The present invention relates to a tape cassette, in particular a magnetic tape cassette, which possesses one or more rolls of tape on an essentially flangeless hub having an external diameter onto which a tape can be wound and/or from which a tape can be unwound, liners which have regions which are bent over or folded over toward the middle plane of the cassette, correspond to one another, are opposite one another with respect to the central axis of the cassette and exert a spring force on the roll or rolls of tape being provided between the tape roll, containing the tape windings, and the bottom and lid walls of the cassette, the liner pressure on the tape roll periphery which faces the back of the cassette being exerted by the back liner area and the liner pressure on the front part of the tape roll, which faces the front of the cassette, being exerted by the front liner area.

German Patent 2,251,746 discloses a magnetic tape cassette possessing support liners of the type described at the outset. The folded-over liner edge areas begin between the circumferences of the tape roll which are determined by the half radius and the maximum radius, so that the guiding function begins only at half the roll diameter and consequently causes stepping, which in the worst case results in jamming of the tape roll in the cassette or at least in permanent damage to the tape. The central part of the known liner lies in each case flat against the inner wall of the cassette and does not exert any guiding or centering influence at the hub. When a bent-over front edge parallel to the longitudinal axis of the liner and located close to the front of the cassette is provided, or when lateral folds are present, the tape section which is being wound on or unwound is folded over or its edge is damaged, so that mechanical and electroacoustic damage occurs. Temporary contact between the liner and the said free tape section may also cause or reinforce wow and flutter. The known forms of liners also include circular channels arranged above and below each roll of tape and possessing inlet and outlet openings for the magnetic tape being wound on or unwound.

Liners of this type are too expensive to produce and install by mass production methods.

Furthermore, US Patent 3,977,626 discloses liners which have at least radial or longitudinal folds or edges for centering the hubs, the folds or edges facing the hub, and which additionally have a guide channel at the back of the cassette to prevent slipping of the tape and jamming of the hub. The centering action on the hubs is relatively constant and independent of the particular operating situation of the cassette.

German Laid-Open Application DOS 2,736,760 discloses a liner for audio tape cassettes which is supposed to act directly on the hub by means of pressure folds and is supposed to effect uniform tape guidance just by hub centering. Apart from the said pressure folds, the conventional liner has no special properties and therefore acts as a completely flat audio tape guide.

Japanese Preliminary Published Application 48/83 817 discloses a roof-shaped folded liner having radial incisions at its ends. The guide folds, which are located fairly far toward the outside relative to the maximum diameter of the tape roll, are disadvantageous since they cause stepping of the tape roll. Although the incisions reduce the spring force exerted by the liner on the tape section being wound on or unwound, the incisions nevertheless do not eliminate possible contact between the tape and parts of the liner, so that folding of the tape and tape damage may occur.

Furthermore, liners for magnetic tape cassettes have been disclosed (German Laid-Open Application DOS 2,732,083) which possess radial ribs which face the tape rolls and are located above and below these. These ribs serve for centering the tape roll but are provided in particular in the run-in and run-out area of each tape roll, so that the undesirable contact between tape and ribs occurs.

A known compact cassette possesses liners which each have three arc-shaped indentations parallel to one another, the two edges in between and the two

longitudinal outer edges being supported on the particular inner wall of the cassette. Furthermore, the longitudinal outer edges are provided with projecting lobes which just overlap the maximum area of the tape roll toward the back of the cassette but do not extend over the entire tape roll toward the front of the cassette.

The middle arc is symmetrical with respect to the line joining the centers of the hubs. The lateral arcs lie with their central lines within the first half of the maximum radius of the roll or rolls of tape. Consequently, constant supporting forces act on the tape roll over a narrow strip, virtually over the entire radius, ie. almost over the entire area of the roll, from the virtually empty to the fully wound hub. The central arc too exerts on the hubs, over a strip-like area, a pressure which is relatively constant over the entire area of the roll. In any case, the "strip-like" contact pressure is dependent on the shape of the arc and the spring properties of the material and is set unalterably during manufacture. Apart from acting as sliding surfaces in particular areas and from time to time, the edge parts of the liner, between the central lines of the lateral arcs and the outer edge of the projecting lobes, do not perform any guidance function at all for the roll or rolls of tape. The central arc merely exerts a constant contact pressure on the hubs over a strip-like area.

This results in a retaining force being exerted on the hub or hubs over a narrow area; this measure is not sufficient for centering. Another disadvantage is that, because the beginning of the arc shape of the lateral arcs is located at the periphery of the hub, even the first tape windings are not wound concentrically on the hub. Furthermore, the outer tape windings of the full tape roll are scarcely held effectively by means of the projecting lobes.

It is an object of the present invention to provide a tape cassette with support liners which has advantages in terms of large-scale serial production as

particular, it is intended to improve the winding and running characteristics of the cassettes.

We have found that this object is achieved by a tape cassette of the type defined at the outset if the liners have longitudinal folds in the central area which are located within the outer diameter of the hub and are adjacent to the inner bottom and lid walls of the cassette and between which a relatively flat central part is provided, and the back and front areas of the liners are bent through an angle with respect to the central part, so that these areas exert spring forces on the periphery of the empty hub or on the tape roll, with the result that the relatively flat central part arches toward the hub or hubs and exerts a continuously increasing compressive force on the latter, the said force having a minimum value from about 1 cN to about 4 cN when the hub is empty and a maximum value from about 7 cN to 15 cN when the roll of tape is full.

Consequently, centering of the tape roll or rolls is improved while at the same time greater protection is afforded against folding and slipping of the tape, so that the winding speeds during production of the cassette can be increased several times compared with conventional tape cassettes which possess conventional liners having an essentially constant spring characteristic.

In a practical embodiment, the back area of the liner can be formed by a continuous longitudinal fold extending as far as the narrower side of the liner.

Advantageously, the front area of the liner can be formed by one or more folds which essentially extend in the longitudinal direction of the liner, end before the run-in or run-out area of the tape when the latter is being wound onto or unwound from the tape roll, and cause the run-in and run-out area of the liner to curve.

This ensures simple liner design and production, which can be effected by cold stamping or hot stamping.

The force characteristics in the given range can be achieved in practice and ensure that, as the roll diameter increases, the centering forces also increase in

order systematically to counteract the greater troublesome forces which are then effective and may influence the winding of the tape. Furthermore, the empty hub is held just sufficiently centrally by the minimum compressive force so that the first tape windings are wound on cleanly.

Advantageously, the minimum value of the compressive force should preferably be set to about 2 cN and the maximum value preferably to about 10 cN.

Advantageously, the force characteristics claimed can be obtained by means of a film whose edge areas are folded toward the central plane of the cassette through an angle of from about 8° to about 30°, in particular from about 10 to about 25°.

In a practical embodiment, the front area of the liner can be folded through about 13 - 20° and the back area of the liner through about 20°, the angles being with respect to the central plane of the cassette. Folding through these angles gives compressive forces which are adequate in practice, preferably with a 50 µm polyester film.

The stated stamping methods make it possible to obtain the desired angle and hence the desired compressive forces simply and economically on a large scale.

The gradient of the compressive force as a function of the instantaneous tape roll diameter is advantageously from about 0.1 to about 0.3 cN/mm, and preferably falls from about 0.3 cN/mm in the region of the minimum compressive force to about 0.1 cN/mm in the region of the maximum compressive force.

In an advantageous embodiment of the cassette, the distance of the longitudinal fold for the back area of the liner from the back edge of the latter is greater than the distance of the longitudinal fold for the front area of the liner from the front edge of the latter. Consequently, greater spring forces can be exerted on the tape roll area at the back of the cassette than on the tape roll area close to the front of the cassette.

In a version of the cassette according to the

invention, the liner may possess, in the run-in and run-out areas, cutouts through which the tape passes in the region of the periphery of the tape roll.

In another embodiment of the invention, tape guide elements which guide the tape to and from the periphery of the roll can be provided in the run-in and run-out areas of the liners.

Advantageously, a 50 μm thick polyester film can be used in the cassette to obtain the compressive force values of the liners.

The invention is illustrated by the examples described below and shown in the drawings. In the drawings,

Figure 1 shows a perspective view of an unloaded support liner for a cassette according to the invention,

Figure 1a shows a side view of the support liner according to Figure 1,

Figure 2 shows a plan view of the support liner of Figure 1,

Figure 2a shows a cross-section through the liner along the line I-I,

Figure 3 shows a liner with curved areas, in a cassette according to the invention, shown schematically,

Figure 4 shows a liner with areas of contact with the hub and the tape roll, in a cassette according to the invention, shown schematically,

Figures 5A-5C show a cross-sectional view of a cassette according to the invention with various sizes of tape roll,

Figure 6 shows a cross-sectional view of a liner having loaded edge areas for a cassette according to the invention and

Figure 7 shows views of curves of the effective compressive forces of the liners as a function of the instantaneous tape roll diameter.

The liner 10 is shaped like a sloping roof, the continuous longitudinal folded edge 11 being the highest

line. The second highest line, the non-continuous folded edge 12, ends substantially before the narrow edges 19 and 20 of the liner and extends beyond the circular cutouts 13 and 14. The longitudinal outer edges 15 and 16 rest on the flat supporting plane 23, which is shown hatched. All other contour edges, obliques 17 and 18 and narrow edges 19 and 20 make no contact with the supporting plane. Thus, the drawing shows clearly that the narrow ends 21 and 22 project beyond the supporting plane 23.

Figure 1a shows that the narrow ends 21 and 22 have a rounded curvature which is formed by virtue of the fact that the folded edge 12 does not extend as far as the narrow edges 19 and 20 but ends substantially before these. Figure 3 shows how far the curved areas 24 and 25 extend in spatial relationship with the position of the tape rolls 26 and 27 in a two-reel cassette 30, in particular a compact cassette. In this cassette, the tape 28 is guided over guide rolls 29, along the front 31 of the cassette 30, where the head (not shown) comes into contact with the tape 28. 32 denotes holding pins for the liner 10, which itself possesses appropriate cutouts.

The sections of the tape 28 being wound onto the particular periphery of the tape roll or being unwound from this are located within the curved areas 24 and 25, within which the liners 10 are intended to guide the tape 28 in order to be able to wind or unwind the tape in a predetermined position. The folded edge 12 does not continue as far as the narrow edges 19 and 20, in order that effects on tape running, such as folding, deflecting, etc., and tape damage, such as abrasion of the tape edges, etc. are avoided. The shape and position of the curved areas 24 and 25 can be varied by varying the length of the non-continuous folded edge 12.

As shown in Figure 2, the main part of the liner 10 is bent over toward the central plane of the cassette 30 so that it is roof-shaped. The area of this main part coincides roughly with the shaded supporting plane 23 of Figure 1. The supporting plane 23 essentially corresponds

to the central plane of the cassette within the cassette 30.

The liner 10 possesses, at the rear, the back area 33, which is located between the longitudinal fold 11 and the back edge 15, and possesses at the front the front area 34 which is located between the folded edge 12 and the front edge 16 of the liner 10. Provided that the liner material is a 50 μm thick polyester film of type RN50 from Kalle, Wiesbaden, both areas of the liners should be folded over through angles α,α' of from about 8 to about 30°, in particular from about 10 to about 25°, with respect to a horizontal plane, for example the central plane of the cassette 30. In practice, and with the selected dimensions for the liner areas 33 and 34, an angle α' of from 13 to 20° in the front area 33 and an angle α of 20° in the back area 34 have proven advantageous, although folds through other angles which can easily be achieved by the stamping method are also possible. A practical folding angle α' is 20°, which, however, is established only in the middle of area 33. The run-in and run-out areas then have an angle of about 13°. In the example, the distance a) between the folded edge 12 and the front edge 16 of the liner 10 is smaller than the distance b) between the folded edge 11 and the back edge 15, so that the corresponding lever arms are such that b) > a).

Surprisingly, the compressive forces or retaining forces of the liners 10 in their central part 35 can be set by means of the magnitudes of the angles α,α' and the lever arms a) and b), and, starting from a basic setting, for example for an empty hub, a compressive force or retaining force dependent on the instantaneous actual diameter of the tape roll can advantageously be exerted on the hub or hubs. This compressive force or retaining force, which serves to hold and center the hub or hubs and hence also the tape roll present thereon at the time, can in practice be varied from about 1 to about 4 cN (for an empty hub) and from about 7 to about 10 cN (for a full tape roll), and is preferably about 2 cN and 7.5 cN,

respectively. Surprisingly, the compressive forces on the tape roll in the back area 34, at about 1 - 4 cN, are greater than those in the front area 33, which are about 0.5 - 3 cN.

The variable pressure exerted on the hubs is illustrated in Figures 5A to 5C. In Figure 5A, the hub 37 in the cassette 30 is wound with only a few tape windings, ie. carries a very small tape roll 38; this tape roll is larger in Figure 5B, where it is denoted by 38', and reaches its full size in Figure 5C, where it is denoted by 38". Comparison of the curvatures of the arched parts of the middle part 35 of the liner shows that the greatest curvature (35') is present with the shortest contact line in Figure 5A; in Figure 5B, at half roll diameter, this curvature becomes substantially smaller and the contact line (35') becomes longer; in Figure 5C, the said curvature becomes even smaller and the contact line (35") reaches its longest length. In practice, the compressive forces and retaining forces are from about 2 to 3 cN in Figure 5A, from 4 to 6 cN in Fig. 5B and from 6.5 to 7.5 cN in Fig. 5C.

The continuous dependence of the compressive force and retaining force on the instantaneous diameter of the tape roll is evident from the measured curves in Figure 7, as described below.

Figure 6 shows the liner 10 when the lateral areas 33 and 34 are pressed flat by loads P, causing the central part 35 to curve. For a compact cassette containing a 50 μm polyester film, the height c of the curvature of the liner 10 is about 1.5 mm.

In the unloaded polyester film, the height of the rear fold 11 was about 6 ± 1 mm and that of the front fold 12 was 4 ± 0.5 mm. The measurements below are also based on these values.

The curvature and the resulting spring characteristics are adequate for the conditions in the compact cassette having a free internal distance between the hub and the inner wall of 2 × 0.6 mm, and give excellent results in respect of stability and tape running.

Figure 4 shows the instantaneous contact conditions in the cassette 30 when one hub is empty and the other is fully wound. It is clear that the light hub 37' is held with a smaller compressive force and retaining force than hub 37". Furthermore, the tape roll 27 is held on both sides by the areas 33 and 34 of the liner, although with a smaller compressive force and retaining force of from about 0.5 to about 4 cN.

With these force conditions, it is possible to produce cassettes which have excellent tape running and winding properties and whose measured mechanical and dynamic characteristics are outstanding.

Figure 7 shows the curves F = f (d), ie. the effective compressive force and retaining force F as a function of the instantaneous diameter of the tape roll. The hub diameter is 22 mm and the maximum tape roll diameter 52 mm, and the beginning and end of the measuring range is therefore defined by these values.

The compressive forces F were measured in each case for different roll diameters, using aluminum disks of different diameters and a load cell, by the inductive transducer principle. The load cell was supplied by Hottinger-Baldwin.

In carrying out the experiment, the liners in the bottom part of the cassette are simulated by positioning the disks and measuring the forces which have to be applied to compress the liner to a residual height of 0.6 mm, corresponding to the space between the lateral surface of the tape roll and the inner wall of the cassette.

The curves of Figure 7 denote the following types of liners:

A) arc-type liner of the above, known compact cassette of type UDI, from a Japanese manufacturer,

B) the Applicant's liner folded to form a Z-shape, similar to German Patent 2,251,746,

C) Teflon liner with circular indentations and

X) the dynamic foil described, of the present invention.

Discussion of curves:

Curves A and C show virtually constant compressive force behavior over the entire measuring range. They therefore act as a static glide cushion without any dynamic properties. Curve B exhibits dynamic behavior for a short time, over an interval corresponding roughly to diameters between 33 and 40 mm, but overall shows a step-like compressive pressure curve which preprograms corresponding step formation in the roll.

Curve X shows a steady, ascending curve whose gradient is from 0.3 to 0.1 cN/mm (the latter value in the upper diameter range).

Accordingly, a full tape roll is held with a force of about 7.5 cN (centinewtons) compared with about 2 cN for an empty hub. The increase in weight can therefore be compensated, and a full roll is held, and hence centered, in virtually just as stable a manner as the empty hub.

When the novel X liner was used, it was possible to increase the speed at which the tape was wound into empty cassettes to about 4 times the speed for cassettes containing glide liners (eg. A and d, see above). Wind-on speeds of 15 and 35 m/sec were achieved in practice and good winding results were obtained (smooth tape roll).

There were the following advantages during operation of the cassette:

Because of the mechanical and dynamic improvements to winding and centering, substantially smaller fluctuations in output level were measured compared with conventional cassettes. The occurrence of mechanical errors due to jamming and folding could be substantially reduced, for example by a factor of 4 compared with compact cassettes containing the Z liner (curve B in Figure 7). It was also possible to reduce the running noise by a factor of about 2. By means of the non-continuous folded edge 12, it was possible for errors due to folding of the tape to be virtually completely eliminated.

Claims

1. A tape cassette, in particular a magnetic tape cassette, which possesses one or more rolls of tape on an essentially flangeless hub having an external diameter onto which a tape can be wound and/or from which a tape can be unwound, liners which have regions which are bent over or folded over toward the middle plane of the cassette, correspond to one another, are opposite one another with respect to the central axis of the cassette and exert a spring force on the roll or rolls of tape being provided between the tape roll, containing the tape windings, and the bottom and lid walls of the cassette, the liner pressure on the tape roll periphery which faces the back of the cassette being exerted by the back liner area (34) and the liner pressure on the front part of the tape roll, which faces the front (31) of the cassette, being exerted by the front liner area (33), wherein the liners (10) have longitudinal folds (11, 12) in the central area which are located within the outer diameter of the hub (25, 17) and are adjacent to the inner bottom and lid walls of the cassette (30) and between which a relatively flat central part (35) is provided, and the back and front areas of the liners are bent through an angle (α,α') with respect to the central part (35), so that these areas exert spring forces on the periphery of the empty hub (26, 37) or on the tape roll (27, 38') with the result that the relatively flat central part (35) arches toward the hub or hubs (26, 37) and exerts a continuously increasing compressive force on the latter, the said force having a minimum value from about 1 cN to about 4 cN when the hub (26, 37) is empty and a maximum value from about 7 cN to 15 cN when the roll of tape (27, 38') is full.

2. A cassette as claimed in claim 1, wherein the back area (34) of the liner is formed by a continuous longitudinal fold (11) extending as far as the narrow sides (19, 20) of the liner.

3. A cassette as claimed in claim 1, wherein the front area (33) of the liner is formed by one or more

folds (12) which extend essentially in the longitudinal direction of the liner, end before the run-in and run-out area of the tape (28) to and from the tape roll (27, 38') and cause the run-in and run-out area of the liner (10) to curve.

4. A cassette as claimed in claim 1, wherein the minimum value of the compressive force is preferably about 2 cN, and the maximum value is preferably about 10 cN.

5. A cassette as claimed in claim 1 or 4, wherein the gradient of the compressive force as a function of the instantaneous tape roll diameter is from about 0.1 to about 0.3 cN/mm, and decreases preferably from about 0.3 cN/mm in the region of the minimum compressive force to about 0.1 cN/mm in the region of the maximum compressive force.

6. A cassette as claimed in claims 1 to 5, wherein the back and front areas of the liners (10) are folded through an angle (α, α') of from about 8° to about 30° relative to the central part (35), with the result that the continuously increasing compressive forces can be exerted on the circumference of the empty hub (26, 37) or on the tape roll (27, 38').

7. A cassette as claimed in claim 6, wherein the back and front areas (34 and 33 respectively) of the liners (10) are folded through an angle of about 10 - 25°.

8. A cassette as claimed in claim 6, wherein the front area (33) of the liner (10) is folded through about 13 - 20° and the back area of the liner through about 20° relative to the central part (35).

9. A cassette as claimed in either of claims 7 or 8, wherein the back area (34) of the liners (10) are formed by a continuous longitudinal fold (11) extending as far as the narrow sides (19, 20) of the liner and the front area (33) of the liner is formed by one or more folds (12) which extend essentially in the longitudinal direction of the liner and end a distance away from the narrow sides (19, 20) of the liner.

* C L M S *

10. A cassette as claimed in any of claims 6 to 9, wherein the distance of the longitudinal fold (12) for the front area of the liners (10) from the front edge (16) of the liners (10) is smaller than the distance of the longitudinal fold (11) for the back area (34) of the liners from the back edge (15) of the liners (10).

11. A cassette as claimed in any of claims 7 to 10, wherein the liners (10) consist of a 50 mm thick polyester film material.

12. A cassette as claimed in any of claims 6 to 11, wherein the liner (10) possesses, in the run-in and run-out area, cutouts, through which the tape passes into the region of the periphery of the tape roll.

13. A cassette as claimed in any of claims 1 to 12, wherein tape guide elements which guide the tape to or from the periphery of the tape roll are provided in the run-in and run-out area of the liners (10) for the tape.