United States Patent

[11] **3,620,481**

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[21] Appl. No. **730,805**
[22] Filed **May 21, 1968**
[45] Patented **Nov. 16, 1971**
[32] Priority **May 23, 1967**
[33] **Great Britain**
[31] **23,956/67**

[54] **WEB TRANSPORT SYSTEMS**
2 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **242/203,** 226/108, 226/188, 242/206, 355/99
[51] **Int. Cl.** **B11b15/32,** G03b 1/04
[50] **Field of Search** 355/99, 103, 104, 108, 109, 110, 111; 242/203, 206; 226/108, 188

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Assistant Examiner—M. L. Gellner
Attorney—Darbo, Robertson & Vandenburgh

ABSTRACT: A web of photographic film or the like is stretched between two spools. A constant torque is applied to the spools in senses such that the web between the spools is placed in tension. Between the spools the web is wrapped about and engages part of the periphery of a drum. The drum is driven by a step-by-step motor through a worm gear transmission.

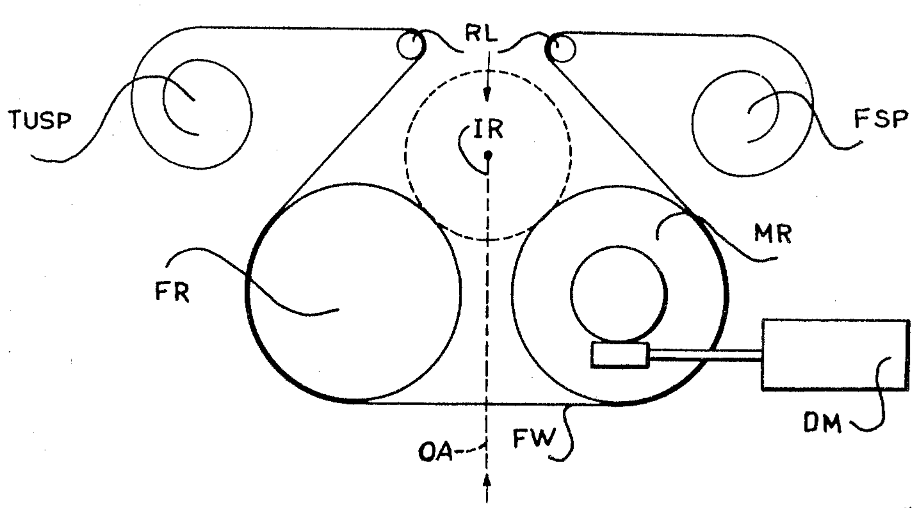

FIG.1

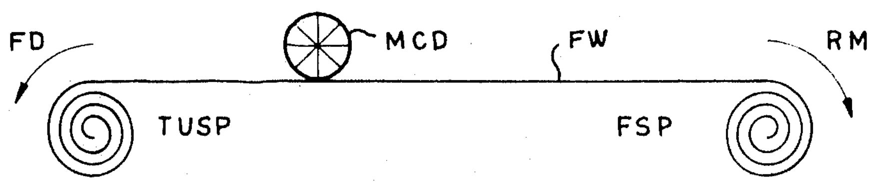

FIG.2

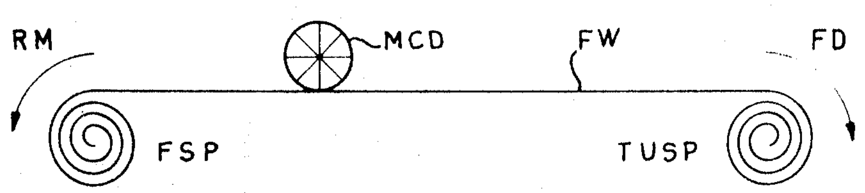

FIG.3

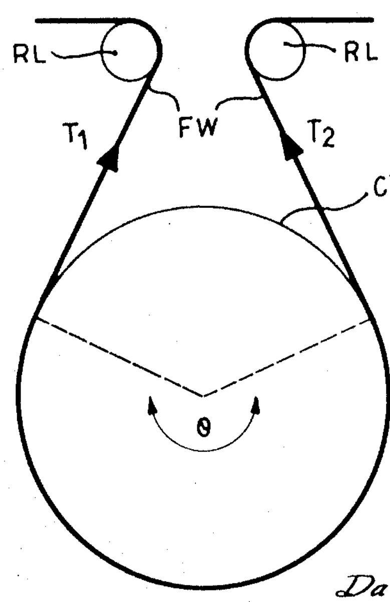

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FIG. 4

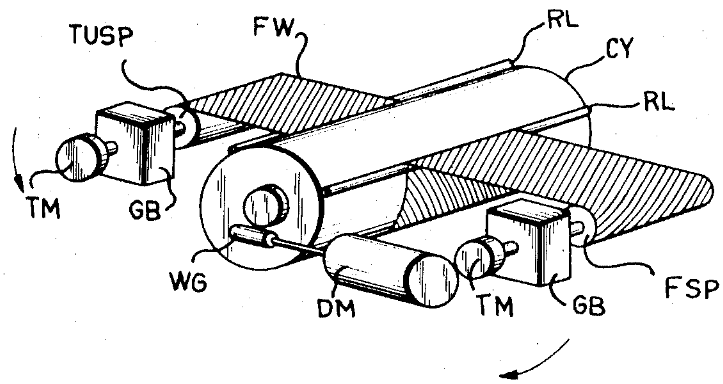


FIG. 5

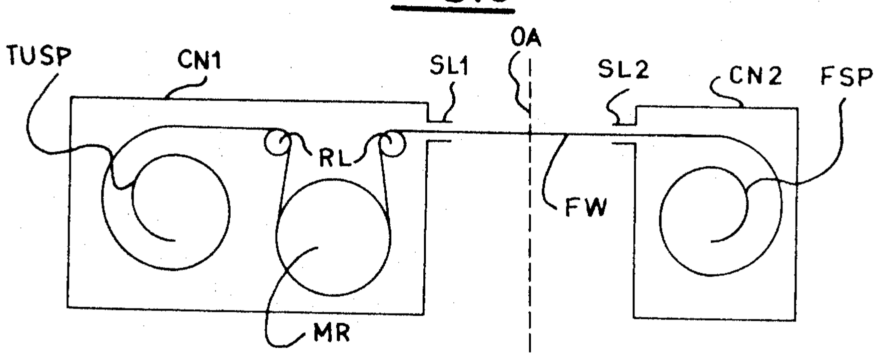
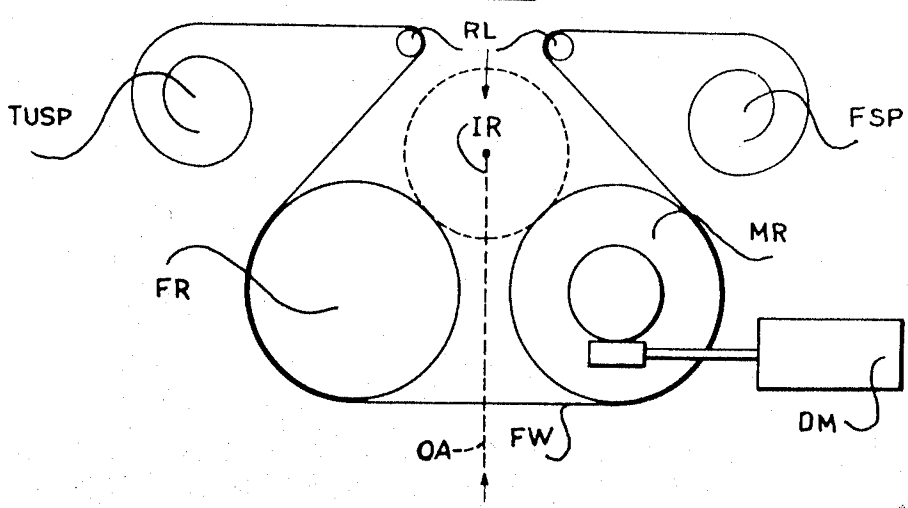


FIG. 6



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WEB TRANSPORT SYSTEMS

This invention relates to transport devices for the controlled longitudinal movement of material in strip, ribbon, tape, or web form so as to render a particular region thereof accessible. The term "web" is used in various industries to mean long continuous sheets of material of various widths; for instance, of paper and photographic film, and the term "web" will be used herein for such long continuous sheets of any desired material and width. An example of such a transport device is a film transport system, designed to move photographic film or paper between spools in order to bring a desired region into a position at which an image may be exposed upon it. In the description of the invention which follows, the example of photographic film moved for the purpose of exposure will be used, without prejudice to the use of the invention for other materials and processes.

A particular aspect of the film transport problem in which this invention offers improvements over methods used heretofore is the need to position a predetermined region of the film stationary at a particular location in space to high positional accuracy, and to perform a series of such film movements, with or without reversals of direction, without loss of positional accuracy.

The invention will be described with reference to the accompanying drawings in which:

FIGS. 1 and 2 indicate schematically existing web transport systems,

FIG. 3 illustrates certain theoretical considerations involved,

FIG. 4 shows schematically a perspective view of an embodiment of the invention, while

FIGS. 5 and 6 show variants of FIG. 4.

Before describing the embodiment of the invention it is instructive to identify the physical factors which enter into the problem.

FIGS. 1 and 2 show the situation in moving a film web FW between spools FSP, TUSP in the forward direction FD and in the reverse direction respectively under the action of drive forces which are opposed by a resistance-to-motion RM which prevents uncontrolled feed of the stock, and which is normally provided by a passive device such as a friction clutch.

FIGS. 1 and 2 also indicate means MCD for metering the passage of film, and for generating a control function to halt the motion at any desired position of the film.

These features are commonplace in known transport systems of this general character, and exhibit the following fundamental disadvantages. It will be appreciated readily that mechanical means for metering and braking the film depend upon maintaining reliable mechanical contact with the film, and therefore, on the maintenance of longitudinal tension in the web within a prescribed range of values. The lower limit of these values is set by the requirements of the metering method, and the upper limit by the strength and other properties of the web.

In the case of sprocket or pinwheel metering, the lower tension limit is small. In the case of frictional drive between the web and the metering member, the lower limit is comparatively large. It is a salient disadvantage of previous transport systems as outlined above, that the act of stopping or reversing the film movement causes a temporary relaxation of tension and consequent loss of positional information. Momentary slip or loss of contact between web and meter roller, or differential relaxation of feed and takeup spools due to cessation or exchange of these functions, can contribute to this loss of accuracy.

It is a further drawback of known systems that under stationary conditions additional means have to be provided to maintain the web in position in the direction normal to its surface, an important consideration if an optical image has to be focused thereon.

These disadvantages are overcome, according to the present invention, and as shown by way of example in FIG. 4, by attaching the feed and the takeup spools FSP, TUSP to opposed sources of torque TM, conveniently electric motors capable of remaining energized at stall, which act in opposed directions so as to tension the web throughout the period during which positional accurate has to be maintained, the function of driving the web being performed by a separate unit DM acting on a region of the web between the feed and takeup spools.

A given design of torque motor may require a gear box GB between torque motor and spool, depending upon the nature of the web FW to be transported. For example, the gear box may be an antibacklash worm and wheel system. An adequate degree of matching of the forces applied to the web FW via the spools, the rolls of web on which are obviously of variable radius, is necessary, but it is found in practice that this is easy to achieve using separate motors having the same specification: alternatively, one motor acting through a differential system may be used.

This system provides a virtually constant web tension which can be designed to have one of a wide range of values, and at the same time allows the force needed to keep the web stationary, bearing in mind the varying diameters of the web rolls on the spools; or to move it in either direction; to be very small, an important advantage, the significance of which will be explained later in relation to metering.

A third advantage is that there is no loss of tension on reversal or during a stop and restart sequence. Fourthly, full symmetry may be maintained: that is, substantially no difference in tension between the forward and reverse directions. Fifthly, no additional means are required to maintain the web in focus at the site of photographic exposure, since the web maintains its position normal to its own plane.

It is now necessary to consider the control of the film advance. It is common to advance film and to measure the distance which has been moved: although this invention may offer improvements over the state of the art in this respect, this problem is trivial compared with that of presetting the distance which the film has to move, and then performing that movement to high accuracy. An obvious approach to that problem is to design a brake which responds in a very short time after receiving the signal denoting the passage of the appropriate length of film. Some success has been achieved in this way, although it involves the conflicting requirements that the components shall be of low inertia, but also strong enough to withstand the shock loadings involved. Additionally, the consequent sudden decelerations tend to produce slip between the web, and the drive and metering members. Alternatively, deceleration can be initiated at some point before the final distance has been moved, but with the disadvantages of added complexity and less efficient use of time.

It is proposed to combine the function of providing drive and braking forces with that of distance measurement, thus avoiding the need for braking systems which should act in virtually zero time.

This combination of functions is provided by the electrical "stepper motor." When energized, but in the absence of drive pulses, such a motor exhibits a holding torque which, in practice, is large compared to the force needed to stabilize the web under the action of the opposed torque motors. When a pulse is applied, the motor develops drive torque and moves its rotor by one step, typically one one-hundredth or one two-hundredth or 1 revolution. A predetermined number of pulses can be chosen and applied conveniently by well-known digital methods.

It is necessary to relate the drive torque, holding torque, number of pulses per revolution, and number of pulses per second, of the stepper motor, which are themselves interrelated quantities, to the desired characteristics of the film transport system as a whole. In this respect, further advantages of the opposed drive system become apparent.

FIG. 3 shows a web FW wrapped about a cylinder CY over a reflex angle Θ and under tensions T1 and T2 in opposite directions, the difference T_1-T_2 equaling the reaction of the cylinder, due to friction. At the limit before slip occurs, T_1/T

$_2=e^{\mu\theta}$, where e is the base of Naperian logarithms and μ is the coefficient of friction between the web and the roller materials. The tension system adopted permits T_1 and T_2 to have high values, but the value of T_1/T_2 needed to start and stop motion, need only be small. Keeping θ large, by means of rollers RL, for efficient geometry, advantage can be taken of this situation by selecting a stepping motor of low torque output, or by achieving high acceleration rates of web and mechanism, or by using a material for the roller which gives a low coefficient of friction. This last is of value because materials which are rigid, stable, and easily machined to high accuracy (plastics and metal) or which are transparent (plastics and glass) have low coefficients, whereas the high coefficient materials such as rubber, are resilient and more difficult to produce to tight dimensional tolerances.

In the embodiment of the invention shown in FIG. 4, the principal members will readily be recognized from the above description. Antibacklash worm reduction gear WG is provided to render the increments of stepper motor rotation, and of film advance, compatible. With appropriate care in the design and construction of this gear, films between 2 inches and 11 inches in width, and of lengths up to 60 feet have been moved in increments which are multiples of 0.007 inches, or 0.18 mm. The loss of accuracy, after a sequence of some hundreds of separate movements, including reversals of directions, is of the order of 0.001 inches, or 0.02 mm.

This apparatus can be used for page printing on photographic film to produce a printing transparency. The film is precessed by interline (i.e., line-by-line) steps, and can be precessed down one column, and in the reverse direction up a second column on the same page.

The number of steps to be taken by the stepper motor is determined by the number of electrical pulses applied thereto, which can be controlled, for example, by the well-known fixed-capacity count-out binary register, which is initially set by suitable control means to a position characteristic of the complement of the number of pulses required with respect to its capacity, and then counted out in synchronism with the transmission of pulses to the stepper motor.

The photographic beam can be directed upwards from below on to the film on the vertical axial plane of cylinder CY, when the properties of the associated optical system make the use of the large cylinder CY at the exposure station advantageous.

However, the derived order of location accuracy applies also to that part of the web out of contact with the large drum, hence demonstrating the feasibility of systems such as are shown in FIGS. 5 and 6 which offer plane exposing areas, and which permit the properties of the optical system, in so far as they determine the permissible film curvature at the exposing station, to be separated entirely from the electromechanical design of the transport system. Further advantages may result from the use of the systems shown in FIGS. 5 and 6 in preference to that of FIG. 4, should the weight and portability of the system be of importance.

In FIG. 5, the large cylinder CY, FIG. 4, is replaced by a metering roller MR spaced from the idler rollers RL. The metering roller is driven from the stepping motor, not shown. The feed spool FSP is in one container CN2, and the takeup spool TUSP together with the roller assembly MR, RL are in a second container CN1. The web FW runs between the containers through opposed slots SL1, SL2, which may contain web guides if desired. In any case, the tension on the web, and the length of web between FSP and the adjacent idler roller RL are such that the web between FSP and RL will be uniplanar and at right angles to the axis OA of the photographic light beam applied thereto.

For clarity, FIG. 6 does not show any containers, and the single metering roller MR of FIG. 5 has been replaced by identical spaced rollers MR, FR geared together by an intermediate friction roller IR spring biased vertically downward against the rollers MR, FR. Metering roller MR is driven by stepper motor DM, and roller FR is driven at the same speed and direction via nonslip friction roller IR. In this case, the run of web between rollers MR, FR is used for photographic exposure purposes on optical axis OA.

The electrical power for the torque generators may be replaced by hydraulic, or pneumatic, or spring, or gravity, power; and a single torque generator can provide the opposed torques for the spools via mechanical or other differential transmission systems. Such generators may operate, of necessity or by choice, by limited torque transfer, instead of "at still," via any desired form of transmission; e.g., friction; electromagnetic electrostatic; electroviscous; or eddy current; transmission. An example of such friction transmission would be through a slipping clutch, one plate or the like of which rotates with a slowly rotating generator, while the other, which is connected to a spool, is stationary.

When required, because of the use of ancillary equipment, the surface of the, or each, drive cylinder, may have a high coefficient of friction.

What I claim is:

1. Equipment for moving a web between a pair of spaced spools on which are respectively wound opposite ends of the web and for stopping the web with a particular portion thereof at a given location with a high degree of positional accuracy;
 - torque-applying means operatively connected to said spools for applying torque in opposite sense to the spools respectively for maintaining the web between the spools in static tension; and
 - drive means acting on the web between the spools for moving the web in one or other direction comprising two like, spaced, drive cylinders with a first run of the web from one spool to one drive cylinder and a second run of the web from the other spool to the other drive cylinder, an idler cylinder in pressure contact with both drive cylinders, power-drive means connected to one of said drive cylinders, and means for holding the web around both said drive cylinderns of the first and second runs adjacent said drive cylinders converge.

2. Equipment as claimed in claim 1 wherein said drive means act on the web in step-by-step manner to move the web by a predetermined number of steps of fixed length automatically in response to a command.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,620,481 Dated November 16, 1971

Inventor(s) David John Stewart

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 4 "accurate" should be - accuracy -.

Column 2, line 63 "or" should be - of -.

Column 3, line 22 "60" should be - 50 -.

Claims

Col. 4, line 52 "cylinderns" should be - cylinders -.

Col. 4, line 52 after cylinders insert - so that the portions -.

Signed and sealed this 23rd day of May 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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USCOMM-DC 60376-P69
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