

March 16, 1965

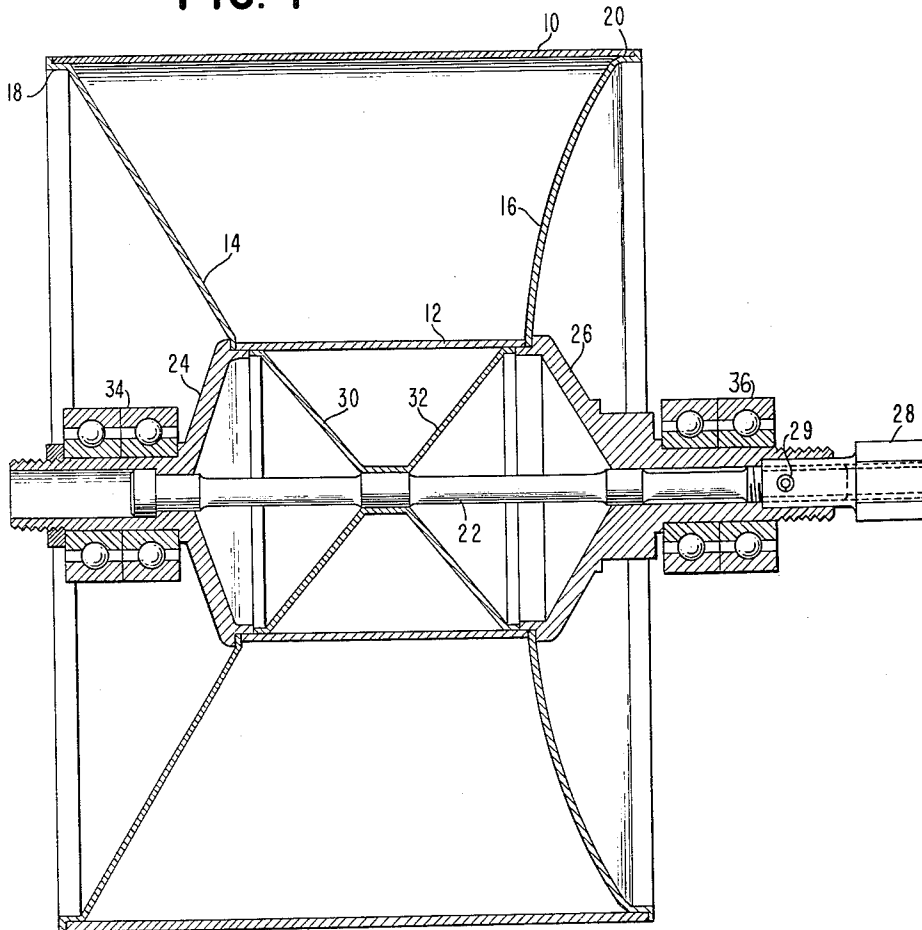
W. R. MACLAY
MAGNETIC DRUM

3,174,152

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2 Sheets-Sheet 1

FIG. 1



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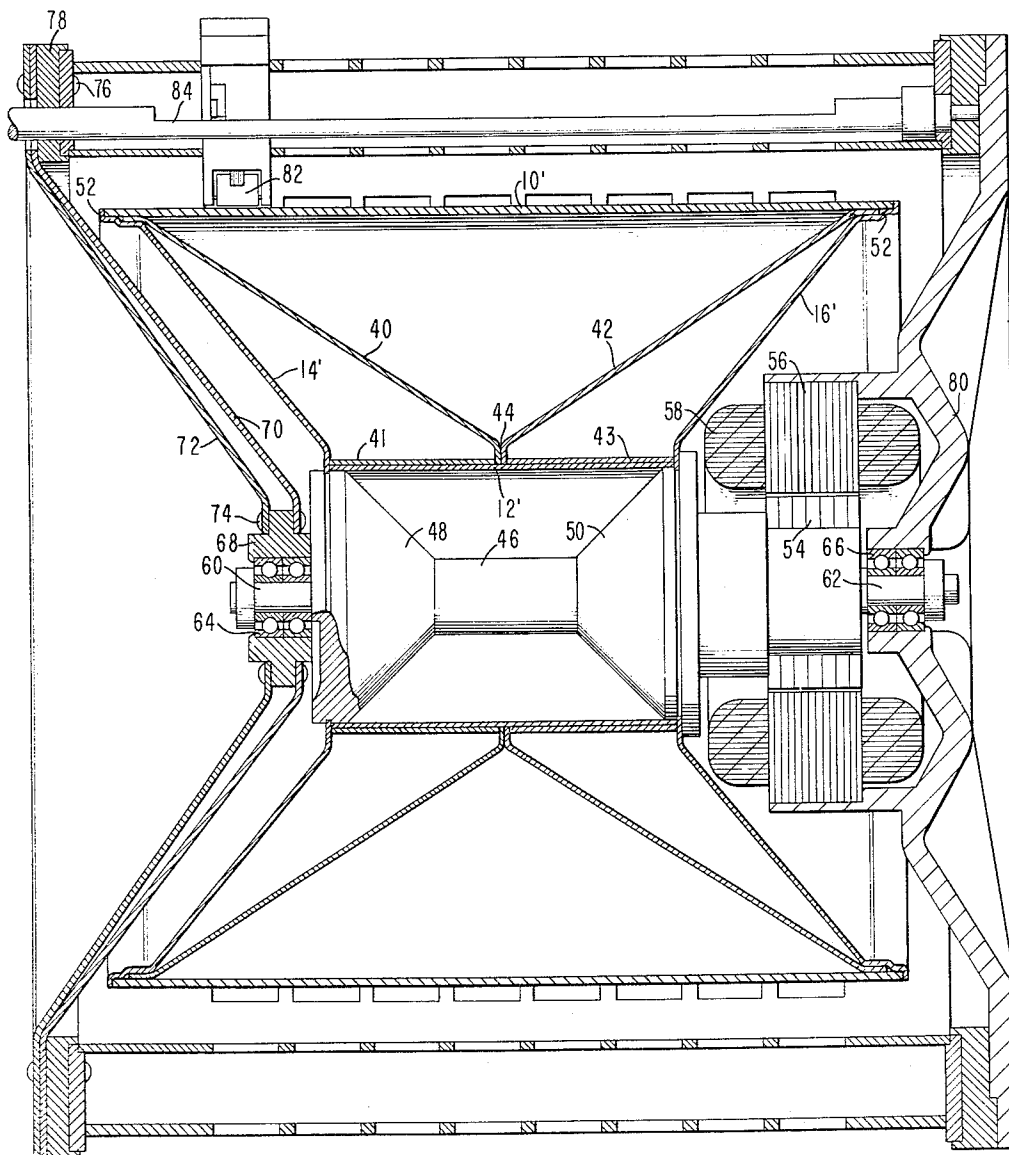
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FIG. 2



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MAGNETIC DRUM

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This invention relates to improvements in magnetic drums of the type having a magnetizable surface for storing information to be used in a data processing system or the like. More particularly, this invention relates to a magnetic drum construction having extremely favorable dynamic characteristics.

In the art of electronic data processing, rotatable drums having magnetizable peripheries are commonly used for storage or memory purposes. The usual magnetic drums are conventionally shaped in the nature of a cylinder, and the peripheral surface of the cylinder must be accurately machined so that the drum will perform satisfactorily when cooperating with magnetic transducer heads. To provide heavy enough stock to withstand the machining operation on the periphery of the drum which is necessary to provide the required accuracy, drums are commonly constructed of cast or other heavy machinable material. Conventionally, these heavy parts were assembled with bolts and screws. The weight of these drums requires a high starting torque and hence a large motor. All of these combined factors in turn make for larger, higher friction bearings and a stronger housing. The end result is generally a heavy, costly and bulky memory system with poor dynamic characteristics for reasons to be explained hereafter.

Although the known magnetic storage drums appear to be adequate for stationary locations, in airborne equipment where they are subjected to high frequency mechanical vibrations, the conventional drums will not perform adequately under the environmental conditions due to a low natural frequency of vibration. Since airborne data processing systems are practically essential on many of the modern day aircraft and space vehicles, it is requisite that in the data processing system the rotatable storage member, such as a magnetic drum, be able to withstand the environmental conditions of high frequency vibrations without introducing an error into the system. Consequently, the prior art magnetic drums, as described above, have not been completely satisfactory for all airborne applications principally because of a relatively low resonant frequency of vibration.

The natural frequency of vibration may be analytically determined for a structure such as a memory drum. The natural frequency of vibration in an axial direction refers to vibrational motion in a plane parallel to the axis or support shaft of the drum. The natural frequency about other axes transverse to the axis of the drum refers to the frequency of vibration in these directions. Most desirably a drum should have a high natural frequency of vibration about all these axes.

It is important that a drum operates below its natural frequency of vibration or the frequency at which it resonates to the extent that it is no longer capable of performing its intended function. In electronic data processing systems, a magnetic drum cooperates with transducer heads adjacent thereto to read and write information on the drum while that drum is being rotated rapidly about its axis. If the drum and transducer heads are placed in an environment characterized by a high frequency vibration and the drum resonates, the information representing signals read from and written on the drum may be subject to errors. These errors will be in the nature of time phase shifts and loss of signal amplitude. The timing shift of the signal picked up by the transducer can in-

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roduce serious errors in the information which is being processed by the data processing system.

The low resonant frequency of known memory drums is principally due to the combination of the large mass of the drum and the relatively large distance between points of support for the shaft. By analysis of the dynamics of a drum assembly, it has been determined that another factor in producing a low resonant frequency in the known drums is the relatively small diameter of the supporting shaft. Under analysis, it appears that the drum is too stiff relative to the shaft. In summary, the low resonant frequency of known memory drums is due to the fact that the stiffness to mass ratio is low because of a lack of stiffness and high mass, and because the moment of inertia about the neutral axis is low.

These enumerated difficulties of the prior art memory drums may be reduced to minimum by the use of an entirely different and unique concept of construction disclosed herein. This concept of construction thus increases the resistance of the drum to vibration about all three orthogonal axes (one axis coinciding with the axis of the drum) by providing a concentration of material for resisting stressing at the points of large stress. For example, this involves locating a large proportion of the material at the maximum distance from the neutral axis to provide a maximum stiffness i.e., maximum moment of inertia. Since the undamped natural frequency of vibration W_n (in radians per second) is equal to the square root of an equivalent spring constant k over the mass

$$W/g \left[W_n = \sqrt{\frac{k}{Wg}} \right]$$

the construction of the drum of this invention achieves a high stiffness to mass ratio by providing light weight parts and arranging the parts to provide a large stiffness both axially of the drum and transverse to the axis of the drum. By providing a minimum length unsupported shaft and a light weight construction the critical speed may be raised substantially. This is because the critical speed N_c (in r.p.m.), using Rayleigh's energy method for a shaft loaded at several points with weights $W_1, W_2, W_3 \dots$, equal to a conversion factor times the square root of the sum of the weight ΣW times deflection y over the sum of weight ΣW times deflection square y^2

$$\left[N_c = 187.7 \sqrt{\frac{\Sigma W \cdot y}{\Sigma W \cdot y^2}} \right]$$

It is thus evident that the greater the deflection the less will be the critical speed. Since the deflection (y) is a function of the weight, flexural stiffness (modulus of elasticity times moment of inertia) and length between supporting bearings, by keeping the weight and length between supporting bearings low and the moment of inertia high in the drum of this invention, the deflection will be lessened and the critical speed increased. The drum of this invention provides a construction which observes the foregoing criteria.

The entire drum of this invention utilizes a thin shell construction, not only favorably effecting the dynamic characteristics, but also making sheet metal techniques available for the first time for the manufacture of high precision rotary magnetic memory drums.

As mentioned above, airborne electronic data processing systems which are subjected to environmental high frequency vibration must have a magnetic drum with a high natural resonant frequency both along and transverse to the drum axis. The drum of this invention is specially constructed to provide axial stiffness by the means of end sections, which are portions of surfaces of revolutions having at least one finite radius of curvature such as a cone, sphere, ellipsoid, or the like and continuously brazed or welded to the drum surface and to the

shaft. The angle at which the end sections are set is determined for optimum resistance to stresses in axial direction, i.e., maximum spring constant compatible with transverse vibration requirements. To resist stresses transverse to the drum rotative axis, the drum supporting shaft is tubular in construction, and a minimum distance is maintained between the supporting bearings. The light weight of the drum components combined with the short distance between supporting bearings greatly reduces the shaft's deflection, thereby increasing the natural frequency of vibration transverse to the drum axis. This light weight also decreases deflection thereby increasing the critical speed. The drum may be driven by a driving motor, the rotor of which is attached to the supporting shaft. This rotor is small because of the light weight of the drum and the low starting torque and is positioned as close as possible to an end section of the drum to reduce whipping. The assembly of all the thin metal parts is accomplished by sheet metal techniques and the need for bolts, rivets, screws and the like is eliminated.

It is, therefore, the principal object of this invention to provide a rotatable magnetic drum for use in airborne environments, which drum is constructed of thin structural members to provide optimum resistance to vibration about all three orthogonal axes. The thin shell construction technique also greatly reduces the weight, improves assembly operations, lowers the cost, and allows substantially lower power consumption.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings which disclose, by way of examples, the principle of the invention and the best mode which has been contemplated of applying that principle.

In the drawings:

FIG. 1 is a sectional elevation view showing one form of the drum constructed according to the teachings of this invention; and

FIG. 2 is a sectional elevation showing a modification of a drum constructed in accordance with the teachings of this invention combined with the driving motor, drum housing and cooperating transducer head.

In general, this invention contemplates providing a magnetic memory drum constructed of thin sheet metal components while utilizing sheet metal assembly techniques, and the construction is adapted to provide high resistance to mechanical vibration about all three orthogonal axes. The drum comprises a thin cylindrical shell or tubular member supported from a thin tubular shaft by end sections, which are constructed as surfaces of revolution having at least one finite radius of curvature. The distance between the supporting bearings of the central shaft is as short as possible to reduce deflection of the shaft. This assembly provides a structure which has high stiffness to mass ratio in both axial and transverse directions and hence a higher resonant frequency than the conventional drum of the same memory capacity.

Referring to the drawings, FIG. 1 shows a simple structure to illustrate the principles of the invention. In FIG. 1, the drum is constructed of a thin tubular member 10, which is sheet metal or the like preferably under .030 inch thick. The outside surface of tubular member 10 may be plated or coated to provide a magnetizable periphery, so that the drum may perform its intended function as a memory or storage device in an electronic data processing system. A tubular member 12 axially positioned within member 10 provides the support for member 10 through end sections 14 and 16. The tubular supporting shaft 12 as well as end sections 14 and 16 are all constructed from thin sheet metal, and the end sections 14 and 16 are secured to the outer tubular member 10 by flanges 18 and 20 which are common in sheet metal assembly operations. It is to be noted that the end section 14 is shown as a section of a conical shell, while end section 16 is dished. These end section shapes, which are surfaces of revolution, provide high stiffness to mass

ratio for resisting vibrations in an axial direction. Although the end sections are shown as a section of a conical shell and a portion of an ellipsoid, they can also be portions of other surfaces of revolution such as portions of a spherical surface.

The assembly may be held together by a tension screw 22 cooperating with end flanged caps 24 and 26. The flanges on end caps 24 and 26 bear against the outside surfaces of end sections 14 and 16 and against the inside surface of tubular support shaft 12. By tightening nut 28 to tension screw 22, the components of the assembly will be tightly held together. A pin 29 holds the nut 28 on screw 22 in the tensioned position. This small diameter tension rod 22 would, if unsupported, have a low resonant frequency and contributes to lowering to resonance frequency of the entire assembly. Therefore, two support pieces 30 and 32 of which are also surfaces of revolution, i.e., cones, support the tension rod 22 from the inside of tubular shaft 12.

The tension rod 22 is not essential to the construction, as other sheet metal assembly techniques may be used. Also, the components are brazed together to further contribute stiffness to the assembly. Preferably, the parts are press fitted together and are brazed or welded after assembly, eliminating the possibility of flexure or shifting of parts and also eliminating the costly assembly technique used with prior art drums. It should be noted that the use of a continuous braze or weld increases the resonant frequency.

Suitable anti-friction bearings 34 and 36 cooperate with journal portions on end caps 24 and 26 to provide a support for the drum and to reduce the length between the support bearings to a minimum. The bearings are located as close as possible to the end sections 14 and 16. This construction of a relatively short unsupported distance between the bearings combined with the light weight of the drums increases the effective spring to mass ratio and hence increases resonant frequency in a direction transverse to the axis of the drum.

It is possible that a number of drums of different lengths having the same outer diameter could be constructed from the components shown in FIG. 1 by merely providing different length tubular members 10 and 12. The flexibility of the construction would be an advantage where it is desired to provide a number of alternate drums of different length from stock parts.

FIG. 2 illustrates an alternative embodiment and also shows the thin shell drum with associated transducers and a driving motor. Referring to FIG. 2, the thin outer drum shell 10' is supported from an inner tubular supporting member 12' by a pair of conical end sections 14' and 16'. The end sections are surfaces of revolution in the nature of cones to provide increased stiffness in axial direction, similar to the end sections of the FIG. 1 embodiment. The end sections 14' and 16' are flanged at 51 and 52 for assembling or bonding to the outer drum shell 10' using sheet metal techniques including brazing welding (continuous and discontinuous). For increased stiffness in axial direction, secondary supporting members 40 and 42 are provided within the space defined by the drum shell 10', the inner tubular support 12' and the end sections 14' and 16'. The secondary supporting members abut each other at 44 and have depending legs 41 and 43 overlying the central tubular member 12'.

A central spool shaped shaft member 46 having end spools 48 and 50 support the drum end sections 14' and 16' and inner tubular member 12'. The intersections 47 and 49 of the end spools 48 and 50 with the shaft portion of spool 46 are surfaces of revolution also.

The supporting shaft 46 carries a motor rotor 54 on one end thereof, and this rotor cooperates with a stator 56 having winding 58 providing an alternating current electric motor. The motor is located as close as possible to the end section 16' to decrease the length between support bearings.

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The central shaft 46 has journal portions 60 and 62 supporting anti-friction bearings 64 and 66, respectively. The distance between the supporting bearings is as short as possible to decrease the deflection of the shaft 46. The outer race of bearing 64 is supported by bearing support 68, which in turn is carried by a pair of conical shaped sheet metal members 70 and 72 riveted to the bearing support 68 by rivet 74. The outer ends of sheet metal members 70 and 72 are secured by similar means, such as rivet 76, to a support member 78. The motor stator 56 and the outer bearing race of bearing 66 are carried by an in support 80, which has portions thereof in the form of a surface of revolution to provide axial stiffness, and this support in turn is secured to a housing by means not shown.

A plurality of transducers 82 are supported adjacent the other periphery of drum shell 10' for selectively applying magnetization thereto or reading information therefrom. A head lifting rod 84 forming a portion of a transducer head lifting system, not a part of this invention, is provided for lifting all of the heads 82 away from the periphery of the drum shell 10' when the drum is starting or stopping to reduce friction between the drum and air supported transducers and thereby allows the use of a small driving motor.

It can be seen that by constructing a magnetic memory drum for use in a data processing system in accordance with the teachings of this invention the resonant frequency of vibration under dynamic conditions is greatly increased by providing an assembly which tends to resist vibrations both axially and transverse to the axis. The drum can be easily and quickly assembled utilizing sheet metal techniques and has a light weight which not only improves the resonance characteristics but also reduces the power consumption and load on the driving motor. The construction allows the drum to be constructed of sheet metal which is pressed, stamped and drawn. The sheet metal used is preferably $\frac{1}{32}$ of an inch thick or less so that the parts can be constructed to the required accuracy by the sheet metal operations described, whereas the prior art drums are constructed from heavy metal at least $\frac{1}{8}$ inch thick to withstand machining. The entire structure constructed according to the teachings of the present invention is economical as well as providing extremely favorable vibrations resisting characteristics.

Drums built in accordance with the teachings of this invention have been built and vibration tested both axially and transverse to the axis with the resultant resonance substantially above the prior art drums and no loss of signal amplitude, timing shift of the signal or structural instability was noted below the resonant frequency.

It should be noted that a drum incorporating the teachings of the present invention could be manufactured incorporating one piece construction of the lateral cylindrical surface and the end pieces.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. A rotatable magnetic drum for storing information on the peripheral surface thereof, the rotatable drum having a high resonant frequency about orthogonal axes, said drum comprising; a thin cylindrical drum shell, an axial thin tubular support shaft concentric within said thin cylindrical shell, thin sheet metal end sections in the form of a surface of revolution having at least one finite radius of curvature connecting said thin shell to

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said tubular support shaft, whereby the moment of inertia about the axis of the drum will be high and further providing stiffness and a high resonant frequency of vibration.

2. A drum as defined in claim 1 wherein the thickness of all of said thin components is no greater than $\frac{1}{32}$ inch and further comprising supporting bearings adjacent the end sections providing a minimum unsupported length of said shaft.

3. A rotatable magnetic drum as defined in claim 2, wherein the components are secured together by bonding.

4. A rotatable magnetic drum as defined in claim 1 wherein the end sections are portions of a conical shell with the smallest diameter of the conical shell secured to the tubular shaft and with the largest diameter of the conical shells secured to the thin shell.

5. A rotatable magnetic drum as defined in claim 4, further comprising a motor for rotatably driving said drum, the rotor of said motor secured to said shaft outside an end section and closely adjacent thereto.

6. A rotatable magnetic drum having a magnetizable periphery for storing information to be used in an electronic data processing system, said drum comprising; a cylindrical drum shell constructed from thin sheet metal, a support shaft for supporting said cylindrical shell, said support shaft being tubular in section to increase the stiffness thereof, end sections connecting said drum shell to said tubular support shaft, said end sections being constructed of thin sheet metal and being formed to provide a large stiffness in an axial direction by having a finite radius of curvature, and bearings supporting said drum, said bearings being positioned adjacent to end sections to provide a relatively short unsupported length of support shaft so that the light weight sheet metal components together with the arrangement thereof and the short distance between the bearings decrease deflection and increase the natural frequency of vibration transverse to the drum axis.

7. A rotatable drum having a magnetizable periphery for storing information to be used in an electronic data processing system, said rotatable drum having a high resonant frequency and comprising; a tubular support shaft constructed of thin gauge sheet metal, a tubular cylindrical drum shell also constructed of thin gauge sheet metal and positioned concentrically about said support shaft, end sections constructed of thin sheet metal and being in the form of a surface of revolution, the smallest diameter of the surface of revolution being connected by sheet metal connecting techniques to said support shaft and the smallest diameter of both of said end sections being closer together than the largest diameter thereof, whereby the drum will have a high stiffness to mass ratio and will have minimum deflection thereby providing a high resonance frequency.

8. A rotatable magnetic drum as defined in claim 7 further comprising a support housing adapted to mount transducer heads, said housing being constructed of thin sheet metal and having end portions which are surfaces of revolution for providing axial stiffness, said bearings being supported from said housing by sheet metal brackets which are also surfaces of revolution to further provide stiffness for the entire structure.

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