June 7, 1960 W. ENKELMANN 2,939,700

FRICTION DRIVE

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Fig. 1

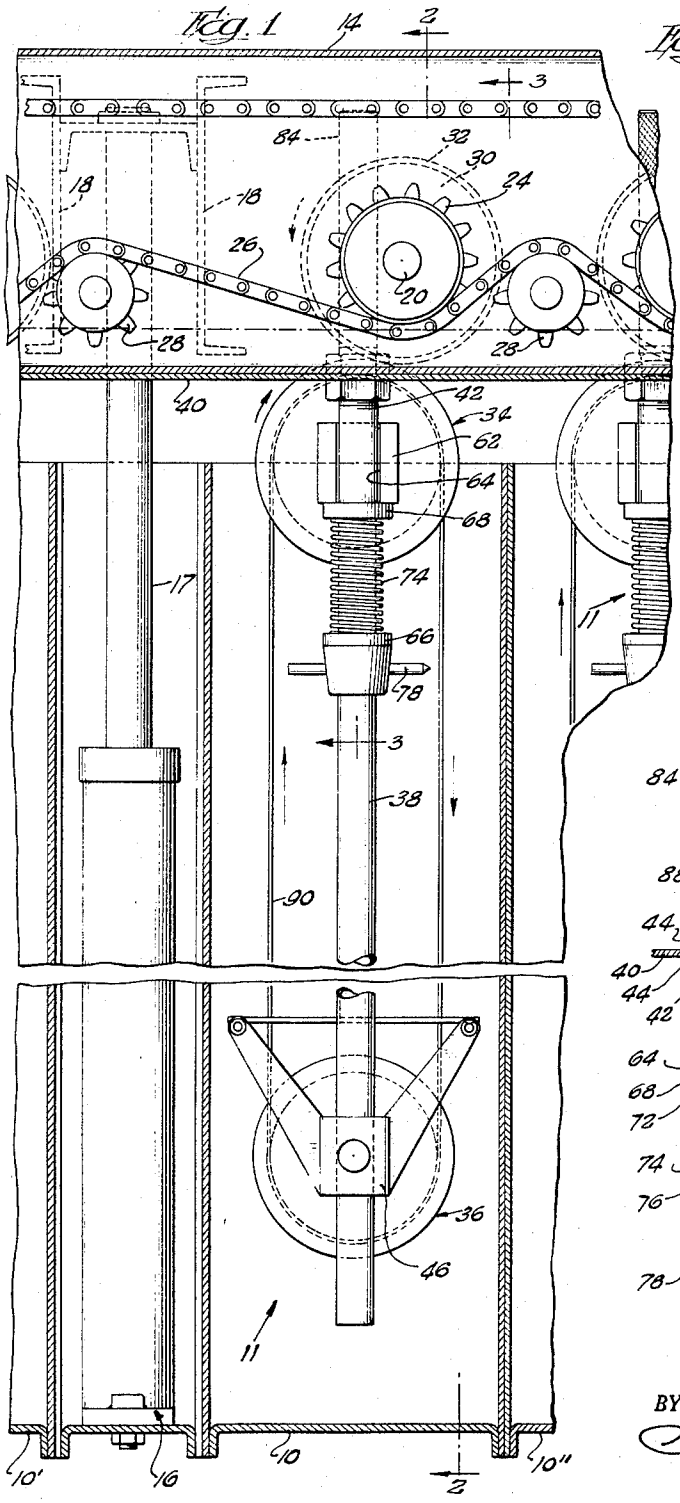


Fig. 4

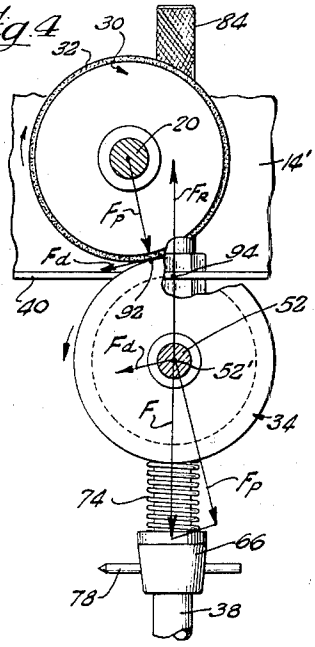
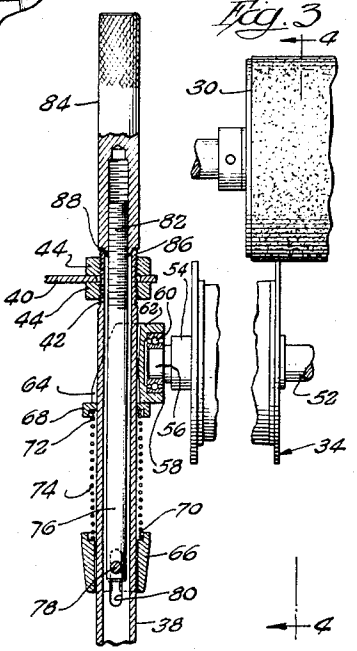


Fig. 3



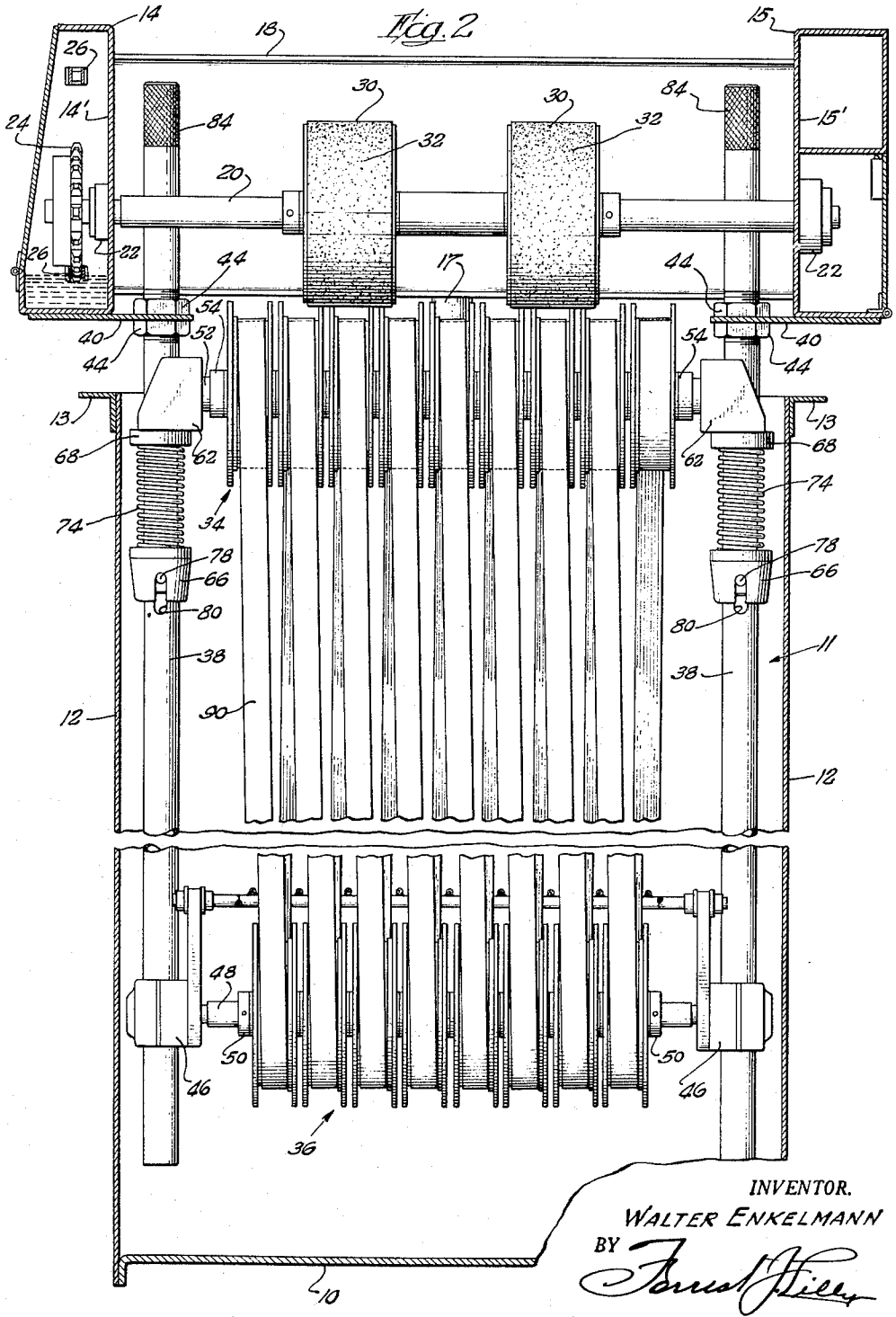
INVENTOR.
WALTER ENKELMANN
BY
ATTORNEY.

June 7, 1960 W. ENKELMANN 2,939,700

FRICTION DRIVE

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Fig. 2



INVENTOR.
WALTER ENKELMANN
BY Ernest Hilly
ATTORNEY.

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FRICTION DRIVE

Walter Enkelmann, Los Angeles, Calif., assignor to Unicorn Engineering Corporation, Los Angeles, Calif., a corporation of California

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This invention relates to apparatus for supporting and feeding strip material such as motion picture film, and more particularly to an improved strip transport which embodies a novel friction drive.

The present transport is somewhat similar to the film transport disclosed in Patent No. 2,146,170, entitled Film Supporting and Driving Means, issued February 7, 1939, wherein sets of film feed rollers, driven from friction rollers, and idler rollers, around which roller film to be processed is looped, are carried on dependent, pendulum-like supports to permit suspension thereof in various film processing solutions.

In this patented apparatus, and in other equipment of this general nature, the friction drive rollers are rotatably supported on suitable framework at the open upper ends of the film processing tanks, the film feed and idler rollers associated with a given drive roller being suspended below the latter by means of tie rods carrying cross bars journaling therein the roller shafts. The tie rods supporting the idler rollers are rigidly fixed at their upper ends to the supporting framework while the tie rods supporting the feed rollers are resiliently suspended on the framework so as to accommodate downward movement of the feed rollers out of engagement with the associated drive roller during periods of excessive tension in the film. The axes of rotation of the associated drive, feed, and idler rollers in a given one of said set of rollers lie in a common vertical plane with the result that the point of tangency, or driving contact, of the drive rollers with the feed rollers is also in this plane. The peripheral driving thrust exerted by the drive roller on the feed roller, therefore, is directed along a line normal to such vertical plane and produces a moment about the points of attachment of the tie rods to the supporting frame.

The moment produced by this normally directed driving thrust, during operation of the equipment, causes the tie rods supporting the feed and idler rollers to swing in the direction of the thrust until the restoring moment of the tie rod support becomes sufficient to overcome the driving thrust whereupon the support will swing back to or slightly beyond its normal position. The driving thrust then again becomes effective to swing the support. It is found, therefore, that during operation of the patented apparatus the tie rod supports for the feed and idler rollers oscillate back and forth with resultant undesirable variations in film tension and non-uniform movement of the film.

A primary object of this invention is, accordingly, provision of a strip transport embodying friction drive apparatus of the class described which is free of the above-noted deficiencies.

Another object of the invention is the provision of a strip transport embodying friction drive apparatus of the class described wherein the driving thrust between the driving and driven rollers does not give rise to any undesired oscillatory movement of the driven roller support.

Another object of the invention is the provision of a strip transport embodying friction drive apparatus of the

class described wherein the support for the driven rollers is subject to undesired movement in a given direction and wherein the driven rollers are contacted by the drive rollers at such points that the resultant of the driving thrust and the roller pressure is directed along a line of action normal to said direction so that undesired movement of the support in said direction by the driving thrust is substantially eliminated.

A further object of the invention is the provision of a transport of the class described which is especially suited to and adapted for the feeding of a film strip through a series of film developing and washing solutions and drying cabinets.

The above and other objects are attained in the present transport by horizontally offsetting the axis of the driving or friction rollers from the vertical plane of the dependent support which resiliently mounts the driven roller shaft. The points of driving contact of the driving rollers with the driven rollers will, therefore, also be offset from the vertical plane of the dependent driven roller support, and the driving thrusts on the driven rollers will have downwardly inclined lines of action passing through said points and directed to one side of the support. The pressure between the driving and driven rollers gives rise to forces on the latter rollers having downwardly inclined lines of action directed to the other side of the support.

The amount of offset or displacement of the driving roller axis is made such that during normal operation of the apparatus, the resultant of the above forces on the driven rollers will be directed vertically downwardly substantially in the vertical plane of the driven roller support so that the aforedescribed tendency of the latter to oscillate under the action of the driving thrust is effectively eliminated.

While the foregoing discussion and the ensuing description relate to a film developing machine, it will be appreciated that numerous other types of apparatus may incorporate friction drive arrangements which possess the above noted deficiencies and in which, accordingly, the present invention may be employed to advantage.

The invention may be best understood by a reading of the following detailed description thereof in conjunction with the accompanying drawings wherein:

Fig. 1 is a fragmentary elevation in section of a film processing machine incorporating a friction drive embodying the features of this invention;

Fig. 2 is a section taken along line 2—2 of Fig. 1;

Fig. 3 is a partial section taken substantially along line 3—3 of Fig. 1, parts being broken away for the sake of clarity; and

Fig. 4 is a section taken along line 4—4 of Fig. 3 illustrating the off-center driving arrangement embodied in this invention and the force components with which this invention is concerned.

Referring now to these drawings, there is illustrated a film processing machine including, in the well known manner, a series of solution tanks arranged in side by side relation and through which a negative film strip is adapted to be successively passed for developing, washing and fixing of the film. Only three of these tanks, indicated at 10, 10′ and 10″ have been illustrated. Intermediate ones 10 and 10′ of the tanks are spaced a distance, as shown, for reasons to be presently described.

Associated with each tank is a film feed and supporting means, generally indicated at 11 to be shortly more fully described. The several tanks and the associated film feed and supporting means are identical and, therefore, only the tank 10 and its corresponding means 11 will be described.

Tank 10 includes side walls 12 along the upper edges of which extend connecting frame members 13. Above

the tank is a horizontally extending frame comprising a pair of hollow drive frames 14 and 15 which, as will be seen, support the several means 11. These frames extend the length of the several tanks, at opposite sides thereof, and are supported in normal operative position a distance above the upper ends of the tanks by a hydraulic lift device 16 disposed in the aforementioned space between the intermediate tanks 10 and 10'. This lift device includes a stationary cylinder and movable piston having a piston rod 17 fixed at its upper end to cross frame pieces 18 extending between and rigidly joined to the drive frame 14 and 15. The arrangement is such that the frames 14 and 15 may be raised from their normal operative position, shown, to elevate the several means 11, and the film carried thereon, out of the tanks.

The present invention is primarily concerned with the film feed and supporting means 11 which will now be described.

Extending between the vertical inner side walls 14' and 15' of the drive frames 14 and 15 is a horizontal shaft 20 having its right hand end, as viewed in Fig. 2, journaled in a bearing 22 in the right hand drive frame 15 and its left hand end journaled in and extending a distance beyond a second bearing 22 in the left hand drive frame 14. This extending left hand end of the shaft 20 rigidly mounts a sprocket 24 for driving engagement with a sprocket chain 26 (Fig. 1) which is similarly engaged with drive sprockets in the other of the means 11, for simultaneous driving of the shafts 20 in the several means 11. Idler sprockets 28 may be alternated with the drive sprockets, as shown, to obtain increased driving engagement of the chain and driving sprockets. This chain 26 is adapted to be driven from a motor, not shown, and the lower run of the chain may move in an oil bath contained in the left hand drive frame 14, as shown. To permit access to the drive frame interiors the frames may be provided with hinged panels or doors, also as shown.

Fixed on shaft 20, for rotation with the shaft, are a pair of spaced friction drive rollers 30 provided about their peripheries with suitable friction material 32. The improvements of the instant invention are particularly concerned with the means for suspending film feed rollers, generally indicated at 34, and idler rollers, generally indicated at 36 included in each means 11, in operative relationship below the drive rollers 30.

The improved roller suspension means of this invention comprises a pair of hanger rod supports including hanger rods 38 affixed at their upper ends, in a manner to be presently described, to horizontal, inwardly extending plates 40 secured to the undersides of the drive frames 14 and 15. As seen in Fig. 2, each of the hanger rods depends from its respective supporting plate 40 in a plane spaced slightly inwardly of the adjacent tank side wall, and, as shown in Fig. 1, the pair of tie rods are disposed in a common, transverse vertical plane horizontally offset from the friction roller shaft 20 in a direction opposite to the direction of movement of the lower peripheral portion of the friction rollers 30 for reasons to be presently described.

As most clearly illustrated in Fig. 3, each hanger rod 38 is tubular in cross section and has an upper threaded end portion 42 which extends through a suitable opening in the respective one of the supporting plates 40. A pair of nuts 44 threaded on the rods at opposite sides of the plates serve to attach the rods to the plates. Rigidly fixed on the lower extremities of the rods 38 are bearing blocks 46 which support opposite ends of a lower roller shaft 48 mounting the idler rollers 36. The idler rollers are rotatably mounted on the shaft 48 and may be retained in axial position thereon by means of collars 50.

The film feed rollers 34 are mounted on an upper roller shaft 52 and retained in axial position thereon by

means of collars 54. Opposite ends of the feed roller shaft 52 are reduced, as shown at 56 and received in the inner races of a pair of ball bearing assemblies 58, the outer races of which are frictionally held in sockets 60 formed in a pair of slides 62. Each of the slides 62 are, on the side thereof opposite the sockets 60, grooved to form a generally U-shaped guide way 64 which slidably receives the respective hanger rod 38 so that the slides, and therefore the feed roller shaft 52 and the feed rollers 34, are mounted for vertical movement on the hanger rods.

Slidably mounted on the hanger rods below the slides 62 are collars 66 and washers 68, the latter abutting the under sides of the slides 62. The opposed end faces of the collars and washers are formed with annular seats 70 and 72 for seating opposite ends of coil compression springs 74. Slidably received in the bores of the tubular hanger rods are adjusting shafts 76 the lower ends of which mount transverse pins 78 whose opposite ends extend through slots 80 in the rods and into the respective collars 66 so that the latter are fixed to their shafts 76 for axial movement therewith.

The upper end of each shaft 76 is externally threaded at 82 and received in a threaded axial bore in an adjusting sleeve 84. The lower end of each adjusting sleeve is peripherally grooved to form an annular seat 86 and a reduced annular extension 88, the latter being rotatably received within the upper end of the respective hanger rod so that the upper end surface of the latter slidably bears on the annular seat 86. The arrangement is such that the axial positions of the adjusting shafts 76 in the hanger rods, and hence the axial positions of the collars 66 on the rods, may be adjusted by rotation of the adjusting sleeves 84 to adjust the normal vertical position of the film feed rollers 34. The film feed rollers are resiliently supported in such normal position by the coil compression springs 74.

From the description thus far, it will be seen that the idler roller shaft 48 is fixed against vertical movement on the lower ends of the hanger rods 38 while the feed roller shaft 52 and the feed rollers 34 thereon are resiliently supported on the rods.

A web 90, which in the illustrative embodiment of the invention is a negative film strip but which may take varying forms depending on the nature of the apparatus incorporating the present friction drive arrangement, is delivered at a constant rate from a supply reel, not shown and then passed in succession around the feed and idler rollers of the several means 11, in the manner illustrated herein and described in greater detail in the aforementioned patent. Film is thus lead from the last, or right hand, feed roller in tank 10' to the first, or left hand, feed roller in tank 10 and the run of film leading off the last feed roller in tank 10 passing to the first feed rollers in tank 10'' and thence to the rollers in successive solution tanks and drying cabinets, not shown.

As shown in Fig. 2, certain of the feed rollers 34 are alined with the drive rollers 30 and in use of the apparatus, the adjusting sleeves 84 are so set that these feed rollers will be resiliently urged, through the medium of the springs 74, into engagement with the drive rollers with the desired force so that the feed rollers may be frictionally driven by the drive rollers to move the film in the direction indicated. As described in detail in said prior patent, successive drive rollers 30 in succeeding ones of the film supporting and feeding means 11 may be of slightly increasing diameter so as to maintain a desired minimum tension in the film, the resilient supporting of the feed rollers providing the means for establishing a predetermined maximum film tension in the apparatus. However, it will be apparent that the features of this invention may be equally well applied in apparatus not utilizing such a differential driving arrangement.

Referring now to Fig. 4, there are illustrated the various force components with which this invention is con-

cerned. It will be seen from that figure, that the peripheries of the friction drive rollers **30** and the aligned feed rollers **34**, at their zone of peripheral contact, move in a transverse direction of the vertical plane of the hanger rods. Further, the friction drive rollers are offset in that direction from the vertical plane so that a plane passing through the axes of the upper roller shaft **52** and friction rollers is inclined at an acute angle in said transverse direction from the vertical plane. The points of tangency, or driving contact, **92**, of the feed rollers with the driving rollers will be disposed intermediate the latter vertical plane and the vertical plane passing through the axis of the friction drive rollers. The tangential driving force or driving thrust, F_d, exerted on the feed rollers at these points will be directed along a downwardly inclined line of action, inclined to plane of the rods **38**, rather than along a line normal to the last-mentioned plane as is the case where, as in the patented apparatus, the drive and feed roller axes are in the same vertical plane.

The feed rollers **34** have applied thereto a resultant force F_r acting upwardly along the axes of the hanger rods which will be equal to the difference between the upward force exerted by the suspension springs **74** and the downward forces represented by the mass of the feed rollers **34** and feed roller shaft **52** and the tensions in the runs of film between the feed and idler rollers. Since said mass remains constant and is directed along the axes of the hanger rods, further discussion thereof will be omitted, the force F_r being hereinafter considered as the differential between the upward force of the springs **74** and the downwardly acting tensions in the film.

The upward force F_r on the feed rollers will have a radial component directed along a line of action extending through the centers of the drive and feed rollers tending to urge the feed rollers into frictional engagement with the drive rollers. The resultant equal opposing or reaction force acting on the feed rollers is designated as F_p. The feed rollers, therefore, have applied thereto the tangential driving force F_d and the radial force F_p, that is the pressure of the drive rollers on the feed rollers.

Considering now the hanger rods **38**, which may be regarded as being, in a sense, pivoted at a point **94** corresponding to the point of attachment of the upper ends of the rods to the plates **40** since any oscillation of the rods will occur substantially about this point, it will be seen that the forces F_d and F_p will be applied thereto through the point **52'** which is the axis of the feed roller shaft.

The present invention proposes such a horizontal displacement of the feed and drive rollers that for the normal operating values of the forces F_d and F_p, the resultant F of these latter two forces will be directed downwardly substantially in the vertical plane of the hanger rods, as shown. When this situation exists, of course, the hanger rods **38** will not be subject to any unbalanced moments tending to oscillate them about the point **94**.

It will be apparent that variation in the tension of the film will result in a variation in the roller pressure F_p and cause the resultant force F to shift in one direction or the other from its normal disposition in the plane of the hanger rods. Such shifting of the resultant force F would, of course, give rise to an unbalance moment on the rods and produce some oscillation thereof. Because of the relatively greater magnitude of the other forces involved, however, the variation in film tension will generally not be sufficient to cause appreciable shifting of the resultant F, especially where means of the character described in said prior patent are employed for maintaining the film or the other from its normal disposition in the plane of the hanger rods. Such shifting of the resultant force F would, of course, give rise to an unbalance moment on the rods and produce some oscillation thereof. Because of the relatively greater magnitude of the other forces involved, however, the variation in film tension will generally not be sufficient to cause appreciable shifting of the resultant F, especially where means of the character described in said prior patent are employed for maintaining the film tension constant within given limits.

The preferred form of the invention disclosed herein is only illustrative in nature, it being apparent that numerous modifications in design and arrangement of parts of the invention was made with the scope of the following claims.

I claim:

1. A transport for strip material such as motion picture film, comprising a horizontally extending frame, a pair of horizontally spaced, vertical hanger rod supports fixed at their upper ends to and depending below said frame, a pair of upper and lower, horizontal roller shafts supported at opposite ends on said supports, at least one strip guiding and supporting roller on each shaft, a friction drive roller in forced peripheral driving contact with the upper strip roller journalled on said frame for rotation about an axis substantially parallel to said shafts, means for driving said friction roller in one direction of rotation whereby to drive said upper strip roller, the peripheries of said friction roller and upper strip roller at their zone of peripheral contact moving in a transverse direction of a vertical plane passing through the upper shaft when said friction roller is driven in said one direction, and said friction roller being offset in said transverse direction from said vertical plane so that a plane passing through the axes of the upper shaft and friction roller is inclined at an acute angle in said transverse direction from said vertical plane whereby when the tangential driving force and radial force exerted on said upper strip roller by said friction roller have predetermined values, the resultant of said forces acts longitudinally of said supports and oscillation of the latter by said forces is avoided.

2. The subject matter of claim 1 wherein each of said supports comprises a single hanger rod, said roller shafts being located in the vertical plane of said hanger rods.

3. A transport for strip material such as motion picture film comprising a horizontally extending frame, a pair of horizontally spaced, vertical hanger rods fixed at their upper ends to and depending below said frame, a lower horizontal roller shaft fixed to the lower ends of said rods, an upper horizontal roller shaft, slides secured to opposite ends of said upper shaft and slideably mounted on said rods, said shafts being located in the vertical plane of said rods, at least one strip guiding and supporting roller on each shaft, a friction drive roller in peripheral contact with the upper roller journalled on said frame for rotation about an axis parallel to said shafts, abutment means on said rods below said slides, springs acting between said abutment means and slides for biasing the latter upwardly along said rods whereby to urge said upper strip roller against said friction roller, means for driving said friction roller in one direction of rotation whereby to drive said upper strip roller, the peripheries of said friction roller and upper strip roller at their zone of peripheral contact moving in a transverse direction of said vertical plane when said friction roller is driven in said one direction, and said friction roller being offset in said transverse direction from said vertical plane so that a plane passing through the axes of the upper shaft and friction roller is inclined at an acute angle in said transverse direction from said vertical plane whereby when the tangential driving force and radial force exerted on said upper strip roller by said friction roller have predetermined values, the resultant of said forces acts longitudinally of said rods and oscillation of the latter by said forces is avoided.

4. The subject matter of claim 3 including means for adjusting said abutment means along the rods to vary the

force of contact of said upper strip roller with said friction roller.

5. A transport for strip material such as motion picture film comprising a horizontally extending frame, a pair of vertical, hollow hanger rods fixed at their upper ends to and depending below said frame, a lower horizontal roller shaft supported at opposite ends on the lower ends of said rods, a plurality of lower strip supporting and guiding rollers on said shaft, an upper horizontal roller shaft, slide means slidably mounting opposite ends of said upper roller shaft on said rods adjacent the upper ends of the latter, a plurality of upper strip supporting and guiding rollers on said upper roller shaft, said shafts being located in the vertical plane of said rods, a collar slidable on each rod below said slide means, a coil compression spring encircling each rod between and abutting at opposite ends the adjacent collar and slide means, a friction driving roller journalled on said frame and peripherally engaging at least one of said upper strip rollers for

frictionally driving the same, an adjusting shaft extending into the upper end of each rod, means on each adjusting shaft extending through an elongate opening in the adjacent rod and connected with the adjacent collar whereby axial movement of each adjusting shaft moves the adjacent collar longitudinally of its respective rod, and means at the upper ends of said rods for axially adjusting said adjusting shafts to urge said one upper strip roller into frictional contact with said driving roller, said strip rollers being adapted to have a strip trained therearound.

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