Nov. 29, 1960 E. A. THOMPSON 2,962,397

METHOD OF MAKING TAPPETS

Original Filed June 23, 1955 3 Sheets-Sheet 1

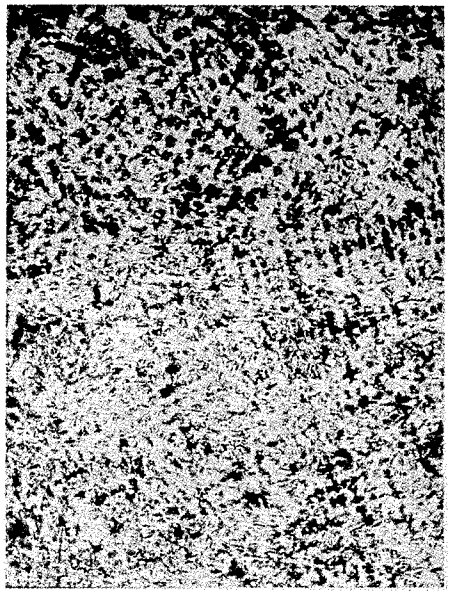


Fig. 1

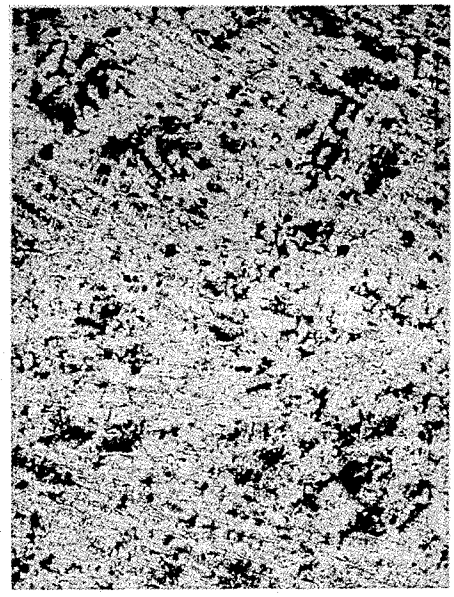


Fig. 2

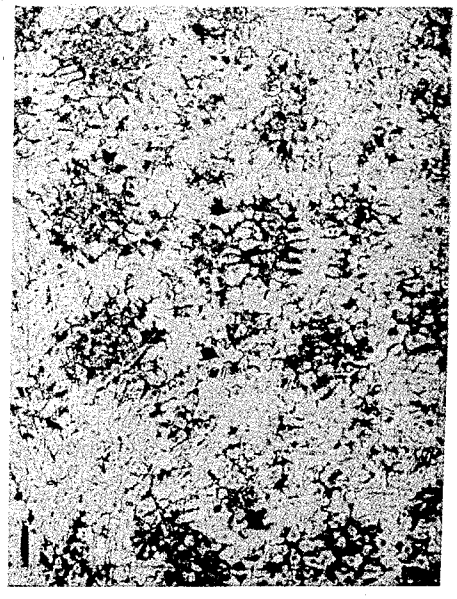


Fig. 3

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Nov. 29, 1960 E. A. THOMPSON 2,962,397

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Original Filed June 23, 1955 3 Sheets-Sheet 2

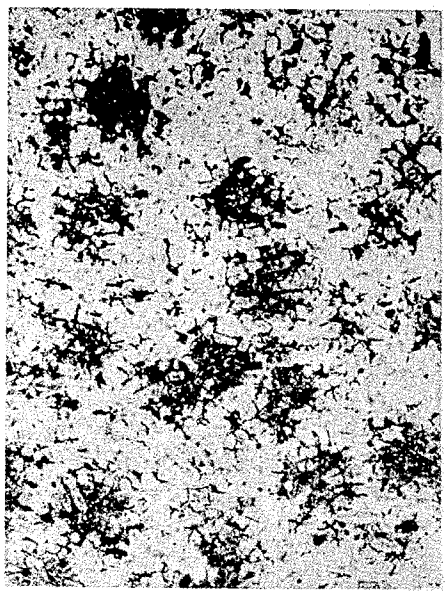


Fig. 4

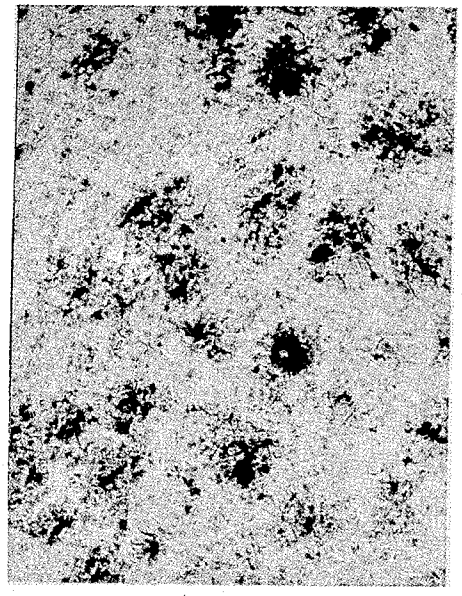


Fig. 5

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Original Filed June 23, 1955 3 Sheets-Sheet 3

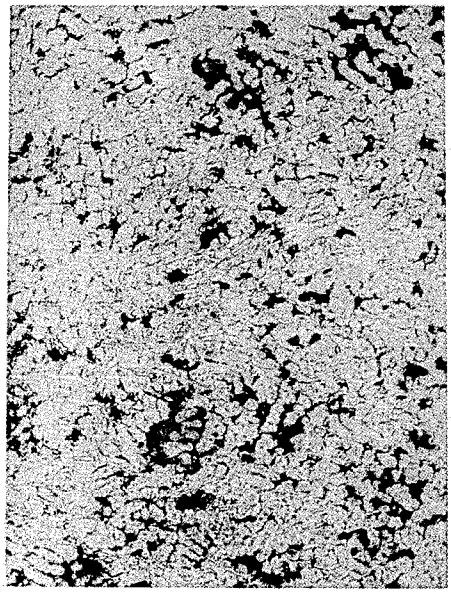


Fig. 6



Fig. 7

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METHOD OF MAKING TAPPETS

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Original application June 23, 1955, Ser. No. 517,520. Divided and this application Sept. 19, 1957, Ser. No. 685,030

2 Claims. (Cl. 148—3)

This invention relates to a tappet and more particularly to a tappet comprising a cast iron base and a tubular steel body bonded, fused, welded, brazed or otherwise permanently joined together, such as shown in my prior Patent 2,887,098, issued May 19, 1959, for Valve Tappet. This application is a division of my copending application Serial No. 517,520, filed June 23, 1955, for "Tappet and the Method of Making Same."

One of the objects of this invention is that of producing a tappet for an internal combustion engine wherein the cast iron base or wear surface which contacts the customary cam for operating such a tappet has excellent wear resistance properties and strength. This object is achieved in part by fabricating the base of the tappet independently of its body from an alloy cast iron which is hardenable by heat treatment. By fabricating the base or wear face of the tappet separately from the tubular steel body one is able to control the micro-structure of the base and thereby achieve the above mentioned wear resistance properties and strength.

My above mentioned copending applications show the preferred method for joining the tubular steel body to the cast iron base. The present invention is particularly concerned with a tappet such as shown in my copending applications wherein the cast iron base or button has a uniform microstructure across substantially the entire wear face of the tappet. This object is accomplished by fabricating the base from a cast iron alloy which is hardenable by heat treatment. By way of example, the base of the wear surface of the tappet can be made from any typical cast iron alloy the elements of which are expressed in percentages by weight of the total composition; such as

Carbon	2.9.
Silicon	2.10.
Manganese	.70.
Chromium	.70.
Molybdenum	.50.
Copper	.50.
Nickel	.25.
Sulphur	About .1 maximum.
Phosphorus	About .2 maximum.
Iron	Balance.

The percentages of these constituents will vary slightly depending on the control exercised in the foundry.

I prefer to melt the iron and alloying constituents in an electric furnace and cast a plurality of individual base castings or buttons in a shell mold. I prefer a shell mold over a sand mold because with a shell mold one can obtain a more uniform and rapid freezing rate than with an ordinary green sand mold. The cast iron is left in the shell mold for only sufficient time to allow all of the metal in the castings to solidify. This, by way of example, is about two minutes. At the end of this time the castings are quickly removed from the molds and the base castings clipped off of the runners and immediately quenched at sufficient rate to produce at least a partially complete martensitic structure, commonly referred to as

mottled iron. This may be done by air quenching when the cast bases are sufficiently separated or they may be dropped into a suitable liquid quenching media, such as oil.

After a cleaning operation the castings are then introduced into a furnace at a temperature of 1700–1800° F. This furnace must have sufficient heating capacity to quickly bring the temperature of the base castings to the temperature of the furnace; for example, in approximately two and one-half to four minutes. The base castings should be distributed in the furnace so that they may be quickly heated to this temperature. Where the base castings are made from the above typical alloy, the time they are held at this temperature of 1700–1800° F. is about eight minutes. However, where the percentage of carbide forming alloy constituents such as chromium and molybdenum or even vanadium is varied, the length of time which they are held at this range of temperature will be varied to produce the desired result.

If the above analysis is varied to increase the carbide forming constituents, that is, chromium, molybdenum, then the length of time that the alloy will be held at furnace temperature can be increased to produce the desired microstructure whereas if the amount of carbide forming alloy constituents is decreased over that stated in the above example, then the time that the base castings are held at furnace temperature will be correspondingly decreased or the temperature decreased.

After the base castings have been left in the furnace at the 1700–1800° F. zone for the above specified time, they are then immediately and quickly transferred to an adjacent zone in the furnace having a lower temperature of approximately 1300° F. The base castings are allowed to remain in this zone about twelve minutes which is sufficient time to insure the transforming of the austenite content of the castings to pearlite. The base castings may then be air cooled, or, if desired, transferred to a third zone in the furnace at around 750° F. for a matter of ten to fifteen minutes and then air cooled.

The above described casting procedure and heat treatment will bring out changes in the microstructure in the castings as illustrated in the attached photomicrographs:

Fig. 1 is a photomicrograph showing the structure of the casting as cast and quenched to room temperature. It will be seen that the white areas, which are the hard carbides, principally cementite, are fairly continuous and connected for large distances in the photomicrograph and that only very small isolated particles of graphite are present, as is typical of mottled iron.

Photomicrograph Fig. 2 shows the changes in the structure brought about the time at heat in the 1700–1800° F. zone. This photograph is taken from a specimen that was removed from this zone after having been in this zone for the specified time and then air cooled. By comparison with Fig. 1, it will be seen that the white carbide areas have just commenced to break up into smaller pieces and to be outlined sharply, mostly in the form of elongated particles but shorter than the long white areas in Fig. 1. This refinement of the carbides is favored by the high temperature, but the time the piece is held at this temperature is too short for precipitation of graphite to progress but slightly. The presence of carbide-forming constituents also retards the progress of graphite formation during this phase of the treatment.

Photomicrograph Fig. 3 shows the structure of the base casting after having been treated as above described in zone 1 (1700–1800° F.) and zone 2 (1300° F.), the specimen being taken out at that point and air cooled. Here the graphite formation has proceeded somewhat further and the separate mottled areas or centers of graphite formation have grown in size but not sufficiently to merge with one another.

Photomicrograph Fig. 4 shows the structure of the base casting after it has been heat treated in zones 1 and 2 referred to above and then additionally treated in the furnace zone at 750° F. for a period of ten to fifteen minutes and then air cooled. This shows how the graphite precipitation in the individual mottled areas or growth centers has progressed further to darken each area individually without causing significant precipitation in the white martensitic areas adjoining them.

After the base casting has been heat treated as above described to produce the structure shown in photomicrographs Fig. 3 or Fig. 4, the base casting is then joined to the tubular steel body, preferably as shown and described in my above specified copending applications. This produces a combined fusion bond and mechanical connection between the base casting and the tubular steel body. The tappet as thus formed is then subjected to a final carburizing treatment in a gas carburizing or carbonitriding furnace at a temperature of from 1525 to 1550° F. and held at the temperature for a sufficient time to produce a case depth in the steel tubing of around .012 to .016 inch. The thus carburized or carbo-nitrided tappet is direct quenched in oil and drawn to a temperature of approximately 400° F. This final carburizing or carbonitriding treatment improves the fusion bonded joint as described in my Patent 2,887,098.

A photomicrograph Fig. 5 shows the structure of the base after the final heat treatment in the carburizing or carbo-nitriding atmosphere.

This quenching from 1550° F. produces a fully martensitic matrix in the casting and further refines the shape and size of the cementite or iron carbide particles. It will be noted that the final microstructure of the base casting is characterized by uniformly distributed cementite particles with predominantly rounded contours and the matrix is martensitic. A minor amount of the carbon content exists as free graphite mostly concentrated in mottled areas.

A study of the final microstructure of the base casting shows that these mottled areas are located on an average over the entire wear face of the base casting of approximately one mottled area per square inch at 100 diameter magnification, that is, about 10,000 mottled areas per square inch of actual surface. The average of mottled areas may range as high as one and one-half mottled areas per square inch at 100 diameter magnification, but preferably should average less than about one per square inch at 100 magnification. The unconnected cementite or iron carbide particles may, in the vicinity of high graphite concentration, be as low locally as approximately ten particles per square inch at 100 diameter magnification. In areas where there is a low concentration of graphite, the cementite particles may range as high as 190 particles per square inch at 100 diameter magnification.

A highly desirable or preferred base casting will contain in the minimum areas of cementite particles of the order of 40–50 particles of cementite per square inch at 100 diameter magnification and in the maximum areas of cementite particles a concentration of the order of 120–140 cementite particles per square inch at 100 diameter magnification.

As a modification of the above method, the base casting after undergoing the treatment in zone 1 at 1700–1800° F. for the time specified, can be transferred into a zone at about 900° F. and maintained in this zone until the casting falls to a temperature of 1300° F. or a little below, whereupon the casting can be cooled in air to room temperature. After reheating to 1550° F. and quenching in oil a microstructure, such as shown in the photomicrograph Fig. 6, is obtained which comprises substantially uniformly distributed discrete cementite particles in a martensitic matrix with some free graphite. The reheating step at 1550° F. can be accomplished simultaneously with the carburizing of the tappet after the base has been permanently joined to the tubular steel body.

Fig. 7 is a photomicrograph having the same disclosure as that of Fig. 5 but at a magnification of 1000 diameters.

I claim:

1. The method of forming a hard, tough non-scuffing valve tappet comprising casting a piece from hardenable alloy iron containing about 2.9% C, 2.1% Si, together with suitable carbide forming metals in smaller percentages and promptly thereafter cooling the piece at a rate to form mottled iron, heat treating the piece at between 1700° and 1800° F. for a period of about 8 minutes, but merely sufficient to break down the hard carbide particles into smaller discrete particles with little formation of graphite, then heat treating the piece at a temperature approximating 1300° F. to cause separate mottled areas of graphite to form and then quenching the piece to produce a martensitic matrix holding the smaller carbide particles and interspersed with separated large mottled areas of graphite concentration.

2. The method of forming a hard, tough non-scuffing valve tappet comprising casting a piece from hardenable alloy iron containing about 2.9% C, 2.1% Si, together with suitable carbide forming metals in smaller percentages and promptly thereafter cooling the piece at a rate to form mottled iron, heat treating the piece at between 1700° and 1800° F. for a period of about 8 minutes, but merely sufficient to break down the hard carbide particles into smaller discrete particles with little formation of graphite, then heat treating the piece at a temperature approximating 1300° F. to cause separate mottled areas of graphite to form, heat treating the piece at a still lower temperature approximating 750° F. to increase the graphite concentration in the mottled areas with little increase in size of the areas of graphite concentration, and then quenching the piece to produce a martensitic matrix holding the smaller carbide particles and interspersed with separated large mottled areas of graphite concentration.

References Cited in the file of this patent

UNITED STATES PATENTS

1,710,997	Rich	Apr. 30, 1929
1,801,742	Hayes	Apr. 21, 1931
1,842,110	Osterholm	Jan. 19, 1932
1,871,544	McCarroll et al.	Aug. 16, 1932
2,008,452	Jewett et al.	July 16, 1935
2,032,906	Biewind et al.	Mar. 3, 1936
2,035,393	McCarroll et al.	Mar. 24, 1936

FOREIGN PATENTS

356,795	Great Britain	Sept. 7, 1931