ABSTRACT: A feeding device for lengthy webs such as photographic strip film and the like wherein spiral ribs define a spiral path having a substantial number of convolutions therethrough which the web is to be fed. A plurality of driving rollers are arranged in angularly spaced location around the spiral path on each of its sides with the roller peripheries intruding through the rib convolutions so as to engage the extreme marginal edges of the web to advance the web as the rollers are rotated. The rollers are preferably arranged on the sides of the ribs in cooperating pairs with the clearance between the peripheries of such pairs being slightly less than the transverse width of the web. Each of the rollers is formed on its periphery with successive frustoconical steps to give a sawtooth profile with the axial length of each step corresponding to the spacing between the ribs, with one step being provided for each convolution of the spiral. The larger diameter of each step is located nearer the center of the spiral so that an increase in tension in the web within any given convolution draws the web towards the larger diameter and thus increases the feeding rate of the web to thereby automatically compensate for tension variations. The rollers are arranged so that their axes of rotation intersect at least one of the spiral convolutions and preferably all of them at an angle extending generally normal to a line drawn tangentially to the spiral at the point of intersection of the corresponding roller axis therewith. The device can be enclosed within a housing which can be arranged to contact the web with a fluid processing medium, for example for photographic development. The device is also useful for storage in the handling of an endless web.
3,563,486

WEB PROCESSING DEVICE

The present invention relates to a winding path web-feeding device, and more particularly to a feeding device for use in processing photographic film of the strip or ribbon type.

Compact film processing units are known; e.g., the conventional amateur film daylight developing tanks, wherein an exposed strip of film is located between two spaced parallel walls provided with matching spiral grooves. With such a unit the film must be inserted in dry condition into the grooves by hand or by means of simple mechanical means located at the entrance of the spiral grooves. Once the film is wet; i.e., such as after processing, it cannot be withdrawn endwise from the grooves but must be carefully peeled out of the grooves. Thus, this device is not suited for continuous operation. A device is also known in the art for transporting film through a spiral groove arrangement by means of an endless leader belt attached to the leading end of the film. The leader is provided with a toothed margin for engagement with positively driven rubber rollers and as the leader is thus forwarded through the groove, the film follows behind.

A disadvantage of the latter device resides in the excessive wear imposed on the toothed edge of the leader belt in overcoming the rather considerable frictional resistance of the wet film against the spiral groove, especially in the case of lengthy films, and the necessity to interrupt the feeding operation to attach and detach the film to and from the leader belt before and after processing.

Other disadvantages of the mentioned device are the high cost of the leader belt and the increased risk of contamination when the film and the leader pass through more than one solution-containing tank during processing. Finally, leader belts are obviously not suited for efficiently processing several shorter strips or copies of the same film after another, since each such strip requires a separate leader.

According to the present invention, a web-feeding device comprises opposed matching winding, preferably spiral, tracks for receiving opposed margins of a web to guide the web along a winding or spiral path and driving means for feeding the web along such tracks, the driving means comprising members, preferably rollers, which are disposed adjacent the track in contact with the opposed extreme ends of the web present in such tracks, and are movable for advancing such web along its path by frictional engagement with such web ends.

For effective operation, the web-advancing members must contact the web ends at a number of different points along the length of the winding path. Preferably, such contact occurs at least at one position in each convolution of the web. This may easily be achieved by providing rollers which intrude into the tracks from the bottom. There may be, arranged in one or more radial positions around the center axis of a spiral track, and on each side of the spiral web path, a series of coaxial rollers which intrude into different track convolutions at that radial position, or a single roller which extends across and is effective for a number of successive track convolutions. It is desirable to facilitate leading of the film into the device for web-displacing members to be present adjacent the entrance to the spiral tracks so that the web does not have to be introduced too great a distance into the tracks before the web-advancing members can assume their web-feeding function.

As the distance between successive points of the contact with web-feeding members along the spiral web path is reduced, so also is reduced the minimum length of web which can be advanced along such path by the web-feeding members. Normally, it will not be necessary to provide more than three or four contact points on each side of the web path in each convolution, but the use of a larger number of contact points is not excluded.

As the invention is primarily concerned with devices for feeding webs along a spiral path automatically, the web-advancing members are preferably designed for coupling to a power source for driving the same.

An important use of the invention is for web processing wherein one or more treatments is applied to the web while moving along the winding path, and devices according to the invention can form part of web processing apparatus including means for holding processing medium in contact with a web, or for directing processing medium against the web, while the web is in the tracks.

Although in the present description the term "processing" mainly contemplates treatments of photographic material, such as developing, fixing, etc., it should be understood that treatments and materials other than photographic in nature are within the scope of the invention.

Thus, a device according to the invention can be used in the coloring or bleaching of weiblike fabrics, in the etching or electroplating of metal webs, etc. According to the type of processing in view, the processing medium may, for example, be in the form of water or liquid wherein the web is immersed, in the form of a spray or a coating, or in the form of a vapor filling a chamber in which the web tracks are located. Alternatively, the processing medium may be heated air, radiation, etc.

As used herein, the term "web" embraces any strip of material having a length sufficient to ensure engagement with the web-advancing members located at successive points along the path, as well as longer strips with a length exceeding the capacity of the device.

For purposes of this invention the term processing also envisages the continuous or closed loop projection of photographic film or the like. In known devices use is made of a special spool, wherein the film is continuously pulled out at the inner winding, passed through the projector or viewer, and fed to the outer winding of the spool, or vice versa. The peripheral speed of the spool necessarily varies from its inside to its outside; since, however, the film must travel at a constant linear speed and is wrapped upon itself in successive windings, the film must slide upon itself and is particularly subject to damage. By using a device according to the invention in an apparatus for closed loop projection of a film, the life of the film projected in such apparatus can be prolonged substantially, even to the point of equaling the life of a film which is projected for the same length of time in a conventional dual reels projector which after projection requires rewinding of the film from the takeoff reel.

A device according to the invention may take the form of a storage means, e.g., the form of a cassette, for storing a web in a wound condition with the windings held separated from each other. At the moment one wishes to process the web, the device may, for example, be immersed in a processing bath.

The web-advancing members may be arranged for drive from a power source through the agency of gearing. To this end the web-advancing members may be connected to one or more gears wheels situated on the exterior of the device and this exterior gear may mesh with a driven gear of a drive mechanism.

According to a preferred arrangement, the device according to the invention comprises two spaced parallel walls provided on their mutually facing surfaces with shallow ribs defining cooperating matching tracks or grooves running along one or more spiral paths having a substantial number of loops or convolutions, and a plurality of driving rollers arrayed on each side of each such spiral path with their peripheries intruding through openings in the corresponding wall into the bottom of the track or groove so as to make frictional contact with the extreme outside edges of a web within the tracks, the rollers in each path having their axes of rotation lying in a common plane and extending generally radially from the spiral center in spaced angular positions around the spiral to thereby contact the web at several points along each loop of its path.

The tracks or grooves defined by the ribs can have any kind of winding or spiral form.

The term "substantially radially" is intended to mean that the axes of the driving rollers need not necessarily pass through the geometric center of the spiral and according to
preferred feature of the invention, the axis of each roller is substantially normal to a line disposed at least substantially tangentially to the spiral track at the point of intersection therebetween (when viewed in plan), which means that each axis will pass slightly away from the geometric center.

Embodiments of the invention, selected by way of example, will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic front elevation view, with parts partly broken away, of a web-feeding device according to the invention;

FIG. 2 is a plan view of the same device, taken substantially along line 2-2, with certain parts shown in phantom for clarity;

FIG. 3 is an enlarged partial sectional view on line 3-3 of FIG. 1;

FIG. 4 is an enlarged partial sectional view on lines 4-4 of FIGS. 1 and 2;

FIG. 5 is a diagrammatic view of the driving mechanism of a photographic processing arrangement;

FIG. 6 is a diagrammatic view of an improved driving roller arrangement;

FIG. 7 is a view of an improved driving roller;

FIG. 8 shows diagrammatically a modified spiral web path;

FIG. 9 shows diagrammatically a device wherein the web path is reversed in the center of the spiral;

FIGS. 10, 11 and 12 are separate illustration of other web paths;

FIG. 13 shows a device according to the invention in combination with a conventional film projector.

The web-processing device shown in FIGS. 1 and 2 comprises a rectangular housing 10 to which is fitted a cover 11.

Guide members 12, 13, 14 and 15 are fixed to the inside of the lateral housing walls and are provided with vertical grooves for locating the pairs of removable square partitions 34, 35 and 36, 37. These partitions are connected two by two in fixed spaced parallel relation by means of spacing blocks 18.

Since both partition pairs are identical in construction, only the pair 34, 35 will be described in detail hereinafter.

It will be understood that the two pairs function in tandem, the first receiving the web from the exterior and guiding it inwardly to the center, and the second 36, 37 receiving the web at the center from the first and returning it to the exterior.

The partitions 34 and 35 are provided on their respective mutually facing sides with spiral ribs 20 and 21 each having a substantial number of matching spiral turns to together define a pair of matching tracks, to receive the outer extreme margins of a web 22, indicated in dash-dot line, and to support it along a spiral path. For clearance sake only some of the outer and the inner turns of the ribs have been shown in the drawings.

A pair of cooperating guide plates 23 and 34 direct the web from the entrance slot 23 of the apparatus to the outer end of the spiral, whereas other guides, such as guide plate 47, deflect the web after it leaves the inner spiral turn and twist the web through two 90° turns in order to transfer it from the first spiral track through the circular opening 26 (shown in FIG. 1) in the partition 35. The web follows a path generally indicated by the arrow 35 in FIG. 2 across the separation between the partition pairs and enters the second pair through an opening in flange 36, coaxial with opening 26 and is directed by the inner end of the second spiral. The general configuration of the spiral paths resembles that shown in FIG. 11 except that the paths are arranged in spaced parallel relation. While located between partitions 36 and 37, the web travels from the inner spiral turns toward the outer spiral turn and leaves the apparatus through an exit opening located next to the entrance opening 25, as indicated diagrammatically by the arrow 23 in FIG. 2.

The driving force for the web passing between the flanges 34 and 35 is supplied by means of an array of radially extending rollers arranged on each of the mutually opposed faces of the partition pairs, the rollers in the arrays associated with each set of partitions being correspondingly located so as to give pairs of cooperating opposed rollers designated 28, 29, 30, and 31, only the top roller in each pair being visible in FIG. 1. The rollers are rotatably journaled at both ends in bearing blocks projecting from the partitions, such as bearing blocks 32 and 33 for roller 28. The shafts of those rollers which are mounted on the exterior partition of each pair; i.e., partitions 34 and 37, are provided at their inner ends with bevel gears 40 which engage a centrally disposed common driving bevel gear 41. At their outer ends, the shafts of each pair of rollers are provided with meshing gears 42 and 43, which gears extend through rectangular recesses, provided in the flanges. Thus, the roller pairs work in unison and by selection of identical sizes for gears 42 and 43 of the pairs, are driven at a common speed.

The shaft of the common driving bevel gear 41 (the bearings for which have not been shown) carries a sprocket wheel 44 which is driven through an endless chain (not shown) which runs over sprocket wheel 45 (see top of FIG. 1) mounted on a driving shaft 46 which extends horizontally near the top of the device. Further details of the driving system are given in FIG. 5 which will be described hereinafter.

The manner in which the web is driven by the rollers is shown in greater detail in the enlarged views of FIGS. 3 and 4. As is apparent in those figures, the extreme marginal portions or edges of web 22 project between adjacent loops or turns of the spiral rib 21. The clearance between the cooperating pairs of partitions is so dimensioned as to slightly exceed the width of the web, so that the web edge does not contact the surface of either partition, but on the contrary, is supported by the driving rollers, e.g., roller 30 in FIG. 3, a portion of the periphery of which slightly projects through openings; e.g., the opening 50, which has been formed in the partition; e.g., by milling. The relationship of the web edges, guiding ribs, and driving rollers is especially clear in FIG. 4.

The distance separating the rollers of each cooperating pair at their nearest points is slightly smaller than the width of the web being fed. Thus, the web edges are necessarily in firm frictional contact with the rollers, so that appropriate rotation of the latter causes the web to advance between the spiral turns of the ribs. The frictional contact of the web with the rollers is greater than might be normally expected by reason of the curvature of the web in the longitudinal direction which considerably stiffens the web against curling in the transverse direction.

It should be noted that the depth of opening 50, while exceeding the thickness of the partition, is substantially less than the combined thickness of the rib and partition, leaving approximately two-thirds of the rib thickness intact. Thereby, enough of the rib remains as to constitute an uninterrupted guide wall for the leading edge and the marginal portions of the web.

During the operation of the device it was surprisingly found that the agitation of the liquid by the webs passing therethrough was optimum when the tank was filled about to the level, indicated by the broken line 60 in FIG. 1., rather than when the tank was filled to such a height that the spiral ribs were completely immersed. Thus, when the device according to the invention was used for development of photographic light-sensitive material, the development was faster and more uniform when the tank was filled to said level indicated by broken line 60, than when the tank was filled to a level situated at a short distance below the entrance slot 25.

The described device accepted webs of a length of about 85 cm.; e.g., conventional 35 mm. amateur film for 20 exposures, whereas also rolls of 35 mm. cine film with a length of exceeding many times the combined length of the spiral paths were continuously unwound and passed without any difficulty through the device. The driving of a web within the web occurred without noticeable slip. Thus, it was possible to feed a plurality of short webs one after the other into the device. The free distance between the successive strips needed be only a
few centimeters. During the travel of the strips between the spiral turns of the ribs, the mutual position changed a few millimeters at most, so that there was no risk of the strips overriding one another. By feeding two films to the device in mutual back-to-back relationship; i.e., with their emulsion sides outwardsly and the bare emulsion sides contacting each other, the capacity of the device could be almost doubled.

The web-advancing efficiency of the device was tested as follows. A web of 35 mm. film with a length of several meters was intentionally damaged by providing the film with a plurality of transverse cuts, some of which extended over more than half the width of the film. The transport in such damaged film provided guidance of the conventional processing apparatus. In the device according to the invention the film was transported as smoothly as an undamaged one, and even at the largest cut-in parts, the film showed no traces of further tearing. No scratching of the web was noticed and no damaging of the web perforations occurred (even after a plurality of passages). The web path in the device described hereinbefore is not limited to that shown in FIG. 11, whereby making a few changes in the web guidance the travel of the web from the first spiral path to the second may also follow the paths shown in FIGS. 10 and 12. It will be obvious that the rotation of the rollers must occur in the appropriate direction to ensure the proper advance of the web.

Devices of the described type have been used for continuously developing, fixing and rinsing 35 mm. films. To this end three dye chambers were connected to each other as shown in FIG. 5, the arrangement comprising a developing tank 51, a fixing tank 52, and a rinsing tank 53. Each tank is provided with two pairs of partition units as shown in FIGS. 1 and 2. The web to be processed enters the developing tank 51 in the direction generally indicated by the arrow 54, and successively enters the other tank along a path in the direction indicated by the central arrow. The web leaves the rinsing tank in the direction of arrow 55, whereafter it may be passed through a compact dryer, and rolled up.

The driving of the web-transporting rollers in the tank occurs, as shown diagrammatically, by means of shafts 56 and 57 which are driven by motor 58. The shafts 56 and 57 are provided with sprocket wheels 59 which are linked through chains (indicated in dash-dot lines) with the sprocket wheels located in the tanks, such as the sprocket wheel 44 shown in FIGS. 2 and 3.

In the just-described arrangement, the dimensions of each processing station were only 23.5 by 54 by 60 cm. The ribs of a flange shows about 26 spiral turns, and each station could contain about 50 meters of film. By varying the number of turns in the spiral, the processing times can be adjusted as desired. The speed of advance of the film was adjustable between 1 and 50 meters per minute in both directions. The tanks were filled with the appropriate processing compositions up to about half their height.

It is clear that the described arrangement, in combination with a dryer and even when equipped with accessories such as a replenishment mechanism and a temperature control device, constitutes a very compact processing apparatus, which is relatively simple of construction.

In the construction of the apparatus, the different sections may be designed for stack-assembly, so that a versatile system is obtained which may be easily adapted to meet most different requirements.

The driving system shown in FIG. 5 is a diagrammatic representation only. It will be understood that since the occurrence of a small degree of slippage between the driving rollers and the web is a reasonable expectation, the rollers of the sections after the first section may be preferably driven at slightly increased speed, for example through the intermediary of sprockets or clutches so as to ensure that the web remains gently tensioned during its transport through the device.

Two features which may considerably improve the web-feeding action through the device according to the invention will now be described. In FIG. 6, there is shown a fragment of an improved design of a driving roller, designated 65, located beneath two successive turns 62, 63 of a spiral rib, which winds toward its geometrical center 64 in an antihorizontal direction. Similar to the rollers in the main embodiment of FIGS. 1 and 2, the axis 66 of roller 65 passes through the center 64 of the spiral. The intended course of the web through the spiral is indicated by the curved arrow 67.

The effect of the position of the roller 65 as just described is that a web, in frictional contact with the roller, is given a thrust in the direction of the arrow 68, i.e., in a direction normal to the axis 66 of the roller. Consequently, the web tends to deviate locally from its ideal intended course, just downstream of the point of intersection 73 of the intended course with the roller axis 66, and to rub at its marginal portion against the outer spiral turn 62 at this point. The same objection applies to the web path at the points of contact with all of the rollers.

The remedy for the warping of the web from its ideal path resides in relocating the roller axis so as to no longer pass through the center of the spiral, but along a line that extends perpendicularly to a line lying tangentially of the spiral at the point of intersection of the roller axis with the ideal path.

Referring to FIG. 6, it is seen that the position of the roller 65 has been changed from that shown in solid lines to that shown in broken lines at 69, so that its axis in the new position, at 71, extends normally to the axis 66 of the spiral at intersection point 73, rather than along a radius 66 passing through center 64. In a similar way the axis of the other rollers are repositioned so as to no longer pass through the center 64, as is depicted symbolically also in FIG. 6, by dot-dash lines 74 and 75, representing the old and new axial positions for another roller.

The second feature consists in providing the driving rollers with a stepped profile, as shown in FIG. 7, for the purpose of achieving an automatic tension compensation for the web. To this end, the driving roller, here numbered 77, shown in conjunction with turns 78 and 79 of a spiral rib, is provided with a sawtooth profile resulting from the steps 80, 81 and 82. Each such step has the shape of a frustraconical section; i.e., is of slightly greater diameter at its base than at its top, with the length or radial dimension thereof corresponding to the distance between two adjacent turns of the spiral rib. A web following the intended ideal course indicated by curved line 83 will normally contact the roller periphery with a given pressure. In case, for one reason or another, a portion of the web should tend to lag in respects of the leading web part, the tension will be increased in said lagging portion and will tend to displace the turns of said lagging part towards the inner spiral turns of the rib. Thereby, the tightened portions of the web are shifted into contact with the portions of greater diameter on the roller steps so that the lagging part is driven at a higher linear speed and finally takes again the desired normal position almost central of the rib turns as shown by the curved line 83.

In the forms embodying the invention disclosed thus far, the web has followed two spiral web paths located one next to the other in side-by-side relation. It will be apparent, however, that a web-processing device according to the invention could just as well provide only one spiral web path, such as is diagrammatically shown in FIG. 8. Starting from the outer spiral turn, the course of web 85 is identical to the course shown in FIG. 1 until the inner spiral turn is reached. Thereafter the web is twisted in two stages 86, 87, through an angle of 180°, as by guiding it through an appropriate shaped guide channel (not shown), so that it can leave the spiral along a path parallel to, but laterally spaced from, the plane of the spiral, as indicated by the arrow 88, rather than being carried off almost in the axial direction for starting a second spiral path as in the device according to FIG. 1.

Another embodiment of the invention is diagrammatically shown in FIG. 9. Here, ribs are so arranged as to provide two separate but intertwined paths for the web through which the web moves in opposite directions. The web is introduced into the device in a counterclockwise direction shown by the arrow...
and is driven towards the center of the spiral by four pair of roller sections 91, each separated by a 90° arc from the other adjacent pairs. At the center of the spiral the web course is reversed through 180° along an S-shaped path so that it moves thereafter in clockwise direction, away from the center of the spiral. The driving of the web in the latter direction occurs through four pairs of roller sections 91 and which are in staggered relation thereto around the spiral. Finally, the web leaves the device in the direction of arrow 93.

The design of a driving mechanism suitable for rotating both sets of rollers in opposite directions is not shown in FIG. 9, but will be obvious. According to one embodiment, the driving may be performed by driving roller pairs 91 by means of a first central bevel gear and outer pairs of gears, as shown in FIG. 1, and by driving roller pairs 92 in a similar way through a second central bevel gear located at the opposite side of the device. Alternatively, the second pair of rollers could be driven from the first pair through idler gears.

It is clear that other driving means, such as timing belts, chains, etc., can be utilized instead of those described in the foregoing embodiments.

An advantage of the device according to FIG. 9 is that the web need not be led obliquely or axially away, out of the center of the spiral. The device is therefore essentially well suited for use as a compact and flat monobath processing apparatus for developing and fixing short strips of photographic film. One potential use of the apparatus resides, for instance, in the known automatic photovending apparatus of the type which delivers a strip of water-impermeable paper carrying a number of pictures of the photographed person.

Although the choice of appropriate materials of construction for the essential elements of the present apparatus should pose no problem for the skilled worker, the following explanation may offer guidance in this task.

It is clear that the rollers must show a sufficient coefficient of friction with respect to the web edges to ensure reasonably reliable advance of the web. If the array on each side of the web includes at least four rollers as shown in FIGS. 1 and 2, it appears that almost any material which is not particularly known for a low coefficient of friction may be used. The rollers, for instance, may be made of hard material, such as stainless steel, copper, hard paper, or hard PVC, or they may be provided with a resilient covering such as butyl rubber. As to the partitions carrying the spiral rib turns, and the bearings for the driving rollers, they preferably are made by injection mouldings from synthetic material with a low coefficient of friction and high dimensional stability, e.g., hard PVC, ABS, etc.

In case several devices according to the invention are used in one processing apparatus, for instance in an arrangement as described in connection with FIG. 5, the friction coefficient of the driving rollers has to meet some more stringent requirements on account of the following reasons.

The friction of a web in respect of the ribs may differ from one station to the other as a consequence of different processing solutions used or of different temperatures of said solutions.

Additionally, the friction of a web in respect of said ribs may differ from that of another web because the coefficients of friction of both webs may differ, e.g. in case of two films manufactured at different periods or manufactured by different firms.

Also, the curling tendency may differ from one web to another so that the pressure of the web edges against the driving rollers may be different.

As a consequence thereof, the mentioned differences involve the great risk when the apparatus is fed with a plurality of shorter strips, in that some strips will considerably lag in respect of others so that at a given moment two or more strips may obstruct the path at some point between the spiral rib turns.

In such event more attention should be paid to the construction of the surface of the rollers engaging the web edges.

Particular good driving properties have been obtained with metal rollers, the peripheral surface of which has been roughened by sandblasting or by embossing.

In a device wherein the surface of the rollers was roughened to a relatively large extent, e.g. by embossing, it was noticed that the edges of certain types of film were slightly roughened by the repeated contact with the rollers. Although the mentioned damaging was not visible as such and in no aspect was detrimental to the image quality of the film upon projection, it became apparent when the film was wound up onto a roll. The sides of the roll of film showed a pale white glance and the diameter had slightly increased.

The mentioned phenomenon could be almost completely avoided in replacing a number or all of the mentioned rollers by rollers provided with a resilient covering of a material with sufficient resistance against wear.

Excellent results were obtained with rollers having a resilient covering of VULKOLLAN (trademark of Farbenfabriken Bayer A.G., Leverkusen, Germany), type 30, with a shore hardness of 94°. The mentioned material which is a polyurethane elastomer has the elasticity of rubber and a high resistance to wear particularly under wet conditions.

In case the device according to the invention is used in an installation for drying a film as it leaves a photographic web processing apparatus, the driving of the film may again put problems.

When the film has left the rinsing station of the processing apparatus and entered into the dryer, comprising one or more devices according to the invention located in a closed cabinet through which heated air is circulated, first liquid adhering superficially to the film by absorption is evaporated whereasupon moisture absorbed by the emulsion layer of the film is progressively evaporated. At a given stage in said drying process the tackiness of the emulsion layer of the film reaches a maximum and the friction of the film margins against the rib turns increases correspondingly.

Furthermore, in the transition from the wet to the dry condition an important unbalance in the forces acting on both sides of the film may arise, and the film will strongly tend to transversely curl. In spite of the stiffening of the film by its curling in the longitudinal direction in the spiral turns, the transverse curvature is not completely eliminated so that the effective film width is reduced and the contact pressure of the film edges with the rollers is decreased.

The proper driving of a film web in the described type of dryer was ensured when the following measures were taken, either separately or in combination depending on the rate of difficulty in the film transport.

The distance between the roller sets at either side of the film path was slightly reduced to increase the pressure on the film edges.

The mentioned reduction in distance increased from a minimum for the inner turns of the spiral to a maximum for the outer turns of the spiral. As a matter of fact the stiffening of the film by the longitudinal curving is lowest at the outer turns of the spiral and the effective width of the film will be minimum at that place.

The diameter of the spiral web turns is reduced in order to amplify the stiffening of the film in the transverse direction.

The spiral ribs are made from or coated with a material which has a particular low coefficient of friction. Satisfactory results have been obtained by using a Teflon (trade mark for polytetrafluoroethylene) plate, the spiral grooves being milled therein.

The walls with the spiral ribs are made from a porous material. A box-like structure is fitted to the side of the walls opposite to the side provided with the ribs. Pressurized air is admitted to said box-like structure so that air is forced through the wall material and escapes through the porous surface of the ribs. As the film tends to contact a rib portion, the air cushion created tends to repel the film.

The closed loop projection of a film, as mentioned in the introduction of the present description, wherein the device ac-
According to the invention is used as a cassette containing the windings of a length of film with the windings being separated from each other, is illustrated diagrammatically in FIG. 13. In this FIG., a conventional film projector 100 is coupled to a cassette 101 constructed according to the embodiment of the invention, shown for example in FIG. 9, wherein the film entrance and exit are located close to each other. The film is continuously advanced by the sprocket mechanism of the projector, and enters the cassette 101 and 102. The rollers which advance the film through said device are rotated through a pulley 103 which is coupled through a belt 104 with the pulley 105 which, via a friction clutch, is driven by the motor of the projector.

The nominal transport speed of the film through the device 101 is slightly higher than the speed imparted to the film by the projector, but the actual speed of the film through said device is determined by the projector drive mechanism. The film leaving the storage device 101 is conveyed over idler rollers 106 and 107 to the projector feed mechanism.

The use of the described close loop system is not limited to the projection of cine-film, but may be extended to any projection viewing or, in general, to any image, information or data reproducing or retrieval system.

In the embodiment of FIG. 5, the angle that a line extending tangentially to the spiral makes with respect to a radius of the spiral will, of course, vary from the outside to the inside windings of the spiral. Hence, in relocating the driving roller axis so as to apply thrust to the web in a direction more nearly coincident with the ideal path of the web in the track, no single new position for the roller axis will be correct for all turns of the spiral. Where the turns are closely spaced together and the innermost spiral turns do not extend to near the spiral center, the selection of an angle of deviation from the radial approximating the theoretical requirements, such as the average of the two extremes for example, will involve no serious problems. Alternatively, a plurality of separately driven short rollers could be substituted for each long common roller, so that the angle of each of the individual short rollers could be matched to the peculiar needs of the few windings for which it is operative. Seldom, however, will the need for precision advancing be of such importance as to justify the added complexity of the latter design.

Other modifications and alterations will occur to the skilled person in this art. The scope of the invention is not, therefore, to be restricted to the hereinafore described examples, but is intended to be commensurate with the scope of the appended claims.

We claim:

1. A web feeding device comprising opposed mutually facing spaced cooperating tracks arranged to define a path for receiving and guiding opposed margins of a web along such path, said path having a plurality of windings around a common center and means for advancing said web along such tracks, such means comprising at least one pair of rollers, each extending transversely of a plurality of said windings and having a continuous peripheral surface projecting into the tracks of said windings from one side of said web path, said roller being mounted for movement of said surface about an axis, extending substantially transversely of said windings, the rollers of said pair being arranged in generally opposed aligned relation with the distance separating the nearest points on their peripheries being slightly less than the width of the web being fed, whereby the web in said tracks is frictionally engaged at its extreme side edges by the peripheral surfaces of said rollers; and driving means for moving said rollers to impart movement to said peripheral surfaces corresponding to the direction of travel of said web in said tracks to thereby advance said web, each of said rollers having a periphery formed with successive frustoconical steps to give a sawtooth profile, the axial length of each step corresponding to the transverse spacing between the tracks defining said windings with one step for each winding, the larger diameter of each step being nearer the common center of the windings, whereby the feeding of the web is automatically adjusted to compensate for tension variations therein.

2. A web-advancing device comprising two spaced parallel walls provided on their mutually facing sides with spiral ribs defining at least one spiral web path having a substantial number of convolutions around the geometric center thereof, an array of driving rollers angularly spaced around the said spiral path on each side thereof, such rollers having their peripheries intruding through said walls between the said rib convolutions, the clearance between the two roller arrays at the nearest points on the peripheries of the rollers thereof being slightly less than the width of the web whereby the extreme opposed side edges of the web are frictionally held between the surfaces of the rollers in said arrays and the web is consequently advanced upon rotation of said rollers, the axis of rotation of each roller intersecting at least one of said convolutions of said spiral path at an angle extending generally normal to a line extending tangentially of the spiral at the point of intersection between said roller axis and said convolution whereby said axis of rotation of each roller is offset from the geometric center of said spiral web path.

3. The device of claim 2 wherein the rotational axis of the roller intersects all of the convolutions of said spiral at said angle generally normal to the lines extending tangentially of the corresponding convolution at the point of intersection of the axis therewith.