Dec. 13, 1960 N. E. GLUECK 2,963,932

ROTARY PERFORATING APPARATUS

Filed June 8, 1956 3 Sheets-Sheet 1

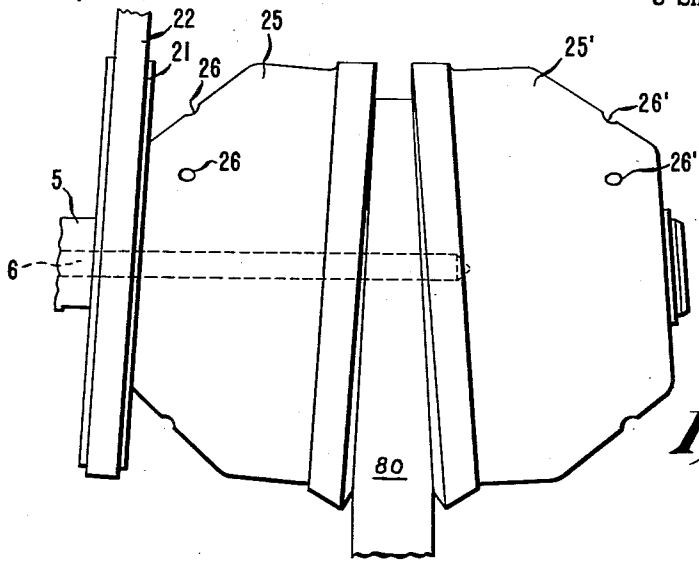


Fig. 1

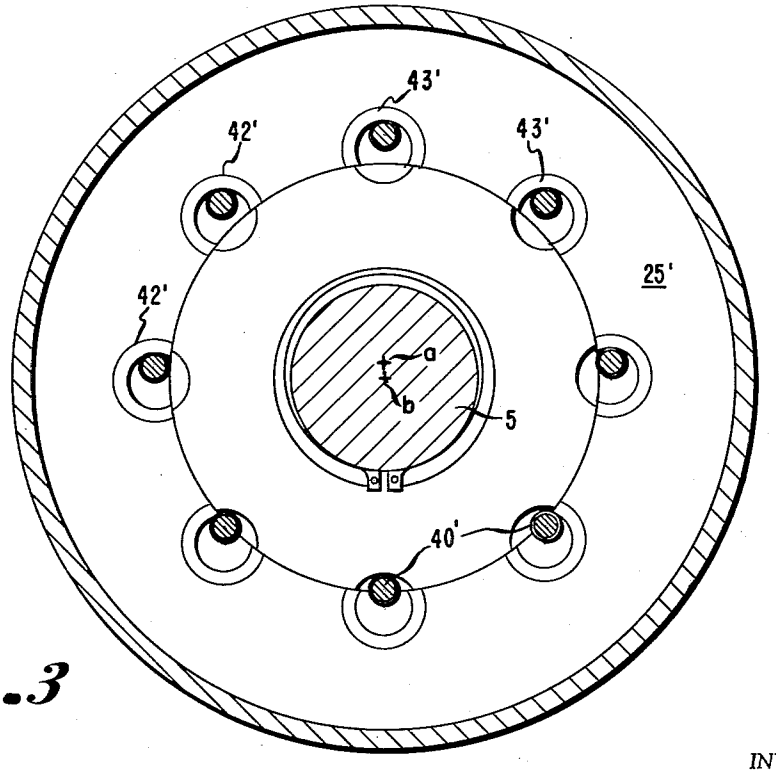


Fig. 3

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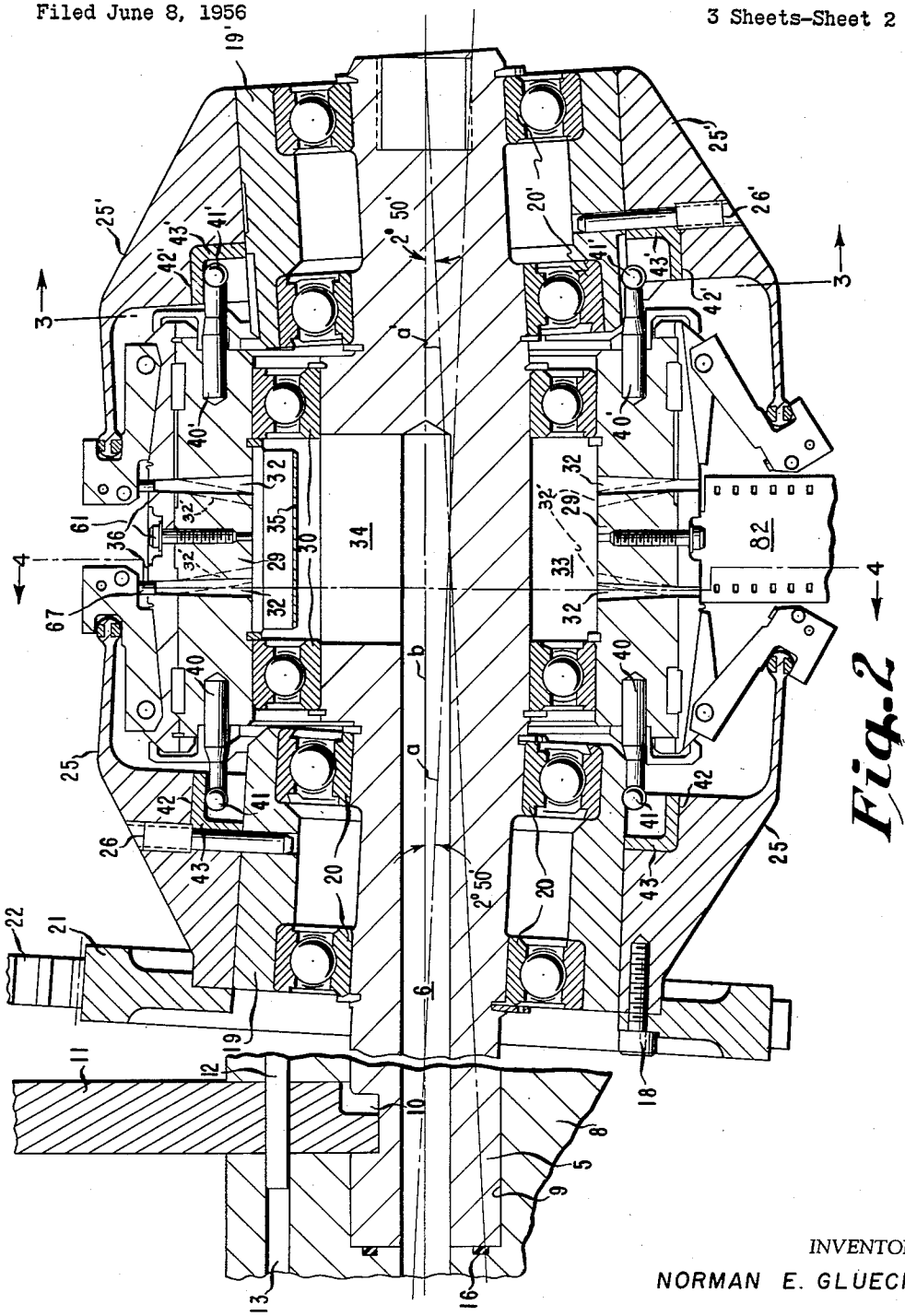


Fig. 2

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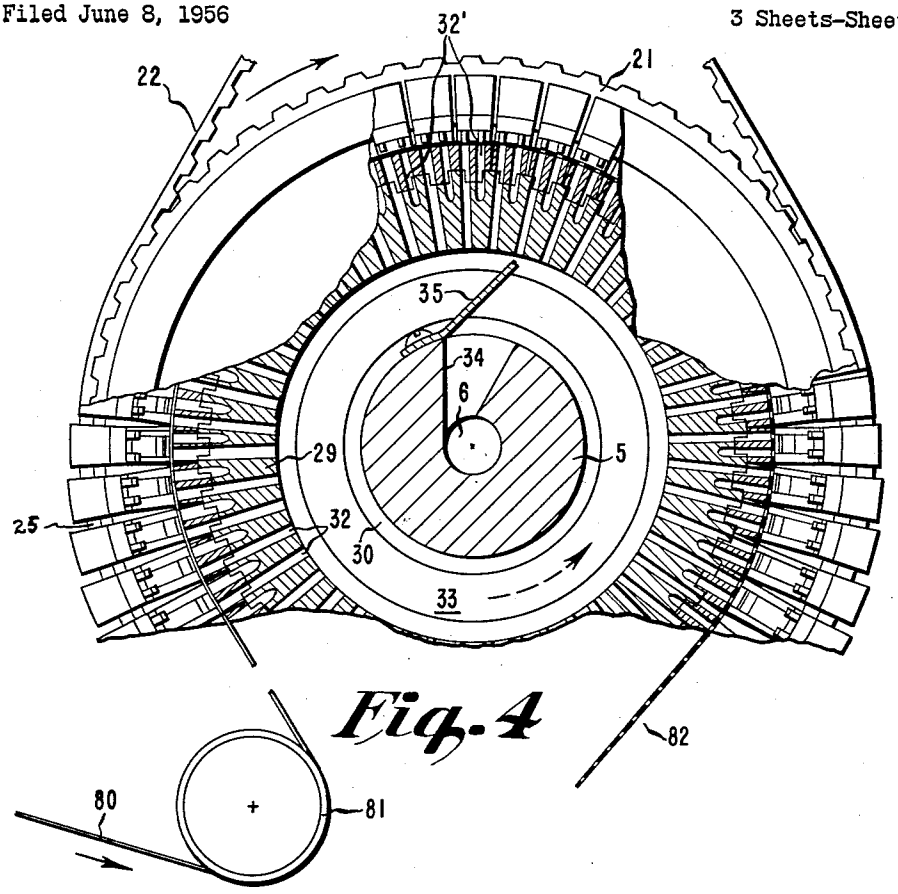


Fig. 4

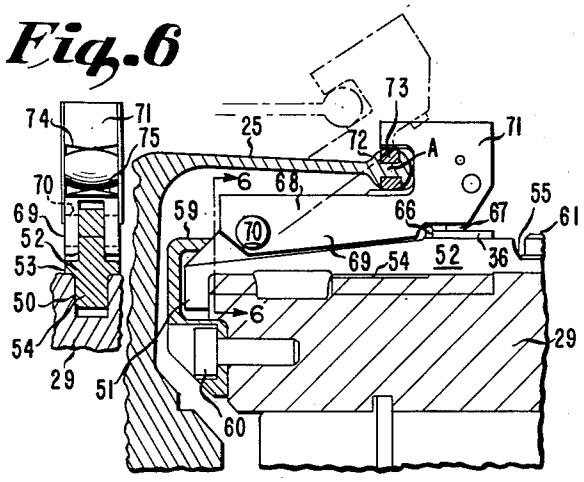


Fig. 5

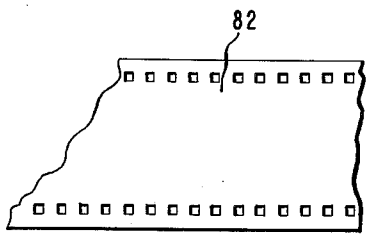


Fig. 7

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2,963,932

ROTARY PERFORATING APPARATUS

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Filed June 8, 1956, Ser. No. 590,263

7 Claims. (Cl. 83—337)

This invention relates to improvements in web perforators and particularly to rotary perforating apparatus utilized for forming the guide perforations in photographic film and the like, such as is taught in U.S. Patent 2,760,576 granted to D. W. C. Spencer.

The perforating of photographic film is necessarily a precise operation in that close pitch tolerances must be maintained for the reason that the high speed feeding of the film is possible only when there is exact matching and engagement of the teeth of feed sprocket wheels with the perforations in the film. Economy in manufacturing practice requires that film perforation be accomplished at extremely high speeds and, therefore, apparatus for this purpose should be simple in construction, while being compact and rugged to meet service demands.

A principal object of this invention is to provide a film perforator which has improved kinematic characteristics. Another object is to provide an apparatus wherein film can be fed into and removed from the device more readily than has hitherto been possible. Another object is to provide an apparatus wherein an extremely high precision of perforation is obtained at all times. Yet another object of this invention is the provision of a perforating apparatus which is compact, simple and cheap in first cost and which has a relatively long operating life.

The manner in which these and other objects of this invention are obtained will become apparent from the detailed description and the following drawings in which:

Fig. 1 is a side elevation to reduced scale showing the skewed disposition of the cam rings of this invention with respect to the film-supporting wheel,

Fig. 2 is a side elevation shown in longitudinal section of one embodiment of apparatus according to this invention,

Fig. 3 is a full-section view taken along line 3—3 of Fig. 2,

Fig. 4 is a partially broken section taken along line 4—4 of Fig. 2, showing a length of film in process of perforation,

Fig. 5 is a side elevation view of a perforator assembly, showing the camming edge of the associated cam ring in full line representation for one limiting position of the perforator and broken line representation for the other limiting position,

Fig. 6 is a rear end sectional view on line 6—6 of the perforator assembly shown in Fig. 5 looking in the direction of the punch and die elements, and

Fig. 7 is a plan view of a length of film perforated by the apparatus of this invention.

Generally, the apparatus of this invention comprises a rotatable web-supporting wheel which is journaled on a stationary shaft, which wheel carries a multiplicity of perforator assemblies mounted in fixed position around the periphery of the wheel, and one or a pair of circular cam rings mounted in skew relationship to the wheel, and driven rotatably in unison therewith, the cams overlying the perforator assemblies on the wheel and progressively urging the punch elements of the perforators into cutting position and then retracting them in sequence during further rotation of the wheel and cam rings to clear the web in process, whereupon the cycle is repeated. In a preferred embodiment, the apparatus is adapted to the simultaneous perforation of both edges of the film or of the web, the film being fed into and removed from the apparatus at a point where the cam rings clear the web-supporting wheel sufficiently so that the film edges do not contact the rings.

Referring to Fig. 2, one embodiment of this invention comprises a main shaft 5 which is drilled axially at 6 to permit vacuum withdrawal of cut-out film slugs in the operation. Shaft 5 is stationary and is supported in cantilever relationship with respect to the machine frame 8, being mounted with a slip-fit within drilled passage 9 formed in the frame. Shaft 5 is provided with an arcuate keyway 10 receiving the inner end of quick-release lever 11 provided with a pivot pin 12, which is rotatably supported within a drilled hole 13 in frame 8, so that the shaft and the entire mechanism supported by the shaft may be readily withdrawn for servicing or replacement whenever required. An annular vacuum sealing washer 16 is provided coaxial shaft 5 at the frame end of the shaft to seal drilled passage 6 against air leakage from the outside.

Drive bushing 19 is journaled on shaft 5 through bearings 20 with the longitudinal axis *a* in skew relationship to the axis *b* of the shaft at an angle of about 3°, although this angle may be chosen somewhat larger as hereinafter described. Cam ring 25 is fixedly attached to bushing 19 by set screws, one of which is shown at 26 in Fig. 1, the cam ring being concentric with bushing 19 and therefore disposed in like skew relationship axially with respect to the longitudinal axis *b* of shaft 5. Drive bushing 19′ is similarly journaled on shaft 5 through bearings 20′ in skew relationship opposite to that of bushing 19 but with longitudinal axis *a′* at the same angle of inclination. On the left-hand end the apparatus is provided with a gear 21, secured to cam ring 25 by bolts 18, the gear meshing with flexible drive belt 22, which may be a conventional Gilmer Timing Belt or the like.

The film-supporting wheel 29 of Fig. 2 is made sufficiently wide to permit the simultaneous perforation of both edges of the film and this wheel is journaled concentrically on shaft 5 through a pair of bearings 30. Wheel 29 is provided with a number of vacuum passages, of which passages 32 are radially disposed and passages 32′ alternating therewith are slightly inclined (refer Fig. 2), which open at their inward ends into the annular clearance 33 between shaft 5 and the inner periphery of wheel 29. As shown in Fig. 4, shaft 5 is provided with a generally radial passage 34 which is reduced progressively in cross section from the periphery of the shaft towards the center, establishing an open connection between the perforator assemblies and the vacuum slug drawoff system. Communication at one side with clearance space 33 is preferably restricted by deflector 35 to obtain a counterclockwise turbulent air sweep peripherally of shaft 5 as indicated by the broken line arrow in Fig. 4. The outer ends of passages 32 and 32′ are disposed adjacent to the undersides of the die elements 36 of the perforators and are of somewhat larger diameter than the die elements to facilitate the vacuum removal of the cut-out film slugs. Preferably, passages 32 and 32′ are slightly tapered to a larger bore in the direction of shaft 5 to facilitate the ready withdrawal therethrough of the slugs to be removed.

The embodiment of apparatus hereinabove described utilizes oppositely disposed skew-mounted cam rings 25 and 25′, as shown in Fig. 1, which are in closest proxim-

ity to each other and to film-supporting wheel 29, at 12 o'clock position and separated most widely from each other and from the wheel at 6 o'clock position. In a typical perforating apparatus for use with 35 mm. film, the apparatus is provided with a wheel 29 having a diameter of 5¾" carrying forty-eight perforator assemblies mounted at equal circumferential spacings around the outside periphery of the wheel. The skew angle between axes *a* and *b* was 2° 50". The skew angle was chosen to be large enough to just permit clearance of the film on introduction to and withdrawal from the apparatus, while still permitting near-normal application of operational loads to shaft 5. Perforation of the film is effected continuously as the film is carried around clockwise as seen in Fig. 4 during rotation of wheel 29 by depression of the punch elements inwardly from about 8 o'clock position to 12 o'clock position by cam rings 25 and 25' of the perforator assemblies. During further rotation of wheel 29 from 12 o'clock position to about 4 o'clock position the punch elements of the perforator assemblies are retracted from the film by the progressively increasing separation of cam rings 25 and 25' from the wheel, and the arc of about 120° between the 4 o'clock and 8 o'clock positions is reserved for the introduction and withdrawal of the film in process.

Referring to Figs. 2 and 4 especially, the drilled passage 6 in. shaft 55 connecting with passages 34, 33, 32, and 32', serves for the withdrawal of the cut-out slugs. The course of the slugs is thus from the perforators through die elements 36 and passages 32 (or 32'), 33, and 34 in sequence, thence into drilled passage 6 and out to the left, as seen in Fig. 2, to a suitable collector maintained under vacuum by equipment not shown. Drilled passage 6 serves as a common slug withdrawal exit for the perforators operating on both the right and left-hand edges of the film.

Referring to Figs. 2 and 3, film-supporting wheel 29 is provided at both ends with drive pins 40 and 40' which are fixedly secured to the wheel, as by shrink fits, keying or in other conventional manner and the outer ends of which extend axially into mating apertures 42 and 42' provided on the inside edges of cam rings 25 and 25', respectively. The drive pins are all identical in configuration and are preferably provided with ball tips 41 and 41' which engage sleeves in the cam rings and effect the actual driving. To minimize noise and at the same time give some self-lubricating action, apertures 42 and 42' are preferably provided with sleeves of a solid plastic material such as a linear polyamide or the like, denoted 43 and 43'. As shown in Fig. 3 particularly, it will be understood that drive pins 40 and 40' are disposed concentrically around the centerline *b* of shaft 5, whereas apertures 42 and 42', with their associated linings 43 and 43', are disposed concentric to the centerlines *a* of cam rings 25 and 25'. With this skew relationship, the drive pins occupy different relative positions in the course of rotation with respect to the apertures and the linings and, of course, the inner diameters of the linings have to be sufficiently large to permit free displacement of drive pins 40 and 40' within linings 43 and 43'. It will be understood that with this construction all of the drive pins, except the single one shown in 6 o'clock position in Fig. 3, are in continuous driving relationship with respect to the cam rings, thereby providing a very positive driving connection without backlash between the wheel and the cam rings. The direction of power transmission is from drive belt 22 through gear 21 to cam ring 25, thence through drive pins 40 to film-supporting wheel 29, and from the latter through drive pins 40' to cam ring 25', the two cam rings and the film-supporting wheel being driven in perfect unison.

Referring to Figs. 5 and 6, the periphery of wheel 29 is machined around the entire outside expanse with a multiplicity of axially aligned grooves 50, as taught in Spencer U.S. Patent 2,760,576 which are adapted to support the perforators in fixed circumferential relationship with respect to each other. One embodiment of perforator which has proved satisfactory in service consists of the positively actuated type detailed in Figs. 5 and 6. These perforators comprise a base portion 52 undercut at 53, the base portion being provided with a tongue 54 fitting snugly within grooves 50. A somewhat deeper tongue element 51 is provided at the ends of the perforators opposite the punch and die ends which abuts against the side of wheel 29, thereby locating the punches precisely in an axial sense to punch perforations in the film with great accuracy with reference to the spacing from the edges. The perforators are retained in position by arcuate segmental spring stock straps 59 provided with a curved outer edge overlying the rear ends of all of the perforators and attached to 29 by machine screws 60, which are located circumferentially of the wheel intermediate drive pins 40 and 40' so as not to interfere therewith. The perforators for each side of the apparatus are identical one to another, but are opposed in disposition as shown in Fig. 2. The front ends of each pair of opposed perforators for both edges of the film are retained against wheel 29 by cap screws 61, the associated washers of which bear against the undercut noses 55 of the perforators. The extent of undercut at the noses is such that the cap screws are below the level of the die elements 36 of the perforators so that photographic film in contact with the surfaces of the die elements clear the tops of screws 61 and are not marred thereby.

The top surfaces of each of the perforator bases 52 are provided with a limiting stop lug 66 which limits the radial movement of the associated punch element 67 into registration with the associated die element 36. Two punch elements 67 may be conveniently mounted on the outer ends of each of the rigid support arms 68 for the forming of adjacent perforations in the film. Each arm 68 is provided with a clevis 69 at its inner end, the arm 68 being pivotally mounted for free movement in a direction generally radial of wheel 29 on pin 70 journaled in base 52. The upper forward end of support arm 68 is provided with a forked follower 71 adapted to receive in sliding engagement therewith the camming edge A of cam ring 25, which is preferably formed to a somewhat rounded bead at 72 to reduce friction to a minimum. It has been found desirable to inlay bead 72 at the points of contact with follower 71 with wear-resisting material, such as Stellite or the like, indicated at 73. Also, due to the offset disposition of axes of cam rings 25 and 25' and film-supporting wheel 29, it is desirable to taper oppositely of the vertical centerline and to a larger bore outwardly the inside upper and lower surfaces 74 and 75, respectively, of the forked follower 71, as shown in Fig. 6, so that the direction of imposition of forces from the cam ring is always in the direction of the center of rotation of the cam rings. A detailed kinematic analysis of the construction hereinabove described reveals that practically the entire relative motion between cam ring beads 72 and follower 71 is of the rolling type, which contributes to smooth operation, increased service life and improved load application to the bearings. The slight amount of sliding movement remaining is applied to the inlay 73 and is so limited as not to be objectionable from the standpoint of wear.

Referring to Figs. 1, 2 and 4, the operation of the apparatus of this invention is hereinafter described for the condition of clockwise rotation of wheel 29 and cam rings 25 and 25' (as seen in Fig. 4), although it will be understood that operation in the reverse direction is equally feasible if the feed of the film is reversed. The unperforated film 80 enters the apparatus in the vicinity of 6 o'clock position by lead around a guide roller 81 journaled on the general stationary framework of the apparatus. As shown in Figs. 1 and 2, the perforators

are in substantially fully retracted position at this point, and thus the running film is led to the surface of wheel **29** without interference from the perforators. The film contacts die elements **36** at about 8 o'clock position and thereafter is trained around the surface of wheel **29** to about 4 o'clock position when the perforated film is led off out of contact with the perforator elements during continued rotation of wheel **29** past 4 o'clock position. From this it will be understood that perforation takes place during about 240° of rotation of the wheel, which affords ample time for the operation, even at exceedingly high film speeds.

As will be apparent from Figs. 1, 2 and 4, the punches of the perforators are in fully depressed position at 12 o'clock position, therefore the inward movement of arms **68** takes place from 8 o'clock to 12 o'clock, the remainder of rotation to 4 o'clock position being consumed in retraction of arms **68** away from the film. The cut-out film slugs punched out are sucked down through the radial vacuum passages **32** and **32'** into annular chamber **33** where they are impelled circumferentially in a counterclockwise direction by the air sweep through the die holes which are open, being drawn off finally through common radial passage **34** and axially drilled hole **6** to a suitable collector. Experience in operation has demonstrated that extreme precision of pitch and spacing is obtained at a typical rotational speed of 350 r.p.m., corresponding to a linear film throughput of 500 ft./min.

When the perforated film emerges from the apparatus in the vicinity of 6 o'clock position, as shown in Fig. 4, it is taken up by a reel or other device not shown. It will be understood that in the course of operation the perforator punches and dies themselves, by engagement with the film, function to some degree as sprocket teeth and permit film feed through the apparatus under substantial tension. This is an advantageous condition because stripping devices are thereby obviated and regulation of the tension applied to the film during perforation makes it possible to control the pitch of perforation to extremely close tolerances.

The double-edge perforating apparatus hereinabove described in detail is preferred for film perforation; however, where single-edge perforation is desired, it will be apparent that a single cam ring operating in conjunction with a wheel provided with an appropriate network of vacuum slug-removal passages constructed as herein disclosed can be advantageously utilized, and both single and double-perforating embodiments are therefore comprehended within my invention.

The embodiment of this invention which has been herein described in detail is particularly preferred, because the arrangement of the apparatus components permits ready accommodation of the design to conventional film manufacturing apparatus supplying raw film to and receiving perforated film from the device, and is advantageous as regards maintenance and the substitution of particular sizes of apparatus for use with particular widths of film. However, it will be apparent that my invention may be modified extensively as described in detail in U.S. Patent 2,760,576 hereinbefore referred to.

It will further be apparent that a great variety of driving arrangements may be utilized for turning both the cam rings and the web-supporting wheel and, while the use of the particular coupling hereinabove described is preferred, other driving arrangements known to persons skilled in the art are equally effective for the purposes contemplated. It will be apparent that the primary driving effort can be applied through either a cam ring or the web-supporting wheel, whichever is most convenient.

From the foregoing it will be understood that I have provided an improved perforating apparatus useful in the perforation of photographic films or like web materials and that many modifications may be made in my invention without departing from its essential spirit,

wherefore I intend to be limited only by the scope of the following claims.

What is claimed is:

1. A rotary perforating apparatus comprising the combination of a frame, a stationary shaft supported on said frame, cam rings corresponding in number to the number of edges of the web it is desired to perforate journaled on said shaft, each of said cam rings being provided with a camming surface, a web-supporting wheel journaled on said shaft, said cam rings being disposed with their axes of rotation disposed oppositely one from another in skew relationship with respect to the axis of rotation of said web-supporting wheel, at least one web perforator fixedly secured to the outside periphery of said web-supporting wheel at a location for cooperation with individual ones of said cam rings, each said perforator being provided with a punch element and an associated die element, the punch element of said perforator underlying the camming surface of the cam ring cooperating with it and being depressible by said cam ring into perforating relationship with the die element associated with said punch at the point of minimum clearance between said cam and said web-supporting wheel and being movable outwardly in a generally radial direction a sufficient amount to clear completely the surface of a web carried by said web-supporting wheel at the point of maximum clearance between said cam ring and said web-supporting wheel, means for cut-out slug removal, and means for rotating in unison said cam rings and said web-supporting wheel.

2. A rotary perforating apparatus according to claim 1 wherein the skew angle between the axes of rotation of said cam rings and said web-supporting wheel is in the range of about 2° to about 6°.

3. A rotary perforating apparatus according to claim 1 wherein said perforator comprises in combination a rigid base member provided with a die element, a rigid support journaled at one end on said base member, a punch element fixedly secured to the end of said support opposite the end at which said support is journaled on said base member, and forked follower means fixedly secured to said support and engaging with said camming surface of said cam ring, whereby to bias said punch element into registration with said die element at said point of minimum clearance and lift said punch element free of said web at said point of maximum clearance.

4. A rotary perforating apparatus comprising the combination of a frame, a stationary shaft member mounted in cantilever relationship on said frame, cam rings corresponding in number to the number of edges of the web it is desired to perforate journaled on said shaft, each of said cam rings being provided with a camming surface, a web-supporting wheel journaled on said shaft, said cam rings being disposed with their axes of rotation in opposite skew relationship to the axis of rotation of said web-supporting wheel, at least one web perforator fixedly secured to the outside periphery of said web-supporting wheel at a location for cooperation with individual ones of said cam rings, each said perforator being provided with a punch element and an associated die element, the punch element of said perforator underlying the camming surface of the cam ring cooperating with it and being depressible by said cam ring into perforating relationship with the die element associated with said punch at the point of minimum clearance between said cam ring and said web-supporting wheel and being movable outwardly in a generally radial direction a sufficient amount to clear completely the surface of a web carried by said web-supporting wheel at the point of maximum clearance between said cam ring and said web-supporting wheel, intercommunicating conduits in said web-supporting wheel and said shaft to permit vacuum cut-out slug withdrawal from the die element of said perforator, and means for rotating in unison said cam rings and said web-supporting wheel.

5. A rotary perforating apparatus comprising the combination of a frame, a stationary shaft mounted in cantilever relationship on said frame, a cam ring provided with a camming surface journaled on said shaft, a web-supporting wheel journaled on said shaft, said cam ring being disposed with its axis of rotation in skew relationship to the axis of rotation of said web-supporting wheel, at least one web perforator fixedly secured to the outside periphery of said web-supporting wheel, each said perforator being provided with a punch element and an associated die element, the punch element of said perforator underlying the camming surface of said cam ring and being depressible by said cam ring into perforating relationship with the die element associated with said punch at the point of minimum clearance between said cam ring and said web-supporting wheel and being movable outwardly in a generally radial direction a sufficient amount to clear completely the surface of a web carried by said web-supporting wheel at the point of maximum clearance between said cam ring and said web-supporting wheel, intercommunicating conduits in said web-supporting wheel and said shaft to permit vacuum cut-out slug withdrawal from the die element of said perforator, and means for rotating in unison said cam ring and said web-supporting wheel.

6. A rotary perforating apparatus comprising the combination of a frame, a stationary shaft mounted in cantilever relationship on said frame, a cam ring provided with a camming surface journaled on said shaft, a web-supporting wheel journaled on said shaft, said cam ring being disposed with its axis of rotation in skew relationship with respect to the axis of rotation of said web-supporting wheel, at least one web perforator fixedly secured to the outside periphery of said web-supporting wheel, each said perforator being provided with a punch element and an associated die element, the punch element of said perforator underlying the camming surface of said cam ring and being depressible by said cam ring into perforating relationship with the die element associated with said punch at the point of minimum clearance between said cam ring and said web-supporting wheel and being movable outwardly in a generally radial direction a sufficient amount to clear completely the surface of a web carried by said web-supporting wheel at the point of maximum clearance between said cam ring and said web-supporting wheel, intercommunicating conduits in said web-supporting wheel and said shaft to permit vacuum cut-out slug withdrawal from the die element of said perforator, a positive torque-transmitting coupling connected between said cam ring and said web-supporting wheel, and rotational drive means connected to one of the pair consisting of said cam ring and said web-supporting wheel.

7. A rotary perforating apparatus comprising the combination of a frame, a stationary shaft mounted in cantilever relationship on said frame, two cam rings each provided with a camming surface journaled on said shaft with said camming surfaces adjacent one another, a web-supporting wheel journaled on said shaft, said cam rings being disposed with their axes of rotation in opposite skewed relationship with respect to the axis of rotation of said web-supporting wheel, at least two web perforators fixedly secured to the outside periphery of said web-supporting wheel, each of said perforators being provided with a punch element and an associated die element, one of said perforators being disposed on said wheel for cooperation with one of said cam rings and the other of said perforators being disposed on said wheel for cooperation with the other of said cam rings, the punch elements of said perforators underlying the camming surfaces of said cam rings in cooperation with each said perforator and being depressible by said cam rings into perforating relationship with the die elements associated with said punches at the point of minimum clearance between said cam rings and said web-supporting wheel and being movable outwardly in a generally radial direction a sufficient amount to clear completely the surface of a web carried by said web-supporting wheel at the point of maximum clearance between said cam rings and said web-supporting wheel, intercommunicating conduits in said web-supporting wheel and said shaft to permit vacuum cut-out slug withdrawal from the die elements of said perforators, and means for rotating in unison said cam rings and said web-supporting wheel.

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UNITED STATES PATENT OFFICE

CERTIFICATION OF CORRECTION

Patent No. 2,963,932 December 13, 1960

Norman E. Glueck

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 27, for "in. shaft 55" read -- in shaft 5 --.

Signed and sealed this 9th day of May 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents