Aug. 27, 1935. M. K. TAYLOR 2,012,780

BALANCING OF ROTATING MEMBERS

Filed Feb. 21, 1933

Fig. 1.

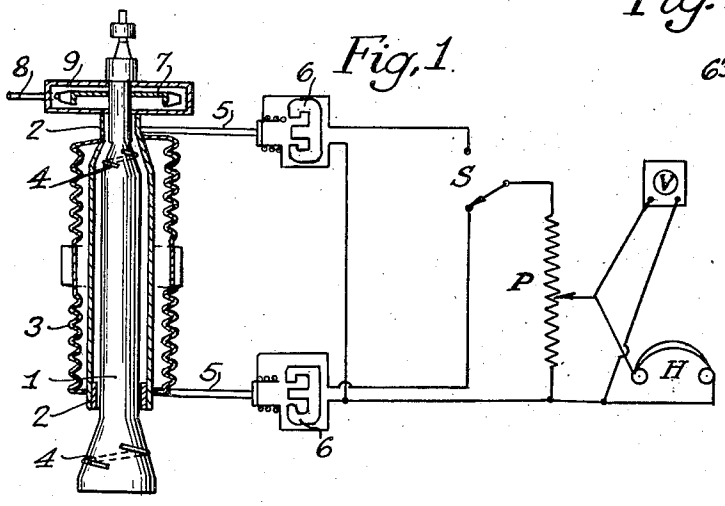
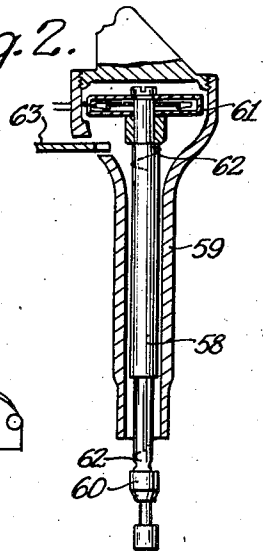


Fig. 2.



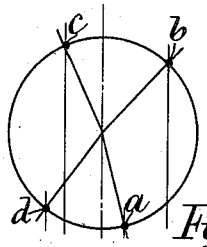


Fig. 4.

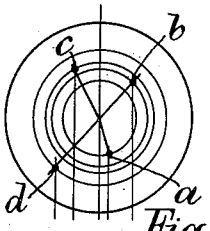


Fig. 6.

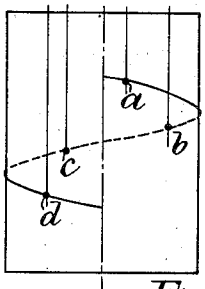


Fig. 5

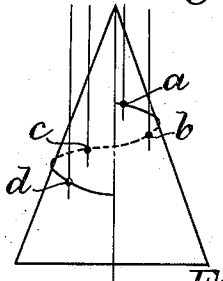
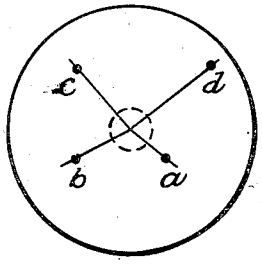


Fig. 7.

Fig. 3.



M. K. Taylor INVENTOR

By Marks & Clark Attys.

Patented Aug. 27, 1935 2,012,780

UNITED STATES PATENT OFFICE

2,012,780

BALANCING OF ROTATING MEMBERS

Maurice Kenyon Taylor, Hollinwood, England, assignor to Ferranti Inc., New York, N. Y.

Application February 21, 1933, Serial No. 657,915
In Great Britain January 13, 1932

2 Claims. (Cl. 74—573)

This invention relates to the balancing of rotating elements and, although in the following description particular reference will be made to the high speed rotative members associated with textile spinning, the scope of the invention extends to other rotating members, such as propellers, engine crank shafts, the rotors of centrifugal apparatus, for instance, turbo alternators, electric motors generally, electric meter discs, rotary members of television apparatus, and in fact to any rotating members which are capable of being dynamically balanced.

The invention in brief consists in producing a rotatable body which may be dynamically balanced while in motion by the removal therefrom of at least one of several masses of material applied for this purpose to the surface of the body to be balanced or which are formed integral with the body when constructing the body and these aforesaid masses are so located that they are consecutively displaced from each other angularly and either radially or longitudinally or both.

Referring to the accompanying diagrammatic drawing—

Figure 1 illustrates a system for the balancing of a suitably shaped textile flyer;

Figure 2 illustrates a means for balancing small high-speed air-operated grinders;

Figure 3 illustrates the locus of weight removal in respect to a flat body;

Figures 4 and 5 represent in plan, and elevation respectively the locus of weight removal in respect to a cylindrical body; and

Figures 6 and 7 represent in plan, and elevation, respectively, the locus of weight removal in respect of a body of varying cross-section, for instance a cone.

As shown in these figures the rotatable body may be made of various shapes. The protuberances or added masses are shown in the relation indicated in the drawing and as applied along an imaginary helix. Reference characters *a* to *d* are the individual masses. The imaginary helix is indicated in Figs. 2, 5 and 7. Said masses, however, are not necessarily arranged along an imaginary helix as is evident. As elsewhere stated, the masses may be applied in any known way to the body or may be formed integral therewith.

In carrying the invention into effect in the form illustrated by way of example in Figure 1, applied to the balancing of a flyer on which there is room or made so that there shall be room to apply a helix of solder or the like, as referred to below, the flyer indicated by the reference numeral 1 is mounted on air bearings 2, 2 in resilient supports 3, 3. Helices or spirals 4, 4 of suitable material, e. g., solder, are applied one at each end of the flyer. Each bearing 2, 2 is connected mechanically by the rods 5, 5 to electric generators 6, 6, for instance of inductor or moving coil type, such that voltage rises when displacement of the bearings 2, 2 increases. The vibrations generate electromotive forces which are measured by an alternating current voltage measuring device *v*, for instance, a Moullin voltmeter or a rectifier type instrument. A voltage limiting device, for instance, a high resistance potentiometer *p*, having a value of about 10,000 ohms, may be inserted in the measuring circuit to safeguard the device *v*. A change-over switch *s* enables the device *v* to be connected to either generator 6, 6 at will. An air-turbine 7 drives the flyer, air entering at the inlet 8 into the air-box 9, giving a nearly constant torque at low speeds, and observation is made as to whether the critical speed of rotation of the flyer is passed. This observation may be made by noting the vibration of the flyer and also the pitch of the note produced by the high speed of rotation. It is found that if the flyer is much out of balance it is unable to exceed the critical speed and the pitch of the note thus rises gradually and then remains constant. On the other hand should the critical speed be exceeded the vibration gradually diminishes and the flyer runs up in speed. Whilst passing through critical speed, however, there will be an increase in the amount of vibration unless the flyer happens to be balanced. In the case of an unbalanced flyer in rotation at critical speed, if the bearing tube be held momentarily in the hand the critical speed will be found to rise slightly so that upon then releasing the bearing tube the speed remains in excess of critical speed.

If the speed of the flyer does not exceed the critical speed even when the bearing tube is held in the hand momentarily as indicated above, it is usually possible to see where the excessive out-of-balance lies. If nothing is apparent, the position for removing the solder may be found by trial and error. It is best to start with the bottom bearing as the radius is larger here and a greater error may be expected. A cutting tool is used in removing a portion of the solder while the flyer is rotating, and this tool is preferably tipped with an extremely hard material such as tungsten carbide. It is easy to see if solder is being removed from the right place by the speed at which the flyer runs. For instance, if the flyer runs slower, then solder is being removed from the wrong place, and a place half the spiral pitch away

should be tried. By this method the correct place for removing solder is very quickly found.

As the solder is removed in the correct place, the flyer exceeds its critical speed, after which the speed increases rapidly. This increase is clearly audible in a pair of high resistance telephones H connected across the voltmeter terminals. With this increase in speed there may be some increase in voltage generated, although the vibration amplitude is being reduced simultaneously. Increase of voltage is consequent upon both increase of speed and upon increase of vibration amplitude, and although the latter is being reduced, the effect of the former is usually such as to lead to a net increase of voltage. Cutting is continued until the voltmeter reading reaches zero, when there should be practically no sound in the telephones, any residual irregularity being heard as a hum. A standard low pass electric filter comprising, for example, a condenser in parallel, or a choke in series, or combinations of both, which possess the property of attenuating high frequencies to a greater extent than low frequencies, may be inserted between the generator and the voltmeter, and so may be used to counteract the increase in voltage with frequency, and it may be removed or short-circuited for the final balancing where a high order of sensitivity is required. When a high order of sensitivity is required for the final balancing, the speed is high, for the reason stated below, so that the voltage is greatly attenuated by the filter. Since the frequency is constant, there is nothing to be gained by leaving the filter in circuit; at the same time, the amplitude of vibration and the consequent voltage generated is small, so that any attenuation is undesirable, and therefore the filter is cut out. The speed need not increase above a certain point, no matter how small the vibration may become if the turbine 7 reduces its torque at high speed. This part of the balancing process should not take more than half a minute. If the spiral has been evenly laid on it should take even less time.

The switch is now moved over so that the instrument reads the top bearing vibration. The flyer is balanced here in just the same way so that the instrument comes down to zero. There is a window cut in the bearing tube for applying the tool to the solder on the flyer near the top bearing. The instrument when again connected to the bottom bearing now gives a very small indication, and when this is finally brought to zero the flyer is practically perfectly balanced. The out-of-balance as shown by the vibration of the top of the flyer is now so small that it cannot be detected by feel or instrument. The total time taken is about one minute.

Referring to Figure 2, illustrating the balancing of a small high speed air-driven grinder, with a rotating spindle **58** housed in a case **59**, and having a chuck **60** at one end to carry a grinding wheel, and a rotor turbine wheel **61** at the other end, driven by an air stream projected on to the vanes of the rotor, balancing is effected by mounting the spindle in a skeleton casing, so that the cutting tool **63** can reach the spirals **62** which are applied at the two ends of the spindle. The skeleton casing also permits the cut away material to be disposed of.

Figures 3 to 7 are explanatory diagrams showing disposition of points or regions of weight removal from a body being balanced.

Figure 4 applies to a flat body the points *a*, *b*, *c* and *d* being chosen or selected points in accordance with the above definition, namely, they are both radially and angularly displaced from each other.

In the cylinder shown in Figures 4 and 5 the points are angularly displaced as shown in the plan Figure 4, and longitudinally displaced as shown in the elevation Figure 5. In the cone of Figures 6 and 7 the points are angularly and radially displaced as shown in the plan Figure 6, as well as longitudinally displaced as shown in the elevation Figure 7.

I claim:

1. A rotor having protuberant masses thereon arranged successively in a spiral formation on the periphery thereof, whereby said rotor may be placed in balanced condition by removing material from said protuberances during rotation of said body.

2. A rotor having at least three protuberant masses located thereon in individual planes containing the longitudinal axis of the body the angle between any two adjacent planes being less than 180° and the circle of rotation of every individual mass being non-coincident with the circle of rotation of any other of said masses whereby said rotor may be placed in balanced condition by removing material from at least one of said protuberances during rotation of said rotor.

MAURICE KENYON TAYLOR.