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W. G. H. FINCH
COLOR FACSIMILE SYSTEM

2,422,778

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2 Sheets-Sheet 1

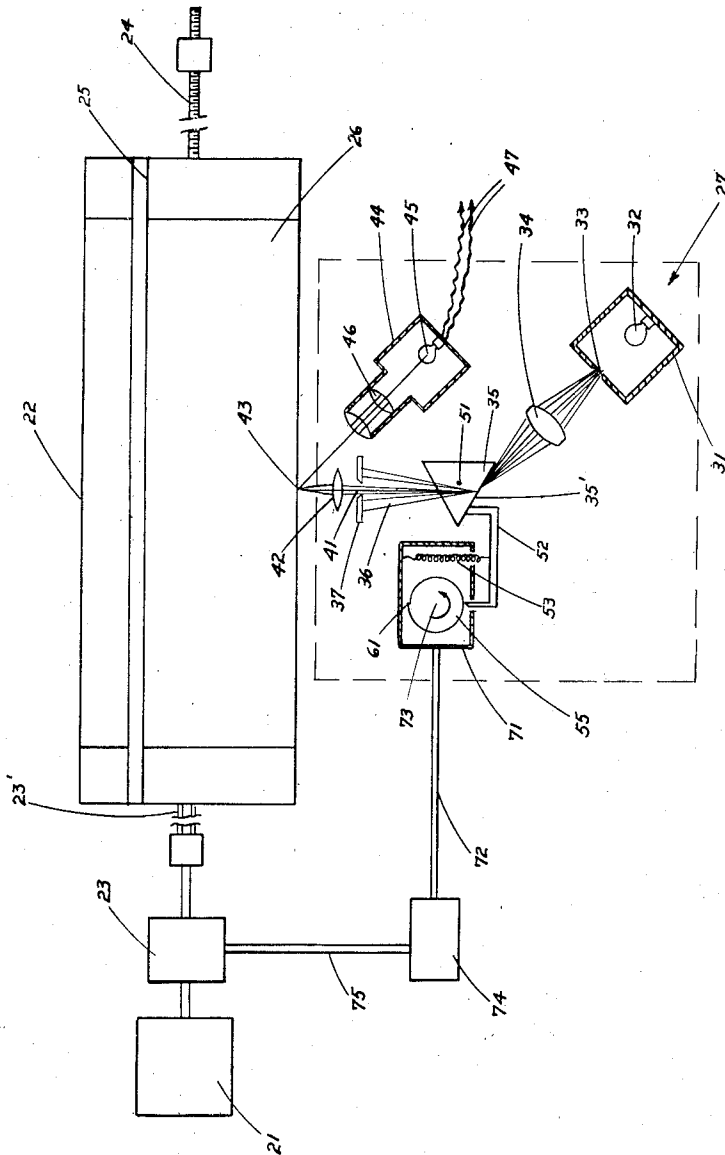


Fig. 1

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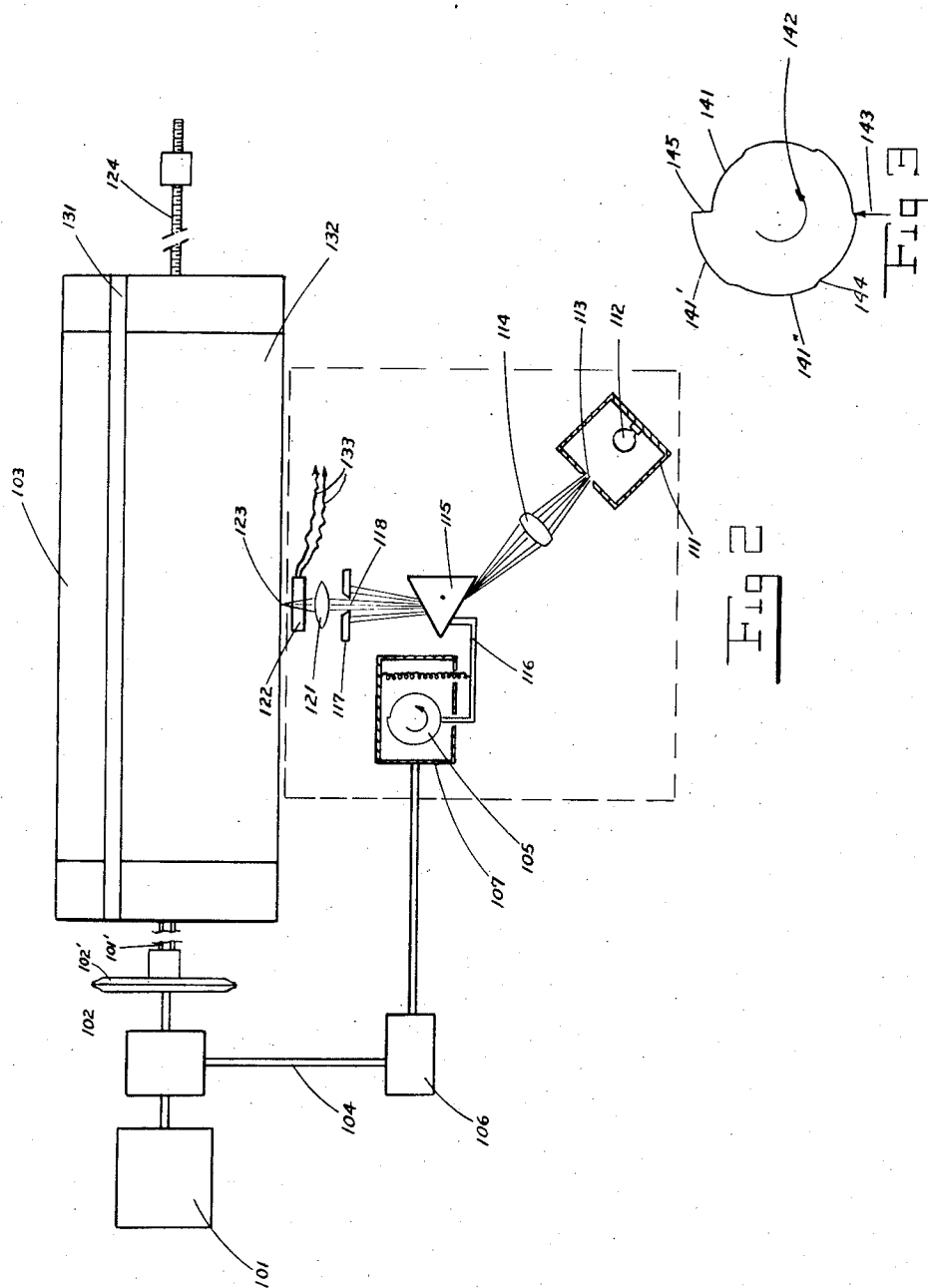
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COLOR FACSIMILE SYSTEM

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3 Claims. (Cl. 178-5.4)

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My invention relates in general to the field of facsimile transmission and more specifically to a novel method and means for transmitting and recording pictures in natural color. In general, in facsimile transmission, a signal is generated which corresponds to the variations in the lights and shades of the picture which is transmitted.

This signal is transmitted in any convenient manner to a remote recorder and impressed upon a variable light source to selectively control the exposure of a photographic film.

The transmission of pictures in natural color has heretofore generally been limited to a three-color separation process, that is, the color image to be transmitted was scanned three times through filters of the primary colors and three distinct color separation recordings were made at the receiver. After development, the individual photographic films were properly dyed and superimposed to form a finished color image.

This type of color transmission process was necessarily lengthy and required, because of the triple transmission, extreme mechanical accuracy within the facsimile apparatus and precise synchronization, so that the three-color separation negatives could be superimposed properly.

My invention contemplates the utilization of natural color film such as "Kodachrome" or "Kodacolor" for the direct recording of a transmitted color image.

In accordance with my invention, a color picture to be transmitted is suitably supported upon a scanning mechanism at the transmitter and is scanned by a novel color mechanism so arranged that each element of the picture is scanned for a range of color covering substantially the entire color spectrum. Thus, instead of a three-color analysis of a picture to be transmitted which has in many cases been found to be insufficient for faithful reproduction upon "Kodachrome" film, I utilize a prism for dispersing a beam of white light into a complete color spectrum, and scan the color picture with a multiplicity of color bands obtained from this spectrum. For example, the scanning mechanism carrying the color picture to be transmitted has each line of the image scanned approximately eight times, each scanning operation utilizing a different color for the scanning spot. The particular color utilized during any single scanning of a line of the image to be transmitted is continuously selected from the color spectrum above mentioned.

A photo-electric cell responsive to light impulses over the complete visible spectrum picks up the

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light reflected from the image, and accordingly develops an electrical signal which at each instant is proportional to the intensity of a particular color of the spectrum at a given point in the picture.

At the recorder, the received signal is impressed upon a mechanism for governing the passage of light therethrough. This light valve controls the intensity of a beam of light dispersed by a prism in a manner similar to that described for the transmitter. The prism is continuously adjusted so that the color of light impressed upon the light valve is the same as the color of light impressed upon the image at the transmitter.

Light passing through the light valve is impressed upon a "Kodachrome" film mounted upon the receiving-scanning apparatus, and accordingly the colored light variation will record directly so that when the recording film is developed, a true "Kodachrome" reproduction of the image transmitted is obtained.

It is therefore an object of my invention to provide means for transmitting pictures in natural color.

A further object of my invention is to provide transmitting and recording facsimile apparatus for producing a "Kodachrome" reproduction of a colored image.

A further object of my invention is to provide means for scanning a color image with lights of varying colors as obtained from a spectrum covering the entire visible range.

A still further object of my invention is to provide a facsimile color recorder utilizing "Kodachrome" film which utilizes a prism as a source of light of various required colors.

These and other objects of my invention will become apparent from the following specification taken in connection with the accompanying drawings in which:

Figure 1 is a diagrammatic representation of my novel color transmitter, and

Figure 2 is a diagrammatic representation of a color facsimile recorder, and

Figure 3 is an enlarged view of a slight modification of the cam member of Figures 1 and 2.

Referring now to Figure 1, there is shown a facsimile color transmitter which generates electrical signals that are at all times representative of the color of a particular point of an image. Motor 21 drives a scanning drum 22 through a gear-ratio box 23 and extensible square shaft 23'. The drum 22 is suitably supported upon a stationary screw 24 which, as will later be de-

scribed, causes lateral displacement of the drum during the rotation of drum 22.

The image 26, which is to be transmitted and which is in natural color, is suitably supported upon drum 22 by a mounting bar 25. The image 23 is scanned by a color scanning mechanism 27 which is fixed to the frame of the facsimile apparatus. Thus continuous scanning is obtained by fixing the scanning apparatus 27 and causing lateral displacement of the drum during its rotation.

The color scanning apparatus 27 comprises essentially a lamp-house 31 enclosing a powerful white light bulb 32. The bulb 32 is preferably a high pressure, high intensity lamp which develops a balanced white light, such that "Kodachrome" when exposed to this light will photograph white.

A vertical slit 33 at the front of the lamp-house 31 is focused by cylindrical lens 34 upon the surface 35' of a triangular prism 35.

As illustrated, the angle of incidence of the focused light rays is such that the prism 35 will cause the dispersion thereof into a uniform visible light spectrum 36 covering the complete visible range from deep red to deep violet.

In the path of the dispersed beam of light 36 is a metallic plate 37 having a small opening 41 which is preferably square, the width of which is approximately $\frac{1}{8}$ the width of the visible spectrum 36 at the point of incidence with plate 37.

The rectangular perforation 41 is sharply focused by optical system 42 at a spot 43 upon the surface of the color image 26 to be transmitted.

Light reflected from the focused spot 43 upon the color picture 26 impinges on photo-electric cell 45 enclosed in light-housing 44 by means of a suitable optical system 46. Photo-electric cell 45 is preferably one which has a uniform sensitivity to light throughout the visible spectrum.

The output of photo-electric cell 45 is transferred through wires 47 to a suitable amplifier which raises the energy level of the signal generated to that suitable for transmission to a remote recorder.

The prism 35 is preferably of glass having a comparatively high dispersion and low absorption, in order to produce a spectrum 36 of maximum width and of great intensity when measured along the plate 37. The prism 35 is rotatably supported by vertical shafts such as 51 cemented to the upper and lower surfaces thereof. These shafts are held in suitable fixed bearings which have been omitted from this diagram for clarity.

Also cemented to the lower surface of prism 35 is a link 52 of the shape shown. A spring 53 attached to link 52 and fixed to the frame at the opposite ends thereof is utilized to bias the edge 54 of the link 52 into engagement with the active surface of a cam 55.

As illustrated in this modification of the transmitter, the cam 55 is so shaped that upon rotation thereof, the edge 54 of the link 52 will be displaced outwardly from the cam center at a uniform speed until the edge 61 of the cam is reached, rotation being in the direction of the arrow indicated upon the surface of the cam.

Upon reaching the edge 61, the cam follower edge 54 will, under the influence of spring 53, swing back to its original position and begin its uniform outward motion once again.

The depth of the cut 61 in the cam 55 and the size and position of link 52 are so arranged that the prism 35 rotates through a comparatively

small angle. This small angle of prism rotation however is sufficient to cause the spectrum of color 36 to sweep across the square perforation 41 in the fixed plate 37. Accordingly, for a single rotation of the cam 55, the spot 43 will continuously change color from deep red to deep violet as determined by the position of cam 55. Rotation of cam 55 is obtained through gear-ratio box 71 which comprises essentially a pair of bevel gears to transfer the rotation of horizontal shaft 72 to vertical shaft 73, to which the cam 55 is secured.

Rotation of shaft 72 is in turn secured from gear-ratio box 74 driven by shaft 75 which is connected to gear box 23.

The driving mechanism, as will later be described, for the drum 22 is arranged so that rotation of drum 22 about its axis takes place for preferably eight revolutions before the drum 22 is displaced laterally for the thickness of a single scanning line as determined by the width of the square perforation 41. Thus, in the transmission of a color picture, the image 26 is mounted upon drum 22 and each circular line about the image is scanned eight times during which time the driving mechanism for cam 55 causes one complete revolution thereof.

It will therefore be evident that during the eight scanning cycles for each line of the image that the scanning color of the spot 43 projected upon the image 26 is continuously varied from deep red to deep violet by rotation of prism 35. Accordingly, since the visible spectrum 36 is divided into a multiplicity of color bands, each scanning cycle of the drum is covered substantially by a different color of the spectrum 36. The light reflected from the spot 43 at any instant is proportional to the component of the instantaneous color projected thereupon, and therefore the output of photo-electric cell 45 is at all times representative of the proportion of the intensity of a particular color of the visible spectrum at the spot 43, since for a complete revolution of cam 55 all colors of the visible spectrum are covered.

The summation of the photo-electric cell output for a given point on the scanning line is equal to the true color for that particular point. The output of photo-electric cell 45 is transmitted to a remote receiver which, as illustrated in Figure 2, is in most respects similar to the transmitter of Figure 1.

As is well known in the facsimile art, it is essential to drive the facsimile transmitter and recorder in synchronism with each other as regards both speed and space. Various methods, such as the use of synchronous motors or the sending of synchronizing impulses once during each revolution of the transmitting drum, are well known in the art of synchronization, and accordingly will not be described here.

It is assumed however that the transmitter and receiver of the particular system described herein are operated in synchronism.

At the recorder (Figure 2), the motor 101 through gear-box 102, extensible square shaft 101' and clutch 102' (which may be used in a well-known manner for synchronizing purposes) drives the rotatable drum 103 in the manner described for the rotatable drum at the transmitter; the rotation of drum 103 along stationary screw 124 results in longitudinal movement of the drum as it rotates. Similarly, the shaft 104 connected to motor 101 through the gear-ratio box 102 drives the cam 105 at a speed corresponding to

an exact fraction of the speed of the drum 103. The gear-ratio boxes 102, 106 and 107 are identical to the gear-ratio boxes 23, 74 and 71 respectively at the transmitter; and accordingly, the speed of cam 105 is identical to the speed of cam 55 at the transmitter.

A lamp-house 111 houses a powerful bulb 112 which is color-balanced so that when "Kodachrome" is exposed under the influence of this light, the correct color gradations are obtained.

At the recording apparatus, a slit 13 is focused by cylindrical lens 114 upon a prism 115 operably connected to the cam 105 by a link 116.

A fixed metallic plate 117 has a rectangular perforation 118 therein which by optical system 121 is focused upon a light valve 122. This light valve 122 is an electro-mechanical means for varying the intensity of the light transmitted therethrough and may assume various forms as is well known in the art. Thus an electro-magnetically operated shutter or other well known means may be utilized at this point.

Light emanating from light valve 122 is sharply focused at spot 123 on the surface of the drum. As illustrated in Figure 2, the drum 103 by mounting bar 131 supports a sheet of "Kodachrome" or "Agfa-color" or "Kodacolor" 132 or other color responsive photo-sensitive sheet which upon exposure to colored light may be developed to produce a colored image.

The received picture signals are suitably amplified by conventional amplifiers (not shown) and are impressed by wires 133 upon the light valve 122. Therefore, the light valve 122 is responsive to the received picture signals to control the intensity of the focused spot 123.

In actual operation of my novel natural color facsimile process illustrated, the image 26 to be transmitted is scanned as previously described. The identical scanning procedure at the recorder produces a picture which at all points represents the true color of the image transmitted. Thus, at the transmitter, each circular scanning line about the drum 22 is scanned by spot 43 preferably for eight complete revolutions. During this continuous scanning of a single circular line about the drum, as previously described, the color of the scanning spots 43 progressively varies from deep red to deep violet throughout the visible spectrum, and accordingly the response of photo-electric cell 45 is proportional to the intensity of the particular color of light reflected at each instance.

At the recorder, Figure 2, the multiple scanning of each circular line of the "Kodachrome" or other color film 132 is again accomplished by a spot 123 which is varying in color in accordance with the color variations of the spot 43 at the transmitter, while simultaneously varying in intensity through the agency of light valve 122, in accordance with the intensity of the particular reflection of that color at the transmitter.

At the termination of the scanning of a single circular line about a "Kodachrome" image 132, the cam 105 will have completed a single revolution and the prism 115 will be instantaneously re-set to scan the following circular line with the complete color spectrum produced thereby.

It is evident that the multiple scanning at the receiver will provide each circular line with all the color components required to reproduce exactly a color image. Of course, the number of scanning cycles of the drums 22 and 132 may be varied dependent upon the desired quality of transmission. Thus the cams 55 and 105 may be

adjusted by means of gear-ratio boxes 106 and 107 to provide a single revolution, that is, a single sweep of the spectrum produced by the prism in a fewer or greater number than the previously mentioned eighth cycle of the drum.

If a lower ratio between the number of revolutions of the drum, for a single revolution of the cam, is desired, it is preferable to vary the shape of the cams 105 and 55 to that shown in Figure 3.

In this modification, since the cam 141 is machined to have a series of circular edges, such as 141' and 141'', all concentric and all cut at evenly stepped radii, the direction of rotation of the cam 141 is indicated by the arrow 142, and the cam follower edge is schematically shown at 143. It will be understood that the cam follower 143 is the extension of the link 52 or 116 connected to the prism 35 and 115 respectively.

The corners, such as 144 between the successive steps of the cams 141' and 141'', have been rounded so that the cam follower 143 may move smoothly along the cam edge. Since the surfaces 141' and 141'' are circular, it is evident that as long as the cam follower 143 rides along one of these surfaces, the prisms 35 and 115 respectively will remain stationary. As the follower 143 crosses a corner such as 144, the prism will turn through a small definite angle and again remain stationary until the next corner is reached. When the edge 145 is reached, the prism instantaneously re-sets itself under the influence of its springs 53 to its initial position. Therefore, with the use of such a cam, the image surfaces at transmitter and receiver are scanned by colors which remain unvarying throughout the fraction of the scanning cycle represented by the portion of a complete circumference which each of the surfaces 141' and 141'' cover. Thus, if the number of scanning cycles for a given circular line about the transmitting and recording drum is reduced and the cam 141 utilized, the image surface will be scanned by a succession of fixed colors.

It is important to note that when this modification is utilized, that the number of drum rotations corresponding to a single revolution of the cam is equal to the number of sectors into which the cam 141 is divided.

For finer color reproductions, it is, of course, evident that the number of revolutions of the drum corresponding to a single circular scanning line may be increased. However, such a procedure lengthens the transmission time and I have found that a suitable compromise between excellent reproduction and rapid transmission time is eight complete revolutions of the drum for each circular line. Evidently, various modifications of this color scanning system may be devised.

For example, the prisms 35 and 115 may be oscillated by various electro-mechanical means rather than the cam mechanism described.

The light valve 122 at the receiver, Figure 2, may of course be disposed in the position indicated or between the vertical slit 113 and the cylindrically ground lens 115. The light valve 122 must also be chosen, such that it does not affect the color transmission characteristic of the scanning optical system illustrated in these figures.

The cam may be modified in any suitable way; thus, for instance, it may have three steps arranged for the red, yellow and blue portions of the spectrum, in which case each line need be

scanned only three times; it may have more than eight steps or an infinite number as shown in Figures 1 and 2. And the drum may be caused to rotate three revolutions per helical line, eight revolutions or any other number. The slight overlapping of the lines as the drum moves longitudinally avoids sharp striations on the film.

Also, it will be obvious that the transmitter and receiver may be combined in a single unit with means for shifting the light valve out of position and locking the clutch when the device is used as a transmitter.

Various mechanisms may of course be utilized to scan the drum at transmitter and receiver in the manner described. Of course, helical scanning of the recording and transmitting drum may be utilized instead of the intermittent type of circular scanning. If helical scanning is used, then the various colors used at transmitter and receiver for scanning the image surfaces may overlap from line to line, but this of course will not affect color rendition, but will slightly affect the detail of the reproduced picture.

Accordingly, various modifications of this type of color facsimile system will be evident to those skilled in the art. I do not wish to be bound by the above specification and drawings, but only by the appended claims.

I claim:

1. In a facsimile transmitter, a scanning device, comprising a drum upon which a picture is mounted, and a motor mechanism for rotating said drum in a predetermined manner; means for inducing longitudinal motion of said drum, a white light source, a prism, means for focusing light from said source on said prism, said prism separating the light into a spectrum, means for focusing said portion on an element of said picture, means comprising a lens system and photo cell for converting light reflected from said picture into electric currents; and means comprising mechanical linkages operably connected to said motor mechanism for oscillating said prism to present each portion of said spectrum to said means for selecting a said portion of said spectrum in a predetermined manner, said drum being arranged to rotate and translate axially in such a manner that each said portion of said spectrum scans each element of said picture once.

2. In a facsimile receiver, a scanning device comprising a drum upon which a sheet of color selective light sensitive paper is mounted, and a motor mechanism for rotating said drum in a predetermined manner and means for inducing axial translation of said drum; a white light source, a prism, means for focusing light from said source on said prism, said prism separat-

ing the light into a spectrum, means for selecting a portion of said spectrum, means for focusing said portion on an element of said sensitive paper, means comprising a light valve for controlling the intensity of said portion in accordance with an electric current; and means comprising mechanical linkages operably connected to said motor mechanism for oscillating said prism to present each portion of said spectrum to said selecting means in a predetermined manner in synchronism with rotative movement of said drum; said drum being arranged to rotate and translate axially in such a manner that each said portion of said spectrum, controlled in intensity by said light valve, scans each element of said sensitive paper once.

3. In a facsimile system, a transmitter comprising means for separating a picture into a series of elements, means for selecting each said element in turn according to a predetermined plan, means for separating each of said elements into its various colors, means for generating electric currents in accordance with the intensity of each of said colors, and a receiver comprising a source of white light, means for separating said light into a spectrum, means for selecting a portion of said spectrum, means for exposing the elements of a sheet of light sensitive paper to said portion of said spectrum, means for controlling the intensity of said portion in accordance with electric currents generated by said transmitter, means for exposing each element of said sensitive paper to said portion of said spectrum in turn according to a predetermined plan, means for coupling said transmitter to said receiver, and means for synchronizing said transmitter with said receiver so that corresponding elements of said sensitized paper and said picture are juxtaposed to their respective light sources at all times and corresponding portions of said spectra are presented to their said selecting means at all times.

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