Jan. 21, 1936. O. M. DUNNING 2,028,197

PHONOGRAPHIC RECORDER

Filed March 6, 1933

Fig.1

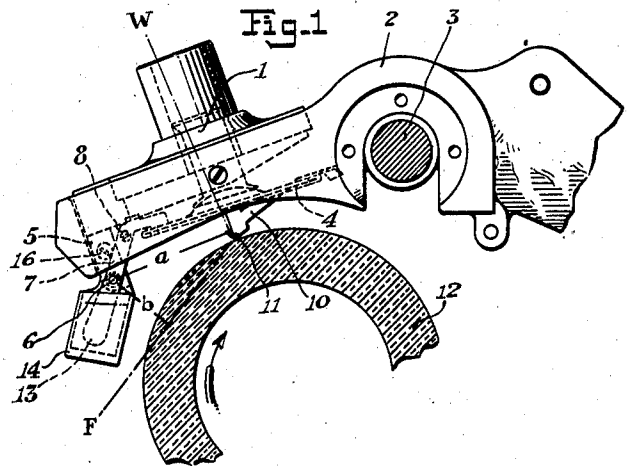



Fig.2

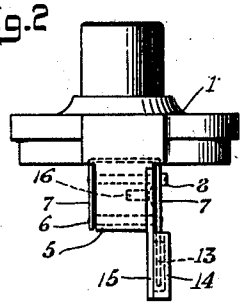
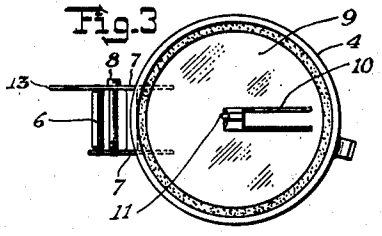



Fig.3




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## PHONOGRAPHIC RECORDER

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6 Claims. (Cl. 274—32)

One of the chief problems in designing a phonographic recorder is to so arrange the parts that the stylus of the recorder will cut a groove which, leaving out of consideration variations due to sound waves, will be of uniform depth at all points on the record tablet. Record tablets of either the cylindrical or the disc type may have certain irregularities in their surfaces or may be warped or improperly shaved so that as the record tablet is revolved the surface beneath the stylus point of the recorder rises and falls. It is essential that the groove which is cut in the record by the phonographic recorder be of uniform depth regardless of such irregularities in the recording surface.

To accomplish this uniform depth of cut, two methods have been in common use in the past. One of these methods is to provide the recorder with a device commonly called an advance ball which comprises a polished spherical surface, usually of sapphire, arranged to glide over the surface of the record tablet in advance of the recording stylus. The relative height of the advance ball and the recording stylus therefore determines the depth to which the stylus will cut into the material of the record tablet. The recorder is made to move freely up and down and, in consequence, will cut a groove of uniform depth on the record tablet. This method of cutting a groove of uniform depth on the record tablet is satisfactory where the recording is being done under laboratory conditions and where it is possible to continually observe the performance of the apparatus and to make adjustments to compensate for variations in the apparatus. The depth of groove which is ordinarily used in making phonographic recordings is of the order of .0005" to .002" and it is obvious that the adjustment of the relative height of the advance ball and the recording stylus is extremely critical. It has been found that this relative adjustment has a tendency to change from time to time and it is usual, where such an arrangement is used to determine the depth of cut, to observe the groove by means of a microscope from time to time and to readjust the advance ball height as necessary to give the correct depth of groove. The variation in height between the advance ball and recording stylus is aggravated by the fact that the advance ball is usually located upon some rigid portion of the frame which resiliently supports the vibratable member while the stylus is, of course, carried on the vibratable member. It is obvious that with such small differences in height, there would be a tendency for change due to expansion and contraction of parts and by other natural changes in the dimensions of materials.

This method of producing a groove of uniform depth on the record tablet is therefore not satisfactory when the recording is to be done by persons unskilled in such fine adjustments or in applications of recording equipment such as in dictating machines where it is desirable that the equipment perform with infrequent adjustment or service. For use on recording equipment of this latter type, it is essential that some other method of cutting a groove of uniform depth be used. In one arrangement for this purpose which has been in common use in dictating machines and other similar recording equipment for a number of years, the recording unit or sound box is made very light and is mounted for pivotal movement toward and away from the record tablet. The pivot is so located and the parts so arranged that the force on the stylus due to cutting through the wax is sufficient to counterbalance the downward weight of the recorder when a groove of the desired depth is being cut. If the mass of the recorder is kept low this type of apparatus will cut a groove of reasonably uniform depth in the record tablet even though there be considerable irregularities in the surface. If a high spot on the record tablet passes beneath the recording stylus, the stylus will tend to cut a deeper groove, but this tendency will immediately cause a greater force to be applied to the front of the stylus which will overcome the downward pressure on the stylus due to the weight of the recorder and cause the recorder to move upwardly until the depth of cut is once more correct.

When this latter arrangement of parts is being used for a recorder one difficulty is frequently encountered. It has been found that the recorder stylus has a tendency to cut an irregular groove because of a stubbing or chattering action. Upon microscopic inspection of the groove formed during such action, it will be found that the depth of groove constantly varies in approximately sinusoidal form, the disturbance occurring in regularly repeated cycles of substantially equal length. It has been found that in overcoming this chattering or stubbing effect, the adjustment of the tightness of the pivots of the recorder is very important. If the pivots are very carefully adjusted to the point where there is no side play in the recorder pivots but the recorder is still quite free to move toward and away from the record tablet, the stubbing is reduced and may disappear. However, this method of overcoming the stubbing or chattering of the stylus has not

always been successful and, furthermore, it is usually undesirable to have adjustments of such a critical nature involved in devices for commercial use. If the pivots of the recorder are adjusted to loosely, the stubbing action described is very likely to occur. If the adjustment is made slightly tighter than the proper adjustment, the recorder will not be sufficiently free to move toward and away from the record surface and as a result will have a tendency to cut a deeper groove at high spots along the record tablet and a shallower groove than desired at low points on the record tablet. This is due to the fact that when the pivot adjustment is too tight the principal force resisting motion of the recorder as a whole is frictional in character rather than inertia as is the case with correctly adjusted pivots.

The main object of this invention therefore is to provide a construction for stabilizing a phonograph recorder and minimizing the tendency toward chatter or stubbing of the record stylus without requiring the fine adjustment of the pivots and without introducing other factors which will cause the recorder to cut a groove of uneven depth on a record tablet having irregularities in its surface.

Further objects and features of my invention will appear in the following specification and appended claims.

For illustration, one embodiment of my invention is described herein. For a clearer understanding, reference may be had to the drawing accompanying and forming part of this specification and illustrating this embodiment, wherein:

Figure 1 is an elevational view of a portion of a recording phonograph having said embodiment of my invention applied thereto;

Fig. 2 is an elevational view of the phonographic recorder only looking from the left in Fig. 1; and

Fig. 3 is a bottom plan view of the sound box proper of the recorder of Figs. 1 and 2.

The recorder is of standard construction and comprises a mounting frame 1 which is supported in a carriage 2 adapted for record traversing movement along guide rod 3 of a phonograph. A sound box 4 is pivotally secured to the lower end of a downwardly extending lug 5 of the frame 1. The pivotal connection comprises a shaft 6 secured in lug 5 and having conical end portions extending beyond the sides of lug 5 and adapted to fit into suitable recesses in two arms 7 attached to the sound box 4. The pivotal connection thus formed may be adjusted to prevent side play of the recorder by means of a screw 8 which is threaded in one of the arms 7 and has its head bearing against the outer side of the other arm. The sound box comprises a circular rigid casing or frame of conventional form and a vibratile element 9, shown as a diaphragm, which is mounted in and carried by said casing and to which is secured a stylus holding arm 10 carrying a stylus 11 for engagement with a record tablet 12 supported on the usual mandrel (not shown). As the record tablet 12 is rotated by means of an electric motor or similar device (not shown) the arm 2 is fed across the surface of the record tablet by means of a feed screw (not shown) in the well known manner and this causes the recording stylus to cut a continuous groove in the surface of the record tablet.

The construction so far described is that well known in the art of phonographic recorders. The pivoted sound box by reason of its mass causes a downward force, indicated as W, to be applied to the record tablet at the point of engagement of the stylus 11. This downward force causes the stylus to sink into the record material and, as the record rotates, to cut a groove in the surface of the record tablet. If the force on the stylus due to the cutting or engraving of the record tablet is indicated as F, it may be seen that the system will be in equilibrium when the couple formed by the weight W multiplied by its lever arm $a$ is equal to the couple formed by the force F multiplied by its lever arm $b$. Now as the diaphragm 9 is vibrated by reason of sound waves impinging thereon, the force W is increased or decreased in accordance with the sound waves and the depth of cut is thereby varied. If at some instant the force due to the sound waves on the diaphragm is downward so that it tends to increase the force W, the stylus will sink further into the material of the record tablet until the force F, caused by the cutting of the wax, has increased in the same degree as the increase in the force W whereby the equilibrium of the system is maintained.

It is obvious that the force F due to the cutting of the stylus through the material of the record tablet will be substantially proportional to the depth of the groove cut by the recorder stylus. The couple formed by the force F multiplied by its lever arm $b$, which couple tends to move the stylus out of the wax and is therefore in the form of a restoring force, is proportional to the depth of cut. It is therefore obvious that for the purposes of analysis we may replace this couple due to the cutting force by a simple spring located beneath the stylus point. The action would in both cases be identical and the substitution of such a spring having a known compliance will enable us to more clearly recognize the nature of the action which is present when stubbing or chattering occurs. For the purposes of analysis the sound box then may be considered as a mass which may react with a spring to form a system which will have a resonant frequency. Experimental observations have shown that the frequency of the chattering or stubbing action is identical with that computed for the effective mass and compliance of the system formed by the pivoted sound box and the record tablet. In most recording mechanisms this resonant frequency is relatively low, of the order of 200 cycles.

There is very little damping associated with this recorder mechanism and there is, therefore, a strong tendency for this system to oscillate at its natural frequency provided some exciting force is present. Free oscillation of the recorder sound box as the result of reaction with the compliance due to the cutting of the groove, is believed to be the explanation of recorder stubbing or chattering.

Most of the damping force present in the ordinary type recorder as described above comes from the friction in the pivots. For this reason it is immediately apparent that the adjustment of the pressure on the pivots is an extremely important factor and that if the pivots are adjusted loosely, the damping will be decreased in a large degree so that the system will tend to oscillate freely. It is believed that the excitation which causes this free oscillation when insufficient damping is present in the system comes from both the vibrations in the mechanism and the chip which is cut out of the record tablet by the stylus. This chip causes a non-symmetrical restoring force to be present and if the system is

sufficiently free from damping, such a force will result in a sustained oscillation.

This stubbing or chattering action can be overcome or at least reduced in a large measure by applying additional damping to the system so as to approach the point of critical damping. However, if the pressure on the recorder pivots is increased so that the frictional force at that point is increased, the sound box may no longer be sufficiently free to follow the irregularities of the record surface and may therefore no longer cut a groove of uniform depth if the record surface is irregular.

The condition which will allow the recorder stylus to cut a groove of uniform depth in an irregular record tablet is that the mechanical impedance of the sound box, as viewed from the recorder stylus, should be sufficiently low so that the sound box itself will quickly respond to the variations, due to the surface irregularities, in the cutting force F on the front of the recorder stylus. If, for instance, a record tablet is out of round the variation in height will be approximately sinusoidal and of a frequency equal to that of the mandrel rotation say of the order of 1⅔ cycles per second. If the only force required to move the recorder were that necessary to overcome the inertia of its mass, the recorder would present a very low mechanical impedance at such a low frequency. However, if a frictional force is introduced, such force is proportional only to the pressure on the pivots and is independent of frequency so that it will tend to retard the motion of the recorder mechanism considerably. However, if as in commercial recorders, the pivots are adjusted very carefully, it is usually possible to hold the impedance of the recorder mechanism to a sufficiently low value to permit fair accuracy in cutting the record groove. However, if a damping force, which is not independent of the type of motion as is frictional damping, be used it will eliminate some of the need for careful adjustment of the pressure on the recorder pivots.

My invention, therefore, comprises the use of viscosity damping in place of frictional damping in a recorder of the type described. In viscosity damping the reaction is proportional to the velocity of motion instead of constant. It is apparent that if the motion imparted to the sound box by the irregularities of the record groove is of the order of a few cycles per second and has an amplitude of a few thousandths of an inch, the maximum velocity will be very low since this velocity is proportional to the product of the frequency and the amplitude of the sinusoidal motion. However, at the stubbing frequency which, as has been said, is of the order of 200 cycles per second and where the amplitude is sometimes as great as .001 of an inch, this velocity will be considerably higher and the damping will therefore be much more effective. I therefore apply damping of the viscosity type to the recorder sound box whereby the resistance to motion due to irregularities in the record tablet is maintained small while the resistance to free oscillation, such as ordinarily occurs in stubbing or chattering of the stylus, is made relatively large. By this means it is possible to reduce the accuracy of adjustment of the pivots of the recorder to a large extent, to cut a groove of uniform depth in spite of irregularities in the record surface, and to eliminate or largely reduce the tendency toward chattering or stubbing of the stylus.

A viscosity damping means is shown applied to the recorder in the drawing. One of the arms 7 attached to the recorder has a paddle-shaped portion 13 extending below the pivot 6. A flat narrow cup 14 is formed on the end of a downwardly extending arm 15 secured by a screw 16 to the lug 5 of the recorder frame. The portion 13 moves within and in a direction parallel to the side walls of the cup 14. The cup is filled or partially filled with a heavy grease or oil. The reaction between the portion 13 attached to the sound box and the cup 14 secured to the fixed frame of the recorder is one due almost entirely to viscosity of the fluid contained within the cup. The amount of viscosity reaction may be varied to suit any desired conditions by proper selection of the damping fluid contained within the cup 14 or by proper choice of the size of the opposed areas of the paddle 13 and the cup 14 or the clearance between them. One side of the viscosity damping means—i. e., the cup 14 containing the viscous fluid—is seen to be maintained vibrationally stationary, it being secured (through lug 5 and frame 1) to the carriage 2 which, while arranged for travel along the guide rod 3, is of large mass and is essentially stationary as to vibration.

It is obvious that many other constructions may be given to the mechanism employed for obtaining damping of the viscosity type wherein the resistance to motion is proportional to the velocity of relative motion, without departing from the spirit of my invention.

Having thus described my invention, I claim:

1. In a phonographic recorder, a frame substantially stationary as to vibration, a sound box comprising a casing and a vibratile element carried by said casing, said sound box being mounted for movement relatively to said frame, and sound box stabilizing means including coacting devices provided in part on said frame and in part on said sound box casing, said coacting devices comprising a viscosity impedance.

2. In a phonographic recorder, a frame substantially stationary as to vibration, a sound box comprising a casing and a vibratile element carried by said casing, said sound box being mounted for movement relatively to said frame, and sound box stabilizing means comprising a plurality of relatively movable surfaces and a viscous fluid intervening said surfaces and arranged for viscosity reaction therewith, said surfaces being provided in part on said frame and in part on said sound box casing.

3. In a phonographic recorder, a frame substantially stationary as to vibration, a sound box comprising a casing and a vibratile element carried by said casing, said sound box being mounted for movement relatively to said frame, and sound box stabilizing means comprising relatively movable coacting devices provided on said frame and sound box casing respectively, one of said devices comprising a viscous fluid, the resistance to relative movement of said devices being chiefly due to the viscosity of said fluid.

4. In combination, a record tablet and a carriage arranged for relative record-traversing movement, a recorder supported on said carriage and comprising a sound box, said sound box comprising a casing and a vibratile element carried by said casing, said sound box being mounted for movement relative to said carriage toward and away from said record tablet, and sound box stabilizing means comprising relatively movable

co-acting surfaces and a viscous fluid intervening said surfaces, one of said surfaces being provided on said sound box casing and the other being secure with respect to said carriage.

5. In a phonographic recorder, a frame substantially stationary as to vibration, a sound box including a casing mounted for movement relatively to said frame and a vibratile element in said casing, and sound box stabilizing means comprising a retaining device for fluid, a viscous fluid in said retaining device, and a device in immersive relation to said fluid, one of said devices being secure with respect to said frame and the other being secure with respect to said sound box casing.

6. In combination, a frame substantially stationary as to vibration, a viscous fluid confined by a portion of said frame, a sound box movably mounted on said frame, said sound box comprising a casing and a vibratile element carried by said casing, and an element carried by said sound box casing and adapted for coaction with said viscous fluid, whereby movement of said sound box and element produces relative motion of said fluid and element to generate a viscosity reaction.

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