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E. FUKUSIMA

METHOD FOR MEASURING THE ROUGHNESS OF THE METALLIC SURFACE

Filed July 2, 1941

Serial No. 400,876

2 Sheets-Sheet 1

Fig. 1

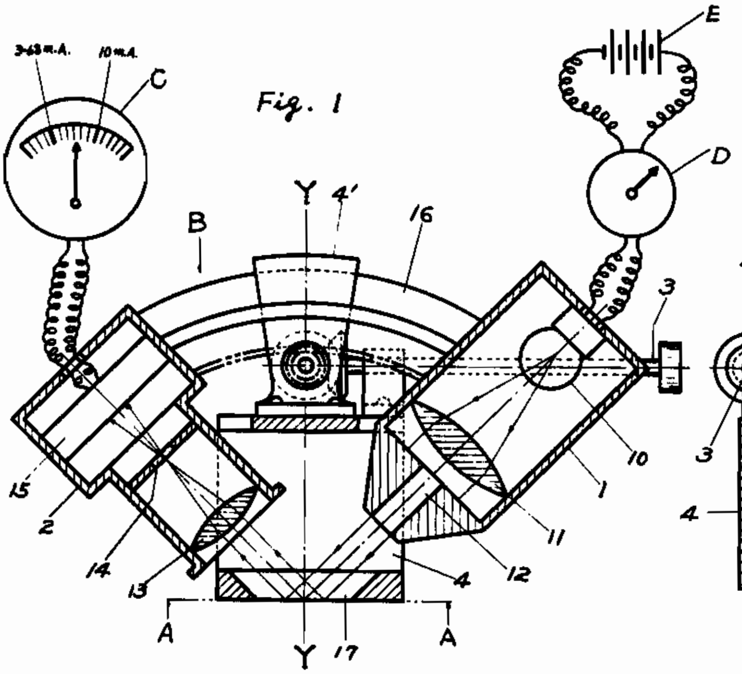


Fig. 3

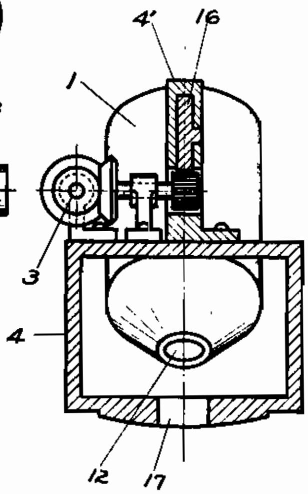


Fig. 2

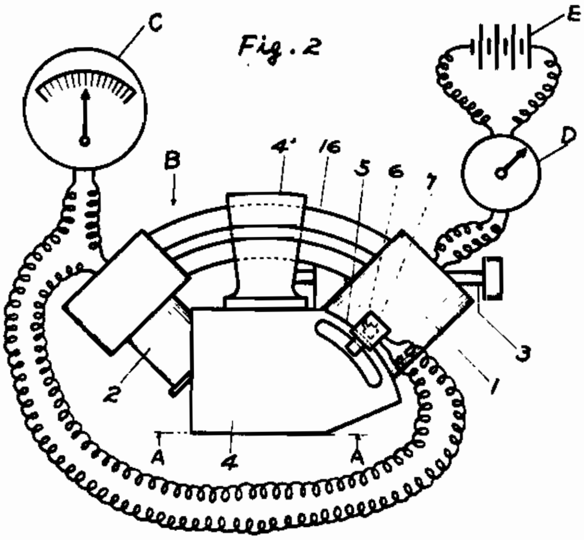


Fig. 4

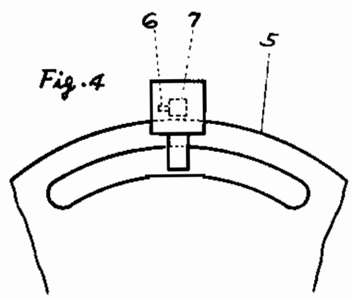
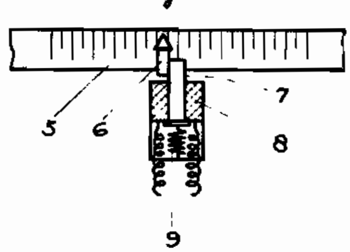


Fig. 5



Einosuke Fukusima INVENTOR.

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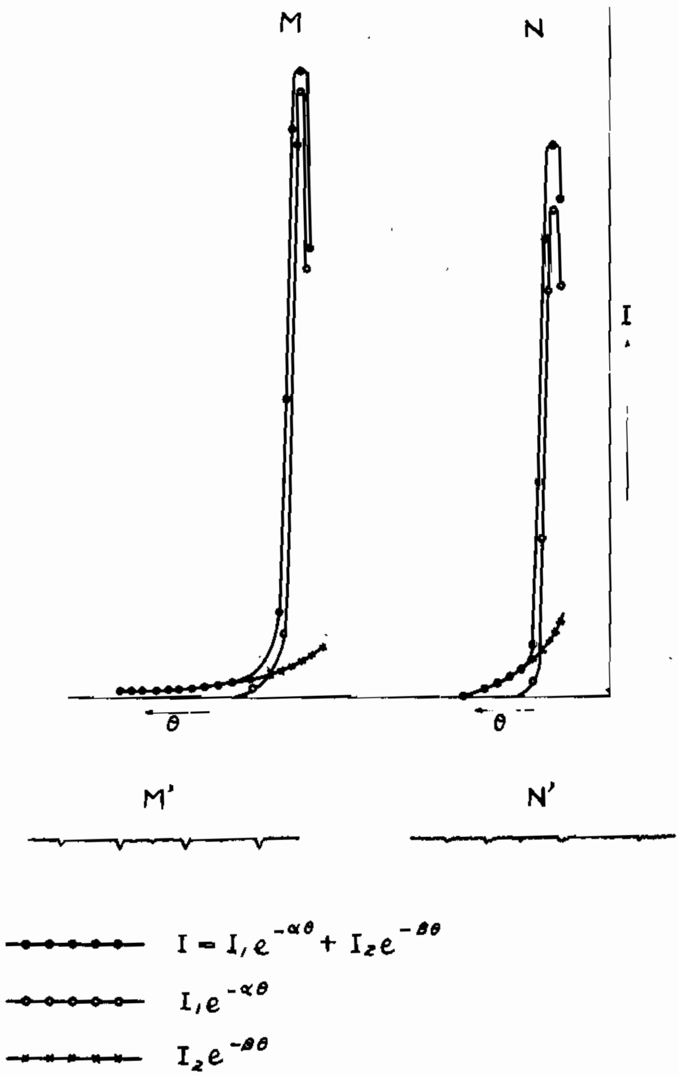
Fig. 6



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ALIEN PROPERTY CUSTODIAN

METHOD FOR MEASURING THE ROUGHNESS OF THE METALLIC SURFACE

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Application filed July 2, 1941

This invention relates to a method for measuring the roughness of a work surface, which is capable of indicating the degrees of the roughness in a more simple and precise way than any of the earlier methods used for shop practice. The gist of this invention lies in that, when the intensity of the angular distribution of light reflected from a metallic surface is measured, it makes an accurate estimate of the degrees of the surface roughness, by measuring a certain range of variations of the intensity of the reflected light to be indicated on the section of the characteristic curve of the intensity of the reflected light that represents exclusively the degrees of the roughness of the work surface.

In the accompanying figures, in which two preferred embodiments of the claimed subject are illustrated:

Fig. 1 and Fig. 2 show rough elevation sketches of the whole apparatus of the two embodiments of this invention.

Fig. 3 is a vertical section of the apparatus shown in Fig. 1 cut by line Y—Y.

Fig. 4 is an enlarged view of the part of the graduated plate shown in Fig. 2.

Fig. 5 is a plane view of the part shown in Fig. 4.

Fig. 6 shows a characteristic curve of the logarithmic variations of the intensity of reflected light as measured by the electric current.

To measure the roughness of a metallic surface is a matter of the utmost importance in discriminating the quality of the finished surface of a work in shop practice. Heretofore, photomicrography, a method of tracing the surface with a needle, and etc. have been applied to this purpose. These methods, however, are practised by means of apparatuses so complex in handling that it was not easy to calculate the degrees of roughness of surface in a simple way, and thus to compare one with others, and to examine them mathematically.

Taking this point into consideration, I have devised a method which, with the application of a method of measuring the intensity of light reflected from the work surface, enables to directly indicate on a gauge the result of measurement as figures representing the degrees of the surface roughness. It is therefore highly effective for examining and discriminating the quality of the finished surface without difficulty at all machine shops.

Now, the novel device of this invention is as follows:

In Figs. 1 and 3,

1 is a projector which projects parallel rays of light for the surface of the work to be tested.

2 is a light-receiving cylinder with a photocell which receives only parallel rays of light reflected from the work surface, and is installed at a rectangular position with 1.

3 is an operating lever. By handling this, a set of 1 and 2 is revolved so as the rays of light may be projected for the work surface A from various directions.

These 1, 2, and 3 form an apparatus B which measures the intensity of reflected light from the surface to be tested.

On the other hand, this embodiment of the claimed subject has a milliammeter C, with an alarm bell which is devised to start in ringing when the compass needle of the milliammeter shows a change of a certain range in the strength of the electric current (for instance, a change between 3.68mA and 10mA).

Now, the position of the measuring apparatus B that holds an angle of 3 degrees with the work surface A, is here regarded as the starting position. (The position in which the work surface A holds 45 degrees with the rays of projected light, is regarded as zero.) In this starting position, the regulator D is regulated so as the compass needle of the milliammeter C points to the graduation of 10mA. The measuring apparatus B is then rotated by the operating lever 3, until the milliammeter C registers 3.68mA, which is at once known by the ringing of the alarm bell, as it is devised as to start in ringing when the strength of the electric current changed from 10mA to 3.68mA by a change of the intensity of reflected light from the surface to be tested. The rotation of the apparatus B is then stopped, and the angular degrees of rotation of B is that which indicates the degrees of the roughness of the surface.

In the above-mentioned appliance, the projector 1 of the measuring apparatus B comprises: a source of light 10, a convex lens 11, and a slit 12, so that the light started from 10 proceeds through 11 and 12 in parallel rays to the surface of the work to be tested.

The rays go into a light-receiving cylinder 2 through another convex lens 13 and a slit 14, thus only the parallel rays being received by a photo-cell 15.

The projector 1 is connected with the light-receiving cylinder 2 by a circular-arc slide-lever 16 so as their optical axes intersect at right angles. The slide-lever 16 moves round unrestrictedly on the supporting part 4' of the supporting frame

4 which has, at the intersection of the optical axes of the measuring apparatus B, a window 17 for attaching the surface of the specimen to be tested.

In Figs. 2, 4, and 5, 6 is a slide-indicator which moves along the graduated curved plate 5 attached to the supporting frame 4 of the apparatus B shown in Fig. 1. 7 is an acting-peg which rotates with the revolving body of B, and acts upon the slide-indicator 6. Around this peg is coiled a coil of wire 8 through which runs an electric current for measuring the roughness of the work surface to be tested. The peg has also a spring 8 at its end. And when the electric current is above 3.68mA, the peg is pushed out on the graduated plate, and thus it acts upon the indicator 6; but, when the electric current becomes 3.68mA, the force of the spring makes the peg separate from the graduated plate, and, thereby from the indicator 6, thus leaving the indicator where it is.

Therefore, if we design the measuring apparatus so as to start from the position that holds 3 degrees with the surface of the work to be tested, and rotate it, sending an electric current of 10mA at this position to measure the surface roughness, then the indicated degrees of the indicator 8 that remained on the graduated plate is that which indicates the roughness of the surface of the work. Thus the roughness of the work surface is measured in quite a simple way, and that, without any difficulties.

What is called the degrees of the surface roughness here in this invention, means $1/\beta$ which is the reciprocal of β in the following expression to be shown as a characteristic expression of the electric current as measured by the above-mentioned apparatus B that measures the intensity of the reflected light.

$$I=I_1e^{-\alpha\theta}+I_2e^{-\beta\theta} \qquad (1)$$

Here, $I_1e^{-\alpha\theta}$ shows the quality of the ground layer of the surface of the work; $I_2e^{-\beta\theta}$, the degrees of surface flaws; and θ, angles of rotation of the measuring apparatus B.

The reason why this invention has defined the foregoing $1/\beta$ as the measurement of the degrees of the surface roughness, and why it has adopted the aforementioned contrivance as a method of measuring the roughness of the surface is as follows:

The characteristic curve of the intensity of the reflected light is, as shown in the expression 1, one in which two curves, $I_1e^{-\alpha\theta}$ and $I_2e^{-\beta\theta}$, are put together. Of these, $I_1e^{-\alpha\theta}$ that shows the quality of the ground of the work is not a matter of greatest importance from an industrial point of view, but $I_2e^{-\beta\theta}$ that shows the degrees of the surface flaws is such that it should be regarded as of the utmost importance in practical surface finishing. To measure β which shows the characteristic of the flaws, therefore, is indeed a matter of the utmost importance in shop practice.

I have therefore defined $1/\beta$, the reciprocal of this β, as the degrees of the surface roughness, and contrived a unique method for measuring this $1/\beta$ in quite a simple way, which greatly facilitates the comparison of the quality of the surface between any two finished surfaces.

Now, while, in the case of the ordinary finished surfaces, the characteristic curve which represents the intensity of the reflected light is seen to curve, when indicated by logarithm, in the neighborhood of zero, it is indicated by a linear charge from somewhere 2 or 3 degrees onwards. And this linear part is that which corresponds to what is indicated by $I_2e^{-\beta\theta}$. (See the accompanying Fig. 6; in which $I(=I_1e^{-\alpha\theta}+I_2e^{-\beta\theta})$ shows the measured values of the work surfaces indicated by the milliammeter C, and the lateral axis θ represents the angles of measurement relative to the work surfaces. The curves M and N show the measured values of such surfaces M' and N' as shown under the respective curves. A long trailed line which indicates only $I_2e^{-\beta\theta}$ part, as shown in the curve M shows the work surface has deep flaws.)

It is therefore possible to determine β by measuring this linear part indicated by logarithm.

For instance, the difference in measured values of two points on the foregoing line will be shown as:

$$\log I_A-\log I_B=-\beta(\theta_A-\theta_B)\log e$$

Hence,

$$\frac{1}{\beta}=(\theta_B-\theta_A)\frac{\log e}{\log I_A-\log I_B}$$

If, therefore, I_A and I_B are taken such that

$$\frac{I_A}{I_B}=e$$

(for example, $I_A=10mA$, and $I_B=3.68mA$), then we have

$$\frac{\log e}{\log I_A-\log I_B}=1$$

Hence,

$$\frac{1}{\beta}=\theta_B-\theta_A$$

(This result may also be derived by a method other than the above-described one.)

From this, it will be seen that $1/\beta$ will be represented by angular units. Thus, in the above-mentioned example of a preferred embodiment of the claimed subject, I have fixed θ_A, the base-angle of measurement, at 3 degrees; the range of change on the measuring apparatus C, at between 3.68mA and 10 mA; thus enabling to read on the gauge the degrees of roughness of any finished surfaces by measuring $\theta_B-\theta_A$, the angle of rotation of the apparatus B between these two ends.

And this $1/\beta$ which is indicated in this invention as the degrees of roughness of surface, has proved quite suitable in shop practice as a means of measuring the roughness of a work surface.

The measurement of this $1/\beta$ will be possible, too, as is suggested in the above-mentioned statement, by confining $\theta_B-\theta_A$, that is, the angular change of rotation of the measuring apparatus, to a certain definite dimension, whereby reading on the gauge the change of the logarithmic values of the electric current, $\log I_A-\log I_B$.

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