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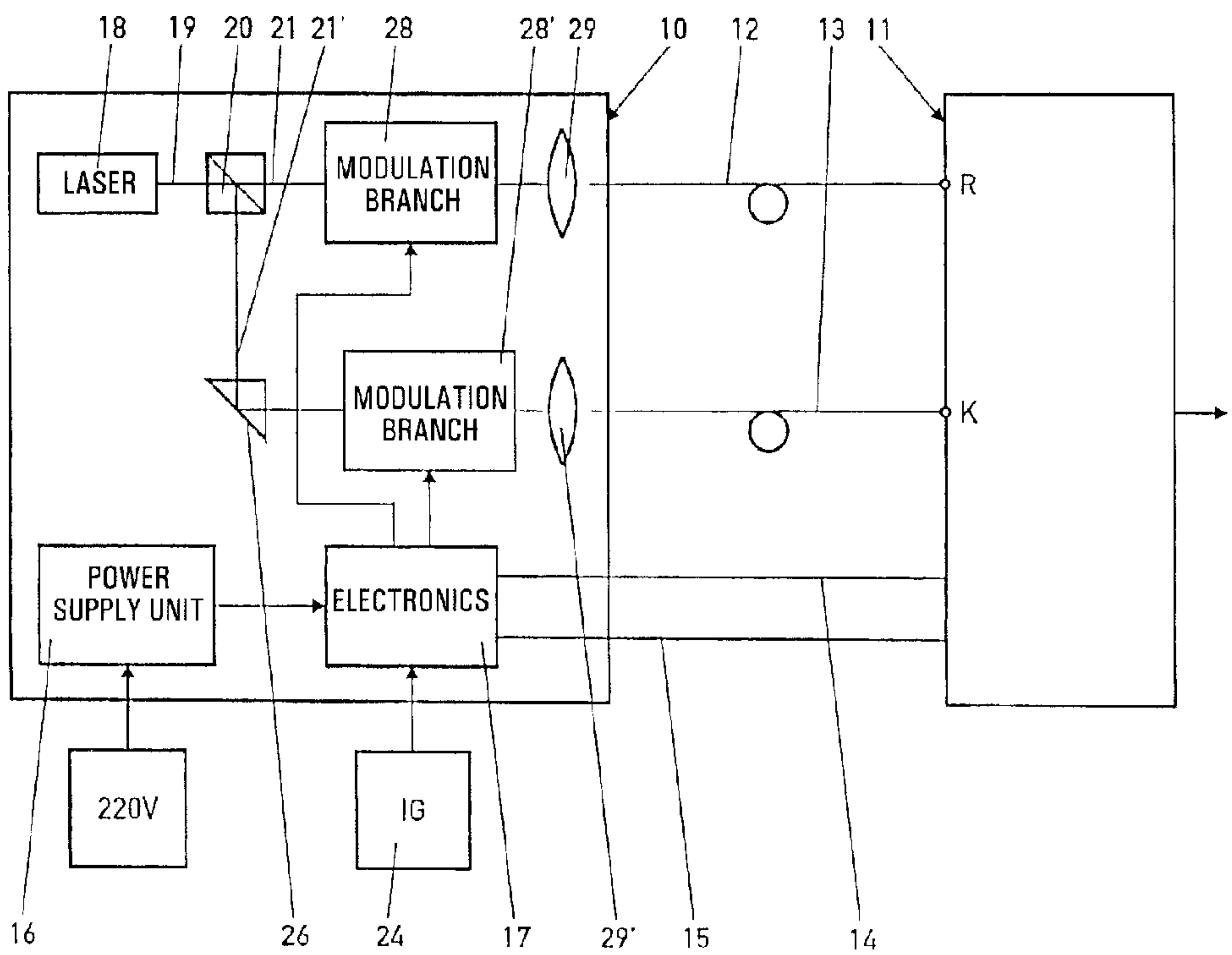

(57) Abrégé/Abstract:
The invention relates to an image projector with at least one projection beam that is controlled in raster mode and in calligraphic mode, for displaying a raster part and a calligraphic part of a total image that is projected onto a display. The aim of the invention is to achieve greater brightness and contrast for projection in non-darkened rooms. To this end, the at least one projection beam is a laser beam (19) that is divided into two linearly polarised partial beams (21, 21'). The two partial beams (21, 21') are separately modulated and deflected in such a way that one partial beam (21') determines the raster part and the other partial beam determines the calligraphic part. The two partial beams (21, 21') are projected onto the display at the same time. They may be optically superposed beforehand.

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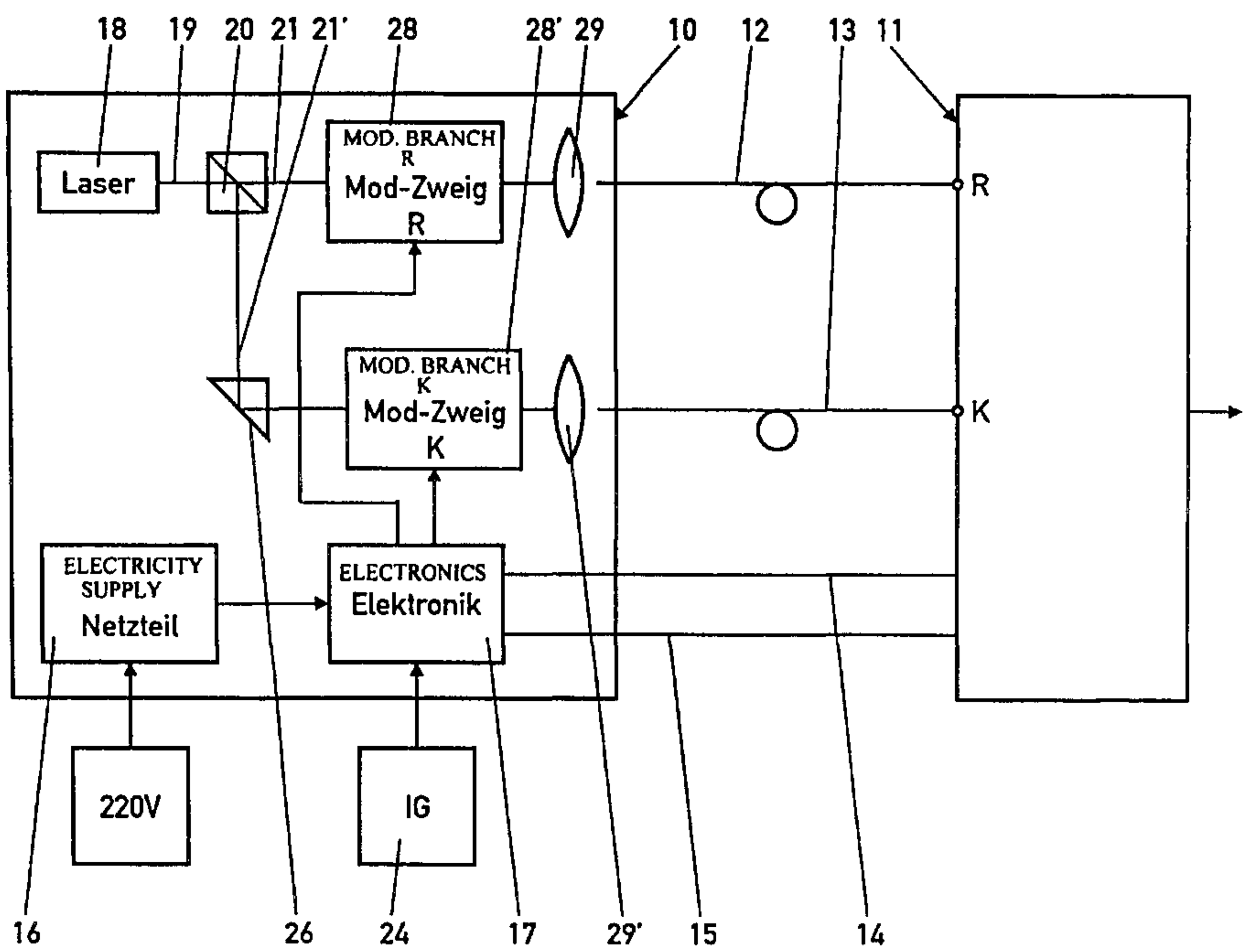

(57) Abstract

The invention relates to an image projector with at least one projection beam that is controlled in raster mode and in calligraphic mode, for displaying a raster part and a calligraphic part of a total image that is projected onto a display. The aim of the invention is to achieve greater brightness and contrast for projection in non–darkened rooms. To this end, the at least one projection beam is a laser beam (19) that is divided into two linearly polarised partial beams (21, 21'). The two partial beams (21, 21') are separately modulated and deflected in such a way that one partial beam (21') determines the raster part and the other partial beam determines the calligraphic part. The two partial beams (21, 21') are projected onto the display at the same time. They may be optically superposed beforehand.

(57) Zusammenfassung

Bei einem Bildprojektor mit mindestens einem im Rastermodus und im Kalligraphiemodus angesteuerten Projektionsstrahl zur Darstellung eines Raster– und eines Kalligraphieanteils eines auf einen Bildschirm projizierten Gesamtbilds ist zur Erzielung einer höheren Bildhelligkeit und eines höheren Bildkontrasts bei Projektion in nicht abgedunkelten Räumen der mindestens eine Projektionsstrahl ein in zwei linear polarisierte Teilstrahlen (21, 21') aufgespaltener Laserstrahl (19), wobei die beiden Teilstrahlen (21, 21') einer getrennten Modulation und Ablenkung derart unterzogen werden, daß der eine Teilstrahl (21') den Rasteranteil und der andere Teilstrahl den Kalligraphieanteil schreibt. Die beiden Teilstrahlen (21, 21') werden gleichzeitig auf den Bildschirm projiziert, wobei zuvor eine optische Überlagerung der Teilstrahlen erfolgen kann.

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Image Projector

The present invention relates to an image projector.

Known CRT image projectors, which operate in the raster-scan and calligraphic mode (US 4 614 941), and which are generally referred to as raster-scan/calligraphic projectors, are used, for example in flight simulators, in order to display a computer-generated image of the area surrounding an aircraft. Whereas in the raster-scan mode–in which the image is developed by horizontal and vertical deflection of a beam of light, as in a broadcast television image–the actual surrounding scenario is displayed with all its details such as towers, runways, buildings, streets, trees, and the like, the calligraphic mode–in which the beam of light or electrons can be moved in every direction at every speed–from stationary to a fast sweeping scan–permits the simultaneous display of the very bright runway lighting and coloured areas within the surrounding scenario, so that the airfield and airfield surroundings as well as landing scenarios can be displayed very realistically.

Raster-scan/calligraphic CRT projectors have a luminous flux that is limited by the cathode ray tube (CRT) and cannot essentially be increased, so that in order to present a sufficiently bright simulated image, the image is usually projected in darkened spaces. In the case of raster-scan/calligraphic CRT projectors, the raster-scan and calligraphic parts of the total image are written one after the other. This limits the projector's image repetition rate. If many calligraphically displayed lights (runway lighting) are shown, or if the resolution of the image is very high, the raster-scan part must be displayed interlaced, the lights being displayed calligraphically between the two half-images. The use of half-images causes the total image to flicker.

In a known image projector of the type described in the introduction hereto (US 5 582 518), the partial beam that writes the raster part is generated by a CRT and the partial beam that writes the calligraphy part is generated by a laser. After appropriate modulation and deflection by a semi-transparent mirror, both partial beams are directed to a fish-eye lens that displays the two discrete images together on a spherical projection screen. In a modified embodiment of this image projector, the CRT is replaced by a second laser, and both parts of the projected image are written in calligraphic mode.

In a known arrangement to generate polarized light (US 5 073 830), two polarized partial beams that are of half intensity are generated from a non-polarized light beam emitted from a light source, e.g., an HeNe laser, by means of a polarization beam splitter; the planes of polarization of these two partial beams are rotated 90° relative to each other. The one partial beam of light is routed directly to a lens, and the other partial beam is routed through a 90°tilted mirror and a $\lambda/2$ plate, and they are then focused onto a common place. The source of light, formed in this way, which emits polarized light, is used, for example, in a video projector that has a liquid-crystal display.

In one known image projector (WO 99/12358), after being modulated with the image content, the laser beams emitted from three lasers--for red, green, and blue--are routed through fibre-optic light guides to a deflection system that images the laser beams on a display.

It is the aim of the present invention to render a raster-scan/calligraphic image projector of the type described in the introduction hereto suitable for lasers, so that images written by raster-scan/calligraphic means can be projected with much enhanced brightness.

This aim has been achieved using the features set out herein.

The raster-scan/calligraphic image projector according to the present invention has the advantage that it uses only one laser beam as the projection beam, and thus has a very much higher light flux available to it. Unlike the case with calligraphic CRT projectors, because of the fact that the laser beam is split into two partial beams, the raster part and the calligraphic part are projected simultaneously, so that the image repetition rate for the raster part is not influenced by the number of lights that are to be presented calligraphically, so that even high resolution images with many image points (pixels) and simultaneously many light points can be projected "non-interlaced." The light points in the calligraphic part can be displayed at much greater contrast.

Their contrast to the raster part results from the longer dwell time of the laser part on the light points, relative to the dwell time of the other laser partial beam at a pixel of the raster lines. If a beam splitter that splits the two partial beams at a ratio of 1 : 1 is used then, given 1000 pixels per line in the raster part, and five points of light that are to be presented in the calligraphic part, the laser partial beam will dwell on the light point 1000 : 5 = 200 times longer on each point. The contrast for one point of light amounts to maximally 200 : 1. When displaying many light points in the calligraphic part, another split ratio can be selected for splitting the laser beam, so that the shorter dwell time of the laser partial beam at the individual light points can be balanced out by the high light flux. The merging of the separately modulated and differently polarized partial beams in a polarization beam splitter permits the almost loss-free superposing of the two partial beams in the projection head.

Functional embodiments of the image projector according to the present invention, with useful developments and configurations of the present invention, are set out in the secondary claims.

According to one advantageous embodiment of the present invention, the directions of polarization of the polarized partial beams are rotated through 90° relative to each other. The use of differently polarized partial beams, as in the present invention, makes it possible to superpose the two partial beams in the projection head almost without loss.

According to one preferred embodiment of the present invention, a λ2 plate is used in the beam path of one of the two partial beams in order to rotate the directions of polarization.

According to one preferred embodiment of the present invention, the modulated partial beams are introduced into the glass fibres that preserve the polarization and routed to a projection head, in which they are once again routed out of the glass fibres and optically superposed for projection on a display. This separation of the image projector into a laser part and a modulation part, on the one hand, and projection part on the other hand, permits spatial separation of the two parts, which is advantageous when used in a flight simulator, since only the low-weight projection head has to be mounted on the moving part of the simulator, which means that the weight of the moving part can be kept very low.

According to a further embodiment of the present invention, there is provided an image projector with a least one projection beam that is controlled in raster-scan and calligraphy mode, for displaying a raster-scan part and a calligraphic part of a total image that is projected onto a display and is made up of two partial beams (21, 21') that are superposed prior to projection and projected onto the display simultaneously, these being subjected to separate modulation and deflection such that the one partial beam (21) writes the raster-scan part and the other partial beam (21') writes the calligraphy part, characterized in that the partial beams (21, 21') are two linearly polarized laser beams with planes or directions of polarization that are rotated by 90° relative to each other, which are generated by splitting a laser beam (19); and in that a polarization beam splitter (33) is provided to superpose the differently polarized laser beams.

The present invention will be described below on the basis of one embodiment that is shown in the drawings appended hereto. These drawings show the following:

Figure 1: A block circuit diagram of a raster-scan/calligraphic image projector with a laser part and an electronic part, and a projection head that can be separated spatially therefrom;

Figure 2: A schematic detailed presentation of the optical beam paths in the laser part and the electronic part shown in Figure 1;

Figure 3: A schematic detailed presentation of the optical beam paths in the projection head shown in Figure 1;

Figure 4: A schematic detailed presentation of the optical beam paths in the laser part and the electronic part in a colour projector.

The image projector shown diagrammatically in Figure 1 to Figure 3 has a laser part and an electronic part 10, and a projection head 11 that an be separated spatially therefrom; these are connected through two glass fibres 12, 13, by way of a signal line 14 and power-supply line 15. The laser and electronic part 10 has a power supply unit 16 with a 220-Volt power supply, electronics 17, and optical components that will be described in greater detail below.

The image projector operates in raster-scan mode and calligraphy mode, a raster part and a calligraphic part of a complete image that is projected onto a display being generated separately. The optical component of the image projector is shown in principle in Figure 2. A beam 19 of polarized laser light generated by a laser source 18 is split into two partial beams 21 and 21' in a beam splitter 20. It is preferred that the split ratio be 1 : 1, although other ratios can be selected for specific applications. Each partial beam 21, 21' passes through a modulation branch 28, 28', respectively. The raster part R of the total image is generated by the partial beam 21, and the calligraphic part K of said image is generated by the partial beam 21'. The polarized light of the partial beam 21 first passes through a polarizer 22, whose direction of polarization agrees with the polarized partial beam 21, and is modulated in a subsequent electro-optical modulator 23, as required by the image content. The double arrows and points shown in the beam path indicate the direction or plane of polarization of the light. The polarization plane is the same plane in which the polarized light oscillates and propagates, in Figure 2 and Figure 3 the plane of the drawing or the plane that is perpendicular to this. The total image that is to be projected is generated in a so-called image generator 24 that controls the electronics accordingly. These, in their turn, control the electro-optical modulator 23 and the electro-optical modulator 23'. The modulators 23 and 23' are so connected that when the maximal modulation voltage is applied, in each instance the plane or the direction of polarization of the partial beam 21 or of the partial beam 21' is rotated through 90°. The modulation is effected so that the maximal voltage for the maximal brightness of a pixel is present at the modulator 23 or 23'. After the modulator 23, there is a second polarizer 25 whose plane of polarization is oriented so as to be perpendicular to that of the first polarizer 22.

After leaving the beam splitter 20, the second partial beam 21' of the laser 18' is deflected by a prism 26 and fed to the modulation branch 28'. Here, in the same way, the partial beam 21' passes through identical optical components as the partial beam 21, so that identical components of the modulation branch 28' are identified by the same reference numbers and are distinguished from the optical components in modulation branch 28 by the addition of an apostrophe (').

The partial beams 21, 21' that leave the second polarizer 25 or 25' are polarized linearly in the same plane of polarization. In order to permit subsequent, loss-free optical superposing of the two partial beams 21 and 21' in the projection head 11, the plane of polarization of one of the two partial beams, in this instance that of the partial beam 21, is rotated through 90°, to which end a λ/2 plate 27 follows the polarizer 22. The two modulation branches 28 and 28' for the raster-scan part R and the calligraphy part K of the overall image differ by the inclusion of this λ/2 plate. Each partial beam 21 or 21' is inserted into one of the two glass fibres 12, 13 through optical insertion coupling optics 29 or 29'.

Each glass fibre 12, 13 is connected to output coupling optics 30, 30' (Figure 3). Each of the partial beams 21 or 21' that leaves the glass fibre 12, or 13 passes through a polarizer 31 or 31' that serves to suppress any rotations of the polarization planes of the partial beams 21, 21' that these can undergo in the glass fibres 12, 13, and to define the plane of polarization clearly. The partial beam 21 is deflected horizontally into a deflection unit 32 or a scanner. This deflection corresponds to the line deflection of the partial beam 21, and it is effected at an appropriately high deflection frequency. One possible embodiment of the deflection unit 32 is a rapidly rotating polygonal mirror. Another embodiment of the deflection unit 32 , e.g., as a micro-optic mirror, is also possible. The partial beam 21' that is responsible for the calligraphy part K, which leaves the glass fibre 13, passes through an identical polarizer 31' for the same purpose, and is deflected horizontally in a deflection unit 32'. In contrast to the line deflection of the raster-scan part, the horizontal deflection of the calligraphy part can take place slowly within a line for the light points. One possible version of the deflection unit 32' is a galvanic mirror that is so driven that it triggers each light point within a line shortly one after the other. In so doing, it writes each line alternately from left to right and from right to left. This avoids a rapid return. Another embodiment of the deflection unit 32' for the horizontal deflection of the partial beam 21', e.g., as a micro-optical mirror, is also possible. Both the deflection units 32 and 32' are controlled by the electronics 17 by way of the signal line 14.

After the deflection units 32, 32', the two partial beams 21 and 21' are superposed in a polarization beam splitter 33, to which end–and prior to this–the partial beam 21' is deflected to the polarization beam splitter 33 by a deflector prism 34. The superposed partial beams 21, 21' are deflected vertically in a further deflection unit 35. It is preferred that a galvanic mirror be used to do this. This mirror changes its angle by a small increment for each line. After each image, it returns to its starting position. Another deflection unit 35, e.g., a micro-optic mirror, which works in the same way, can be used in place of the galvanic mirror. This deflection unit 35 is also controlled from the electronics 17 by way of the signal line 14. The raster-scan/calligraphic image so generated is projected onto the display or another projection surface by means of the projection lens 36.

By applying the principle of separated light modulation for the raster-scan and the calligraphic parts of the total image, as described heretofore, one obtains a monochrome image with n degrees of gray, in the colour of the laser generated by the laser source 18. Generation of coloured images requires three laser sources 18 that incorporate lasers that operate at different wavelengths, as is shown in Figure 4. Each of the laser sources emits light in the red, green, or blue sections of the spectrum. These wavelengths can be 629 nm, 532 nm, and 446 nm, for example. Each laser beam 19 of the three laser sources 18 is split up into the partial beams 21 and 21'–as described heretofore for Figure 2– and passes through the modulation branch 28 or

28'. Before being input into the glass fibres 12, 13, the partial beams 21 of all three laser beams 19 that write the raster-scan part and the partial beams 21' of all three laser beams 19 that write the calligraphic part are optically superposed; this is done by the dichroitic mirrors 37, 37'. The dichroitic mirrors 37, 37' have different transmission and reflective properties in the three spectral ranges of red, green, and blue. Thus, the dichroitic mirrors 371 and 371' have a high transmission factor for red and a high reflective factor for green, and the mirrors 372 and 372' have a high transmission factor for red and green and a high reflective factor for blue. A single deflector mirror 38, 38' is all that is needed to couple the partial beams 21 and 21' in the red spectral range.

After being input into the glass fibres 12, 13 and output from the glass fibres 12, 13 in the projection head 11, the paths of the partial beams 21 and 21' are as described for Figure 3.

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CLAIMS:

1. An image projector with a least one projection beam that is controlled in raster-scan and calligraphy mode, for displaying a raster-scan part and a calligraphic part of a total image that is projected onto a display and is made up of two partial beams (21, 21') that are superposed prior to projection and projected onto the display simultaneously, these being subjected to separate modulation and deflection such that the one partial beam (21) writes the raster-scan part and the other partial beam (21') writes the calligraphy part, characterized in that the partial beams (21, 21') are two linearly polarized laser beams with planes or directions of polarization that are rotated by 90° relative to each other, which are generated by splitting a laser beam (19); and in that a polarization beam splitter (33) is provided to superpose the differently polarized laser beams.

2. A projector as defined in Claim 1, characterized in that the superposed partial beam (21, 21') are routed through a projection lens (36) and a deflection unit (35) that is arranged before the projection lens (36) and deflects the partial beams (21, 21') vertically, by way of a galvanometer mirror.

3. A projector as defined in Claim 1 or Claim 2, characterized in that in order for the laser beam (19) to be split it is routed through a beam splitter (20), and each partial beam (21, 21') emerging from the beam splitter (33) passes through an identical polarizer (22, 22').

4. A projector as defined in one of the Claims 1 to 3, characterized in that an optical modulator (23, 23') through which each partial beam (21, 21') passes is so configured that at maximal modulation voltage it rotates the direction or plane of polarization of the incident polarized partial beam (21, 21') through 90°; in that a polarizer (25, 25') is arranged after the modulator (23, 23'), the direction or plane of polarization of this being rotated through 90°relative to the polarized incident partial beam (21, 21'); and in that control of the modulator (23, 23') is effected in such a way that the maximal voltage is present at the modulator (23, 23') in order to achieve the maximal brightness of a pixel.

5. A projector as defined in Claim 4, characterized in that the rotation of the direction or plane of polarization of the two partial beams (21, 21') is effected in the path of the beam, after the modulator (23, 23'), by means of an optical component (27) that is arranged in the path of a partial beam (21) and rotates the direction or plane of polarization of the incident polarized partial beam (21) through 90°.

6. A projector as defined in Claim 5, characterized in that the optical component is a λ/2 plate (27) that is arranged immediately after the polarizer (25) that follows the modulator (23).

7. A projector as defined in one of the Claims 1 to 6, characterized in that each modulated partial beam (21, 21') is input into a glass fibre (12, 13) that preserves the polarization by

means of input coupling optics (29, 29') and is passed to a projection head by way of the glass fibre (12, 13).

8. A projector as defined in Claim 7, characterized in that each glass fibre (12, 13) is connected to one of two optical output coupling systems (30, 30') arranged in the projection head (11); and in that a partial beam (21) that emerges from the output coupling optics(30) and writes the raster-scan part is routed through a deflection unit (32) a polygonal mirror– that deflects the partial beam (21) horizontally at a high deflection frequency, and the partial beam (21') that emerges from the output coupling optics (30') and writes the calligraphy part is routed to a deflection unit (32') by way of a galvanometer mirror- that deflects the partial beam (21') horizontally at a lower deflection frequency.

9. A projector as defined in Claim 8, characterized in that the deflection unit (32') for the partial beam (21') that writes the calligraphic part is so configured that within a line that is defined by the maximal horizontal deflection all the light points that are to be displayed are triggered briefly one after the other.

10. A projector as defined in Claim 9, characterized in that the deflection unit (32') is so configured that the direction of horizontal deflection is reversed for each successive line.

11. A projector as defined in one of the Claims 8 to 10, characterized in that each optical output coupling system (30, 30') is followed by a polarizer (31, 31').

12. A projector as defined in one of the Claims 7 to 11, characterized in that three projection beams are provided in order to generate a coloured total image, a projection beam being a laser beam (19) in the green, a laser beam (19) in the red, and a laser beam in the blue spectral range; and in that before the partial beams (21, 21') are input into the glass fibres, the partial beams (21) of all three laser beams (19) that write the raster-scan part and the partial beams (21') that write the calligraphic parts of all three laser beams (19) are superposed optically.

13. A projector as defined in Claim 12, characterized in that a dichroitic mirrors (37, 37') with different transmission and reflective properties in the three spectral ranges are provided to superpose the three partial beams (21, 21').

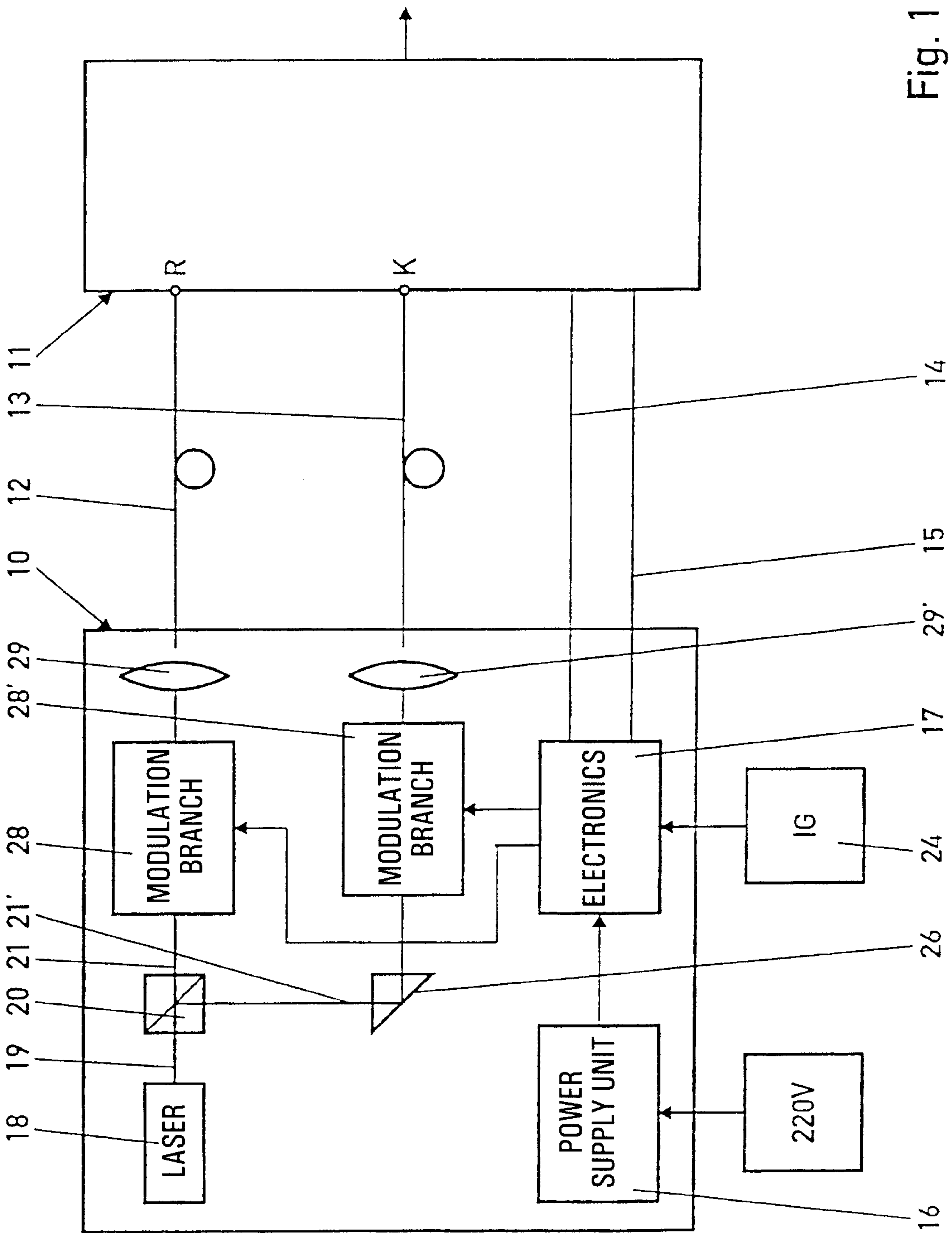
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Fig. 1

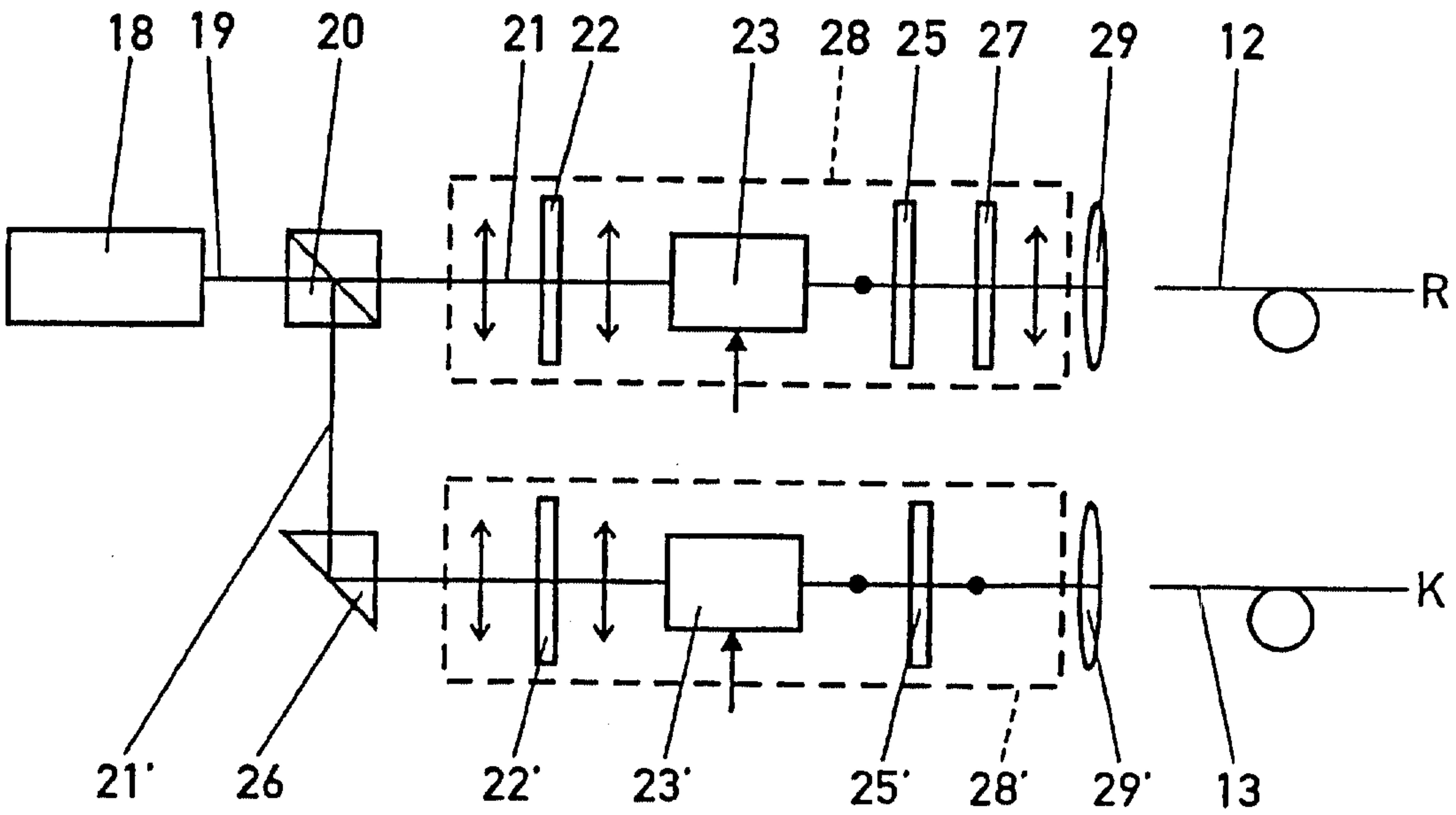
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Fig. 2

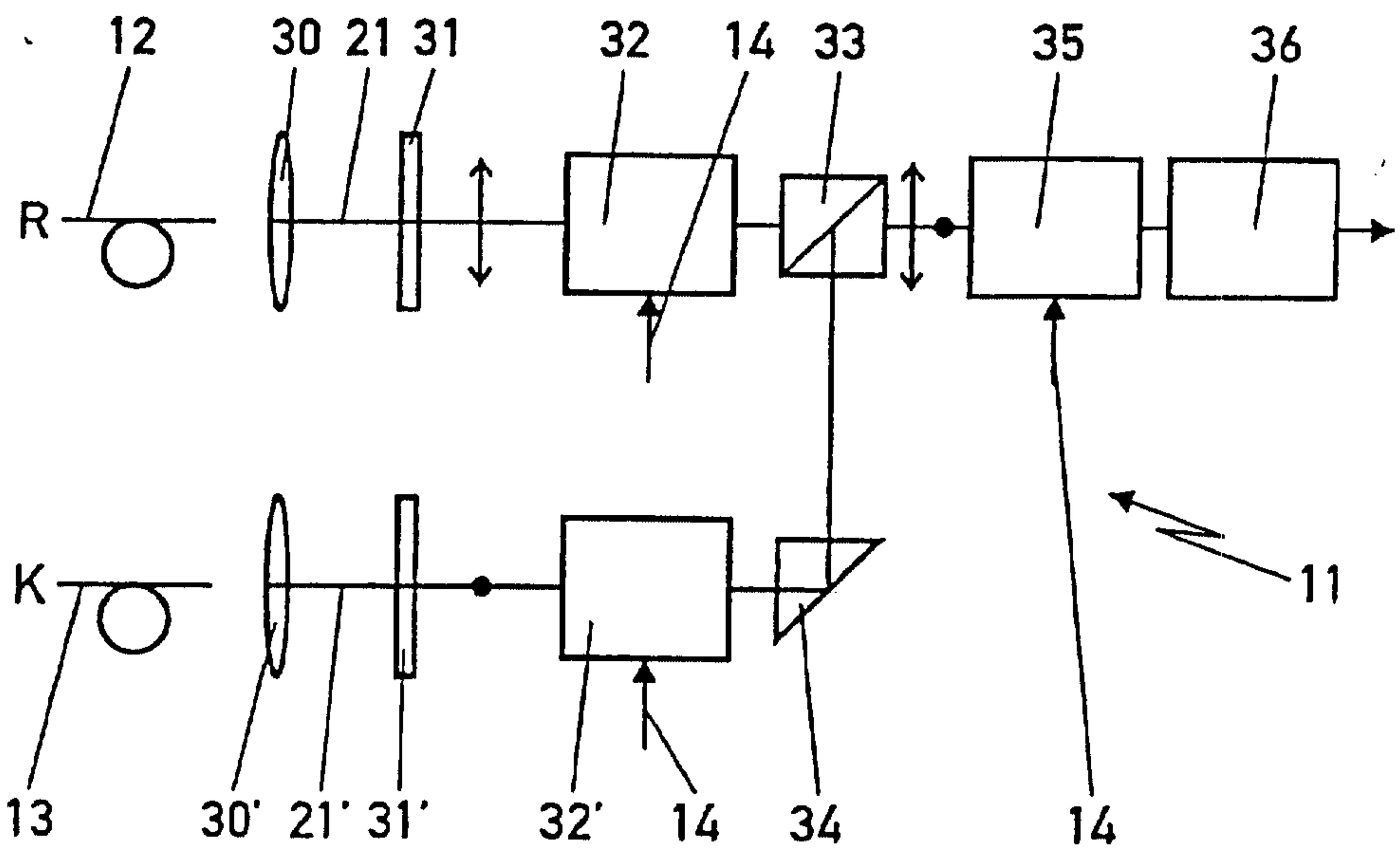
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Fig. 3

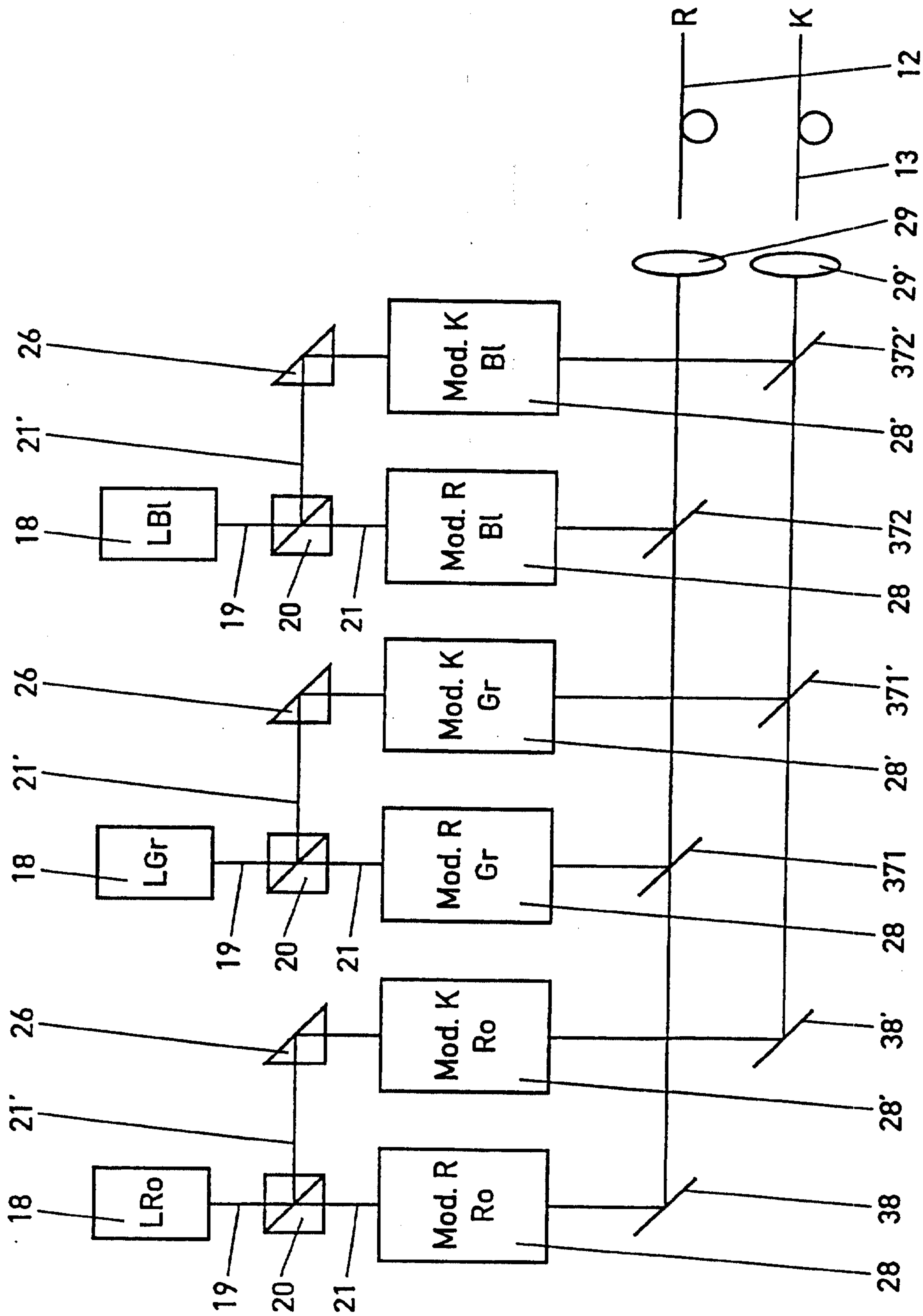
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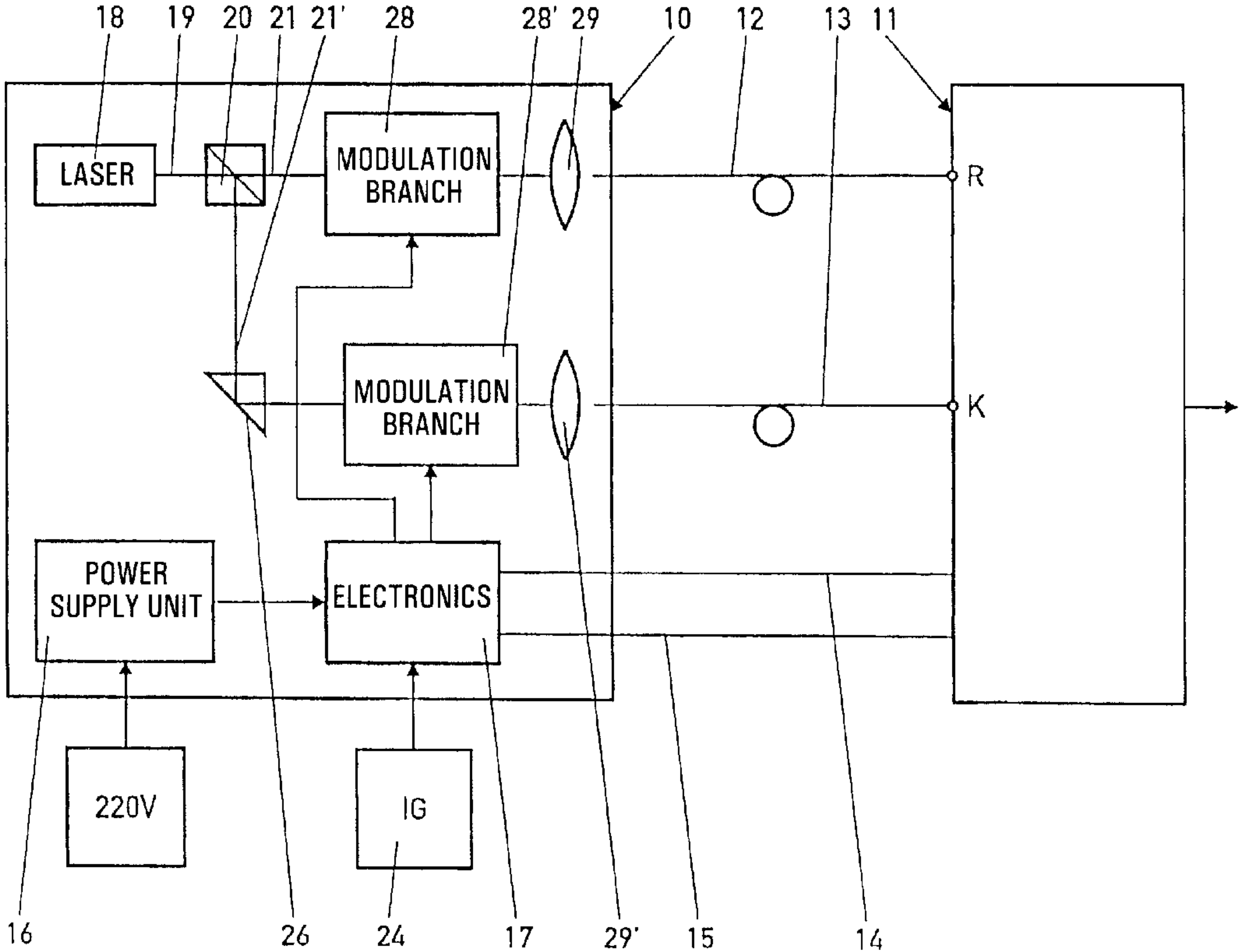
Fig. 4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