

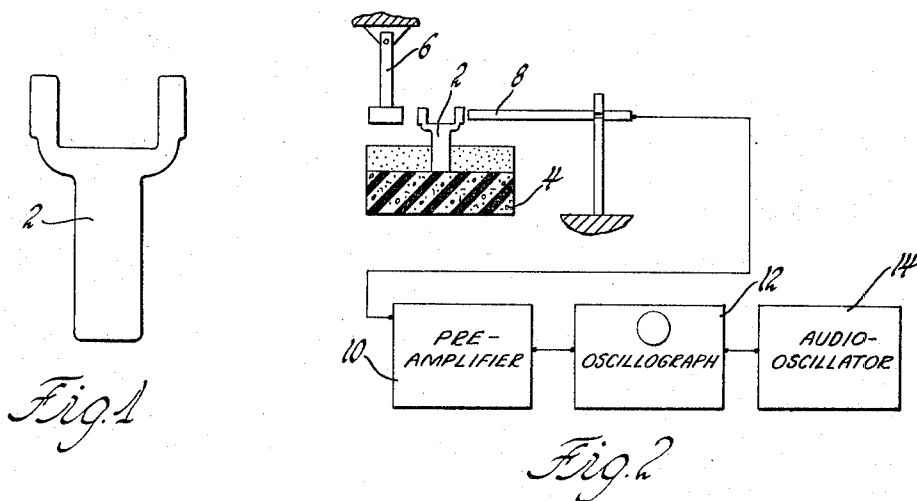
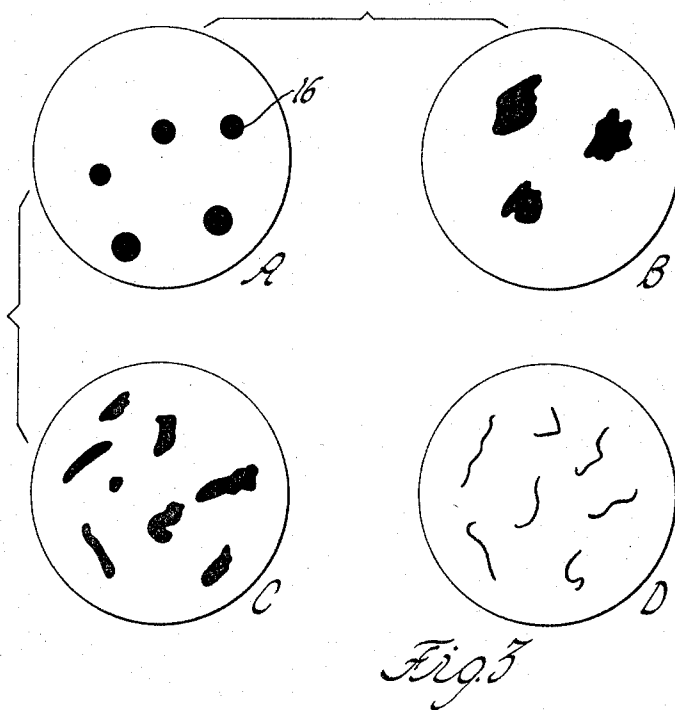
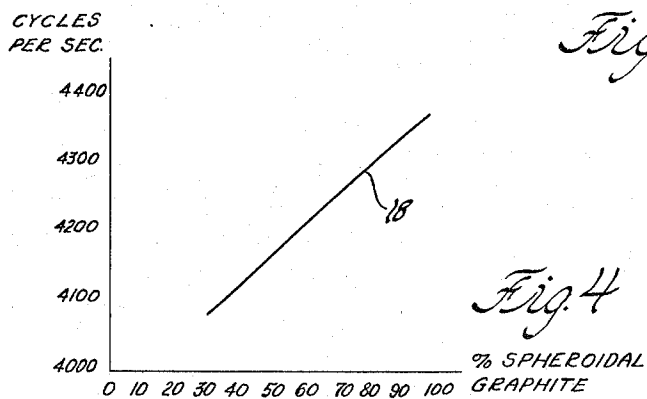
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METHOD OF DETERMINING GRAPHITE SHAPES IN NODULAR IRON

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3,284,192

METHOD OF DETERMINING GRAPHITE SHAPES IN NODULAR IRON

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This invention relates to a method for evaluating the graphitic micro-structure of nodular iron.

The shape and distribution of carbon particles in cast iron influence its mechanical properties such as strength and ductility. Therefore, for any given application it is desirable to regulate the shape and distribution of the graphite spheroids or nodules in the cast iron so that the resultant iron members will have optimum properties for their intended use. It is particularly important to be able to check what the final resultant cast iron is going to be from any melt before that melt is poured so that corrections can still be made, if necessary.

It is a principal object in making this invention to provide a method of evaluating what the graphitic micro-structure of cast iron members from a melt will be in its final solidified state while the melt is yet in the molten state so that corrections may still be made.

It is a further object in making this invention to provide a sample from a melt for testing, whose characteristics can then be used to determine the necessity of adding any ingredients to the melt to obtain desired end properties of castings therefrom.

It is a still further object in making this invention to provide a method of sampling a melt to determine the shape and distribution of spheroid graphite particles in the resulting cast iron while the melt is still in condition to have its chemistry regulated.

With these and other objects in view which will become apparent as the specification proceeds, our invention will be best understood by reference to the following specification and claims and the illustrations in the accompanying drawings, in which:

FIGURE 1 is a sketch showing a form of cast sample used for testing;

FIG. 2 is a schematic and block diagram of a system embodying our invention;

FIG. 3 is a number of sketches showing in enlarged form the various possible shapes taken by the graphite particles in iron; and,

FIG. 4 is a graph of frequency of resonance of the sample part plotted against percent of spheroid particles contained therein.

Referring now more particularly to the drawings the primary purpose of the method is to extract a sample of the melt and to cast the same in a given form so that it can be easily set into vibration and its resonant frequency determined. The resonant frequency of the part is in turn determined by the micro-structure thereof. If all other variables except the shape or form of the graphite nodules are kept the same for all cast samples of iron then the shape or form of these nodules is the only thing which would tend to vary the resonant frequency of the sample part and by measuring the same the shape of the particles can be determined from empirical charts and, therefore, the mechanical characteristics of the final iron found. While various sample test shapes may be used, we have selected as one of the best a shape which resembles that of a tuning fork as it can more readily be set into vibration. The configuration shown at 2 in FIG. 1 may, therefore, be used and molds may be pivoted in which to cast samples of this configuration. After the shell molds have been made from patterns along the lines of the part 2, a sample of molten nodular iron from the

melt to be checked is poured into the mold. After the casting temperature has dropped to, for example, between 1900° and 1800° F. the mold is broken open and the casting is quenched in oil at room temperature. The casting is left in the oil from 15 to 30 seconds when it is removed and quenched in water bringing it to room temperature in about thirty seconds. By the use of this quenching schedule a micro-structure of free graphite in a matrix of martensite results in the casting. The casting may then be sand blasted to smooth it and the riser and gating system removed. The sample tuning fork, such as 2, is then mounted in a sponge rubber base, such as 4 in FIG. 2.

FIG. 2 shows a schematic diagram of the pick-up and indicating system together with the means for ringing or striking the sample. A striker or mallet 6 is pivotally mounted on one side of the sample 2 which can be raised and when released descends to strike the tuning fork sample and set it into vibration. On the opposite side of the sample 2 there is mounted a microphone pick-up member 8 which is connected directly into a pre-amplifier 10 and thence to the vertical plates of an oscillograph 12. The horizontal plates of the oscillograph are connected to the output of an audio oscillator 14. The frequency of vibration of the sample tuning fork yoke 2 is determined by adjusting the output of the audio oscillator 14 until a Lissajous figure is obtained on the screen of the oscillograph. The frequency is then read directly from the dial of the audio oscillator.

All parameters of each sample are kept the same, such as size, shape, rates of cooling, etc. Therefore, the only variable between samples will be the size and number of the graphite nodules, the character of which can be determined by the resonant frequency of the device. Frequencies for different nodularized tuning fork sample yokes are empirically determined and recorded and correlated to their graphite shapes through micro-analysis of the yokes. On this basis frequencies outside of a specific range indicate unacceptable graphite shapes in the final casting and the need of adding corrective chemicals. The use of tuning fork yoke standardizes the size and shape of the sample, leaving the material (size and shape of graphite nodules) as the only variable to affect the frequency. Nodular iron is a ferrous alloy of carbon, silicon and manganese with free graphite. Because the casting is quenched in the same manner each time a sample yoke is poured the alloy develops the same micro-structure martensite. Free graphite is then the main determinant of the frequency of vibration. This free graphite in nodular iron may exist in various shapes. The shape of the graphite is important because it determines the mechanical properties of the resultant cast parts. The optimum graphite shape for the best mechanical properties is a perfect sphere. Deviations toward flake graphite result in a reduction in mechanical properties. The highest frequencies of vibration are recorded when graphite is in the spheroidal form or to state it another way in which the graphite occupies the least volume. As the graphite nodular shape deviates toward flakes the frequency of vibration decreases proportionately.

FIG. 3 shows the various forms that the nodular graphite might take. At A the nodules 16 are substantially spherical which is the best and most desired form. At B the nodules are not in spherical form but are still relatively round and compact. At C the nodules have begun to lengthen out and become elongated so that the mechanical properties of any iron in which these appear would not be as satisfactory as those containing nodules of forms A or B, and at D the nodules have now reached full flake form and the iron would probably be generally unacceptable for many uses.

The graph of FIG. 4 plots resonant frequency of vibra-

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tion of samples in cycles per second against percent of spherical graphite nodules. This curve has been plotted from the results of a series of tests. Thus the curve 18 shows that a sample casting with substantially 100% spherical nodules will vibrate in the range between 4300 and 4400 cycles per second. Such a casting would have satisfactory physical properties. As the amount of spheroid decreases and the amount of nodular flakes increase and the resonant frequency of vibration of the sample decreases until at 30% spheroid the frequency has been lowered to some 4100 cycles. At this point the resultant iron would probably be unacceptable and it would be necessary to add to the melt some material such as magnesium, tellurium or some other appropriate alloying element which would tend to cause the graphite to assume more spherical shape in solidifying to produce satisfactory castings. Actually in tests which have been run, it is found that in testing sample parts from a single heat that the frequency of vibration of these parts did not vary over 46 cycles or over 1.1%. Therefore, this is an excellent and accurate method of testing the melt to determine the characteristics of the final casting at a point where corrections can be made and proper quality iron obtained under most circumstances.

What is claimed is:

1. In a method of testing molten free graphite containing ferrous metal to determine such final physical properties of parts cast therefrom as strength and ductility while corrective measures may be taken including the steps of casting a sample of a given shape and size, reducing the temperature of the sample casting on a defined schedule to room temperature, setting said sample casting into resonant vibration, determining the frequency

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of said resonant vibration as an indication of the size and shape of the graphite particles therein which determines the physical properties of parts cast from the melt and adding corrective materials to the melt if necessary to produce parts of desired strength from the melt.

2. In a method of testing a metallic melt of free graphite containing ferrous metal to determine the physical characteristics such as strength and ductility of parts cast therefrom, the steps of casting a sample of a given size and shape, cooling the sample to room temperature on a defined schedule, setting the sample into resonant vibration, determining the frequency of such vibration, comparing the resonant frequency with a known resonant frequency obtained by an identical test of an identical sample containing known size and shape of graphite particles, and adjusting the composition and cooling rate of the melt to produce cast iron with substantially identical properties as those of said identical sample.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,284,192

November 8, 1966

William B. Larson et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 69, for "pivoted" read -- provided --.

Signed and sealed this 12th day of September 1967.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents