at a temperature to get the desired physical properties therein, and then cold forging the high heat resisting alloy member to finished shape at a temperature lower than the tempering temperature of the alloy steel member to get the desired physical properties therein and then stress relieving the structure at a temperature below the heat treating temperature.

3. The method of making a forging comprising one member of high heat resisting alloy capable of hardening only by cold working and one member of medium carbon alloy steel capable of hardening by a quench and draw operation at about 1300° F., which consists in hot forging the high heat resisting alloy member to partially finished shape of greater thickness and less diameter than the finished shape at about 2000° F., then welding the medium carbon alloy steel member thereto at a temperature exceeding 1300° F., then hardening the alloy steel member by heat treating at the proper quenching temperature and tempering at about 1300° F., and then cold forging the high heat resisting alloy member to finished shape at a temperature below 1300° F. to get the desired physical properties therein.

4. The method of making a forging comprising one member of high heat resisting alloy capable of hardening only by cold working and one member of medium carbon alloy steel capable of hardening by a quench and draw operation at about 1300° F., which consists in hot forging the high heat resisting alloy member to partially finished shape of greater thickness and less diameter than the finished shape at about 2000° F., then welding the medium carbon alloy steel member thereto at a temperature exceeding 1300° F., then hardening the alloy steel member by heat treating at the proper quenching temperature and tempering at about 1300° F., and then cold forging the high heat resisting alloy member to finished shape at a temperature of about 1250° F. to get the desired physical properties therein.

5. The method of making a forging comprising one member of high heat resisting alloy capable of hardening only by cold working and one member of medium carbon alloy steel capable of hardening by a quench and draw operation at about 1300° F., which consists in hot forging the high heat resisting alloy member to partially finished shape of greater thickness and less diameter than the finished shape at about 2000° F., then welding the medium carbon alloy steel member

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thereto at a temperature above 1300° F., then hardening the alloy steel member by heat treating at the proper quenching temperature and tempering at about 1300° F., and then cold forging the high heat resisting alloy member to finished shape at a temperature of about 1250° F. to get the desired physical properties therein and then stress relieving the structure at a temperature below 1300° F.

6. The method of making a forging comprising one member of high heat resisting alloy capable of hardening only by cold working and one member of medium carbon alloy steel capable of hardening by a proper quench and draw operation at about 1300° F., which consists in hot forging the high heat resisting alloy member to partially finished shape of greater thickness and less diameter than the finished shape at about 2000° F., then welding the medium carbon alloy steel member thereto at a temperature exceeding 1300° F., then hardening the alloy steel member by heat treating at the proper quenching temperature and tempering at about 1300° F. and then cold forging the high heat resisting alloy member to finished shape at a temperature of about 1250° F. to get the desired physical properties therein and then stress relieving the structure at a temperature of about 1200° F.

7. The method of making a forging comprising a turbine wheel of high heat resisting alloy capable of hardening only by cold working and a shaft of alloy steel capable of hardening by a quench and draw operation, which consists in hot forging the wheel to partially finished shape of greater thickness and less diameter than the finished shape, then welding the shaft to the wheel, then hardening the shaft by heat treating at a temperature below the hot forging and welding temperatures to get the desired physical properties therein, and then cold forging the wheel to finished shape at a temperature below the heat treating temperature to get the desired physical properties therein.

8. The method of making a forging comprising a turbine wheel of high heat resisting alloy capable of hardening only by cold working and a shaft of alloy steel capable of hardening by a quench and draw operation, which consists in hot forging the wheel to partially finished shape of greater thickness and less diameter than the finished shape, then welding the shaft to the wheel, then hardening the shaft by heat treating at a temperature below the hot forging and welding temperatures to get the desired physical properties therein, and then cold forging the wheel to finished shape at a temperature below the heat treating temperature to get the desired physical properties therein and then stress relieving the structure at a temperature below the heat treating temperature.

9. The method of making a forging comprising a turbine wheel high heat resisting alloy capable of hardening only by cold working and a shaft of medium carbon alloy steel capable of hardening by a quench and draw operation, which consists in hot forging the wheel to partially finished shape of greater thickness and less diameter than the finished wheel shape, then welding the shaft to the wheel, then hardening the shaft by heat treating at a temperature below the hot forging and welding temperatures to get the desired physical properties therein, and then cold forging the wheel to finished shape at a temperature below the heat treating tempera-

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ture to get the desired physical properties therein.

10. The method of making a forging comprising a turbine wheel of high heat resisting alloy capable of hardening only by cold working and a shaft of medium carbon alloy steel capable of hardening by a quench and draw operation, which consists in hot forging the wheel to partially finished shape of greater thickness and less diameter than the finished wheel shape, then welding the shaft to the wheel, then hardening the shaft by heat treating at a temperature below the hot forging and welding temperatures to get the desired physical properties therein, and then cold forging the wheel to finished shape at a temperature below the heat treating temperature to get the desired physical properties therein and then stress relieving the structure at a temperature below the cold forging temperature.

11. The method of making a forging comprising a turbine wheel of high heat resisting alloy containing about 16 per cent chrome, 25 per cent nickel, 6 per cent molybdenum and about .08 to .12 per cent carbon, and a shaft of alloy steel containing about .38 to .45 carbon, .40 to .70 manganese, .040 maximum phosphorus, .050 maximum sulphur, .20 to .40 silicon, 1.40 to 1.80 chrome, .90 to 1.35 aluminum, and .30 to .45 molybdenum, which consists in hot forging the wheel at about 2000° F. to partially finished shape of greater thickness and less diameter than the finished wheel shape, then welding the shaft to the wheel at above 1300° F., then heat treating the shaft by quenching at the proper temperature and tempering at about 1300° F., and then cold forging the wheel to finished shape at about 1250° F.

12. The method of making a forging comprising a turbine wheel of high heat resisting alloy containing about 16 per cent chrome, 25 per cent nickel, 6 per cent molybdenum and about .08 to .12 per cent carbon, and a shaft of alloy steel containing about .38 to .45 carbon, .40 to .70 manganese, .040 maximum phosphorus, .050 maximum sulphur, .20 to .40 silicon, 1.40 to 1.80 chrome, .90 to 1.35 aluminum, and .30 to .45 molybdenum, which consists in hot forging the wheel at about 2000° F. to partially finished shape of greater thickness and less diameter than the finished wheel shape, then welding the shaft to the wheel at a temperature above 1300° F., then heat treating the shaft by quenching at the proper temperature and tempering at about 1300° F., and then cold forging the wheel to finished shape at about 1250° F. and then stress relieving the structure at a temperature of about 1200° F.

13. The method of making a forging comprising a turbine wheel of high heat resisting alloy capable of hardening only by cold working and a shaft of alloy steel capable of hardening by a quench and draw operation, which consists in hot forging the wheel to partially finished shape of greater thickness and less diameter than the finished wheel and having a conical portion on one side and a truncated conical portion terminating in a central boss on the other side, then welding one end of the shaft to said central boss on the wheel, then hardening the alloy steel shaft by heat treating at a proper temperature below the hot forging and welding temperature to get the desired physical properties therein, and then cold forging the high heat resisting alloy wheel to finished shape of less thickness and increased diameter forming said conical portion into a flat truncated conical cone and decreasing

the thickness of said truncated conical portion at a temperature lower than the tempering temperature of the alloy steel shaft to get the desired physical properties in said high heat resisting alloy wheel.

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REFERENCES CITED

The following references are of record in the file of this patent:

10

UNITED STATES PATENTS

Number	Name	Date
63,096	Reynolds	Mar. 19, 1867
1,551,631	Bartlett et al.	Sept. 1, 1925
1,977,845	Emmons	Oct. 23, 1934
2,014,612	Borton	Sept. 17, 1935
2,197,609	Cornell, Jr.	Apr. 16, 1940