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[11] 3,594,065

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Continuation-in-part of application Ser. No. 567,456, July 25, 1966, now Patent No. 3,451,742.

[54] MULTIPLE IRIS RASTER

12 Claims, 9 Drawing Figs.

[52]	U.S. Cl.	350/160, 350/267
[51]	Int. Cl.	G02f 1/34
[50]	Field of Search	350/160, 266, 267, 269, 285

[56] References Cited

UNITED STATES PATENTS

3,451,742 6/1969 Marks 350/160

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Attorney—Albert F. Kronman

ABSTRACT: A variable light-transmitting panel is described having plural spaced electrostatic control electrodes. The control electrodes can be selectively energized to show a picture or other desired graphic information by modulating transmitted light or by controlling selected areas to alter the reflection coefficient of light. The control electrodes are mounted adjacent to a thin layer of nonconductive liquid containing a large number of minute crystal dipoles. The opaque portions of the raster are due to the random distribution of the dipoles caused by Brownian motion of the fluid molecules. Application of an electric field by the electrodes produces an alignment of the dipoles and permits the passage of light. A small mask may be positioned over each electrode area to block out any light produced by voltages below a threshold voltage.

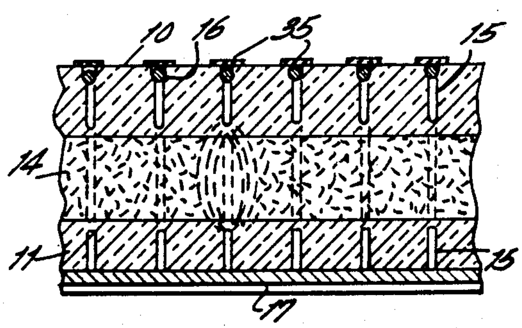


FIG. 1

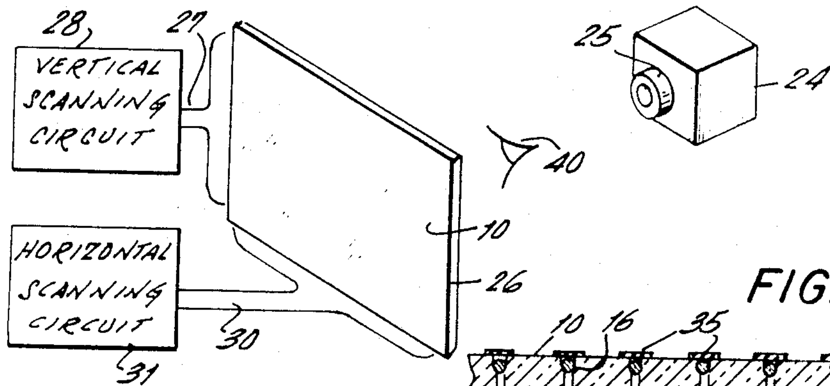


FIG. 2

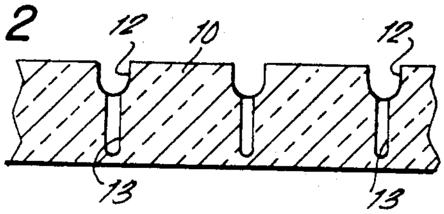


FIG. 3

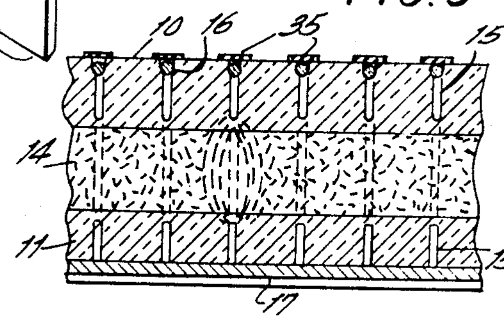


FIG. 4

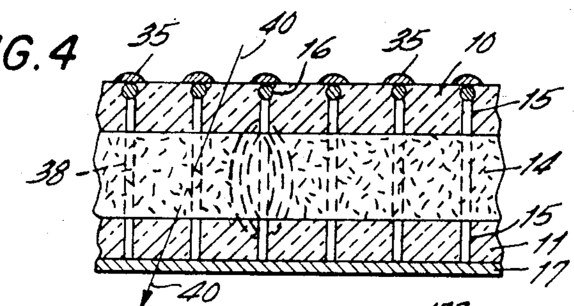
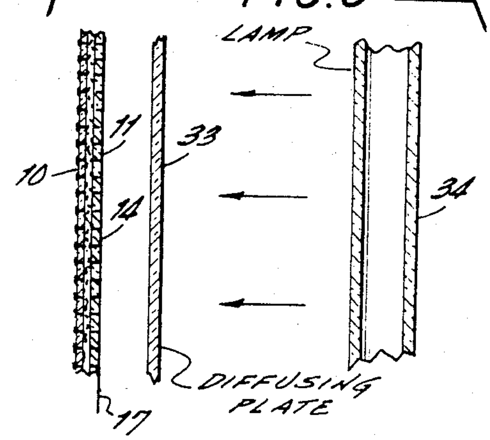


FIG. 5



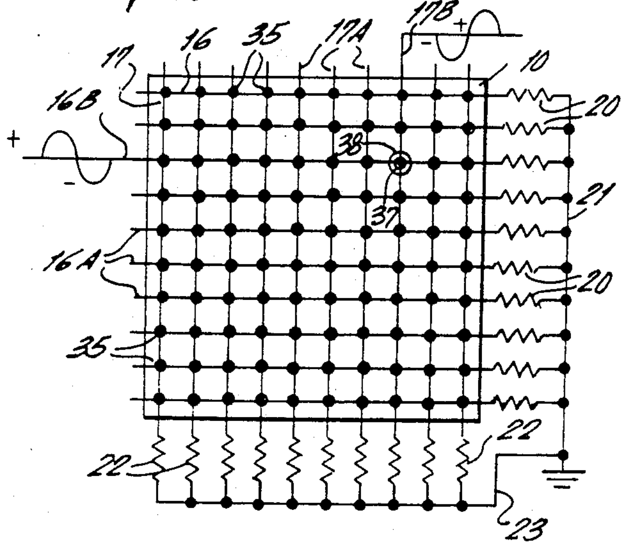


FIG. 6

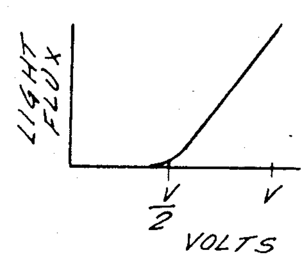


FIG. 7

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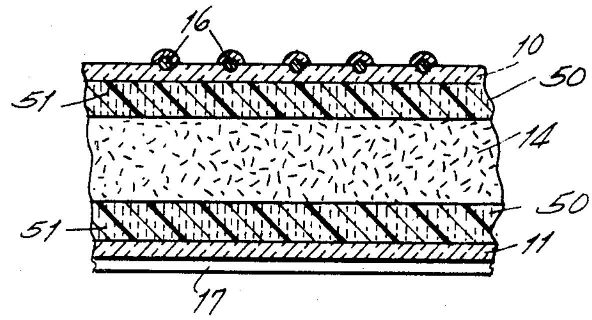
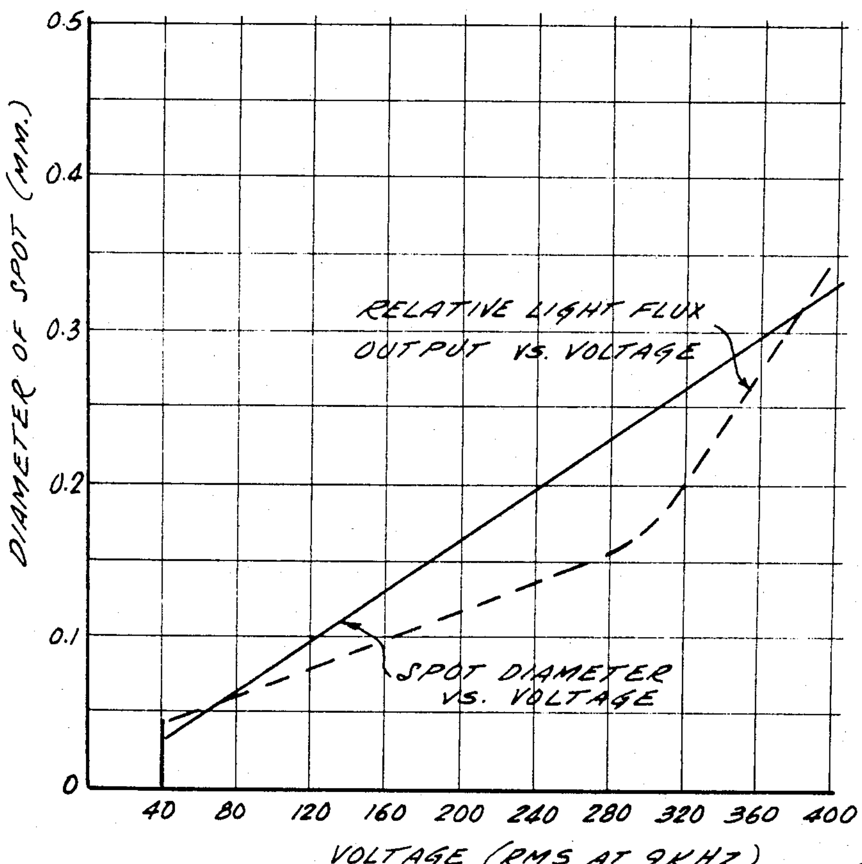


FIG. 8

FIG. 9



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MULTIPLE IRIS RASTER

This application is a continuation-in-part of an application for Multiple Iris Raster, filed July 25, 1966, Ser. No. 567,456, now U.S. Pat. No. 3,451,742, by Alvin M. Marks.

BACKGROUND OF THE INVENTION

This invention relates to a multiple iris raster for selectively passing portions of a light beam through desired minute areas. The invention has particular reference to a simple system of energizing the areas to form small well defined electrostatic fields and thereby align a large number of dipoles suspended in a liquid layer in said areas. The phenomena associated with the alignment of tiny dipoles in an electric field and the dipole movements due to Brownian bombardment have been known for some time and various attempts have been made to control their positions to modulate transmitted light. Generally, the results have not been satisfactory because the application of the electric field was not confined to a small area and the definition of the transmitted light was poor. The present invention employs a plurality of equally spaced crossed electrodes connected to a plurality of conductive pins which extend toward the fluid layer forming a plurality of axial point to point electrodes. The electric fields produced by this arrangement are well defined and more intense than those produced by prior art structures.

The dipoles used in the liquid cell should be quite small, having a length of about one-third to one-half of the wavelength of the transmitted light. Also, the dipole particles must have a width and thickness which is less than one-tenth of the wavelength of the incident light. Dipoles may be made of crystals such as Herapathite or metal crystals which have a natural elongated or asymmetric shape, such as a plate or rod. While larger dimensions may be used, these are generally not preferred since the small particles serve to pass or cut off the incident light and quickly respond to the action of the fluid molecules to form an opaque mass due to their statistical random position.

A minimum critical field intensity or threshold field must be applied before any substantial alignment of the dipoles is accomplished. When the field intensity is less than critical, the Brownian motion of the liquid molecules is sufficient to provide a random position to most of the dipoles so that very little light can pass through the cell. When the field intensity across opposed electrodes is greater than the critical voltage, a narrow cylindrical space is filled with aligned dipoles and a small quantity of light is transmitted. As the voltage increases, the diameter of the cylindrical space is increased, passing more light. It has been found that a linear relationship exists between the diameter of the light spot, the transmitted light flux and the applied voltage above the critical value. To provide a sharp threshold in the light transmission at the critical voltage, suitable masks have been added to the cell structure to eliminate transmitted light below the threshold voltage.

With a dipolar suspension containing ions, the application of a direct current voltage to the electrodes causes a temporary alignment of dipoles and then disalignment causing a momentarily transparent spot. The dipoles quickly disalign due to the formation of a shield of positive ions at the negative electrode, and vice versa. This shield can be avoided by the application of an alternating current voltage having a half period which is less than the relaxation time of the dipole particle. If the half period is of the order of the relaxation time, the dipoles tend to disalign during the time the electric field intensity is going through zero. Such alternate alignment and disalignment produces turbulence in the suspension and the result is a poorly defined transmitted light beam. The frequency of the aligning voltage is preferably within the range of 0.01 to 10 megahertz. With a nonionic dipolar suspension, such as a metal dipole particle in a nonionic fluid (silicone, aliphatic, aromatic, ester, fluoro carbon, or others, or mixtures thereof) a DC field may be used and the pin electrodes may be in contact with the fluid layer, as shown in FIG. 4. When ions are present a transparent insulating layer must be employed between the electrode pins and the dipole fluid layer, as shown in FIGS. 2 and 3.

The average energy applied to the dipoles by the impact of the liquid molecules corresponding to a threshold voltage E_r of about 100 volts /cm. Since the dipole rod is about 2×10^{15} cm. long this provides a potential difference across the dipole rod of about 2×10^{13} volts. The impacts are random in direction, causing a random direction of the dipoles thereby producing an opaque layer. The aligning field intensity must exceed the critical value E_r to produce light transmission.

One of the features of the present invention is a plurality of spots in a raster which operate to produce light transmission in a time interval of the order of 1 microsecond.

Another feature of the invention is the provision of a large flat display panel which can be used in connection with a television receiving circuit.

For a better understanding of the present invention, together with other details and features thereof, reference is made to the following description taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is an isometric view showing the raster, an external illumination means, and two scanning circuits (shown in block) which apply voltages to the raster electrodes.

FIG. 2 is a cross-sectional view on an enlarged scale showing a portion of one of the raster plates indicating its construction and the method of forming the plate prior to the positioning of the conductive electrodes and pins.

FIG. 3 is a cross-sectional view on an enlarged scale showing a portion of the raster cell with details of the pins, insulated from a fluid layer containing a suspension of dipoles and free ions.

FIG. 4 is a cross-sectional view similar to FIG. 3 but showing the pins penetrating the first and second transparent plates to contact a nonionic fluid layer containing a suspension of dipoles.

FIG. 5 is a cross-sectional view of another arrangement showing the raster, a diffusing plate, and an illumination means behind the diffusing plate which may be a gaseous discharge device.

FIG. 6 is a plan view of a portion of the raster showing the external connections of the crossed electrodes and the positions of the masks.

FIG. 7 is a graph showing the relationship of the applied voltage to the transmitted light flux.

FIG. 8 shows a means of employing a random aligned conducting dipole suspension layer in lieu of the pins using capacitive contact.

FIG. 9 shows light flux and spot diameter versus voltage applied between pin pairs.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the figures, the raster includes two spaced parallel plates 10 and 11, shown in detail in FIGS. 3 and 4. These plates are made of transparent nonconductive material such as glass or Lucite. Prior to assembly, each of the plates is formed with a series of spaced parallel grooves 12, (best shown in FIG. 2) on the outer faces thereof. A plurality of holes 13 are drilled or formed in the plates normal to the faces to accommodate pins 15 which will be inserted later. Each hole 13 is drilled or formed at the bottom of a groove 12. After the pins 15 have been inserted into the plates, electrical conductive material 16, 17 is deposited in the grooves 12 to form the crossed electrodes. The plates are then mounted adjacent to but spaced from each other and sealed around their edges, with the grooves 12 of one plate mounted at 90° to the grooves on the other plate. The space between the plates is then filled with a suspension of a nonconductive transparent fluid and dipole particles 14. As shown in FIG. 6, the electrode material

16, 17 on each plate is connected to lead-in conductors 16A on one side for one plate and to similar lead-in conductors 17A for the other plate. In FIG. 3, these conductors are for the application of alternating current signals to modulate the transmission of the suspension 14 On the other side of plate 10 the electrodes 16A are connected to resistors 20 and a grounded conductor 21. In a similar manner the electrodes 17A in plate 11 are connected to resistors 22 and a grounded conductor 23.

Pins 15 on one plate are positioned along the length of the electrode 16A and spaced apart from each other a distance equal to the spacing of the electrodes 17A in the other plate. This arrangement produces a pattern of pins and electrodes in which each pin on one plate is opposite and in line with a pin on the other plate. The pins 15 are generally arranged so that they penetrate each plate 10, 11 for about 90 percent of the plate's thickness. With this construction, the pins are not in direct contact with the fluid between the plates. This construction is shown in FIGS. 2 and 3. In certain applications where longer pins are used, these pins, as shown in FIG. 4, traverse the entire thickness of plates 10 and 11 and make contact with the fluid suspension 14.

Referring now specifically to FIG. 1, one of the uses of the iris raster is shown. A source of illumination, such as an incandescent lamp (not shown), is mounted within a lighttight container 24. The light from this source is focused by a lens 25 onto the assembled raster to provide substantially equal illumination over the entire raster area. In this illustration light is reflected from a reflective layer 26 at the rear of the raster forward to the observer's eye 40. The electrodes 16A on one edge of the raster are energized by pulse circuits and a delay line generally indicated in FIG. 1 as vertical-scanning pulse circuit 28 as previously described in my U.S. Pat. No. 2,670,402 issued Feb. 23, 1954. In a similar manner, the electrodes 17A are connected to a horizontal-scanning pulse circuit 31. Pulse circuit sources 28 and 31 may be a pulse circuit and delay line. The delay lines may be of any suitable type, such as inductance-capacitance, diode or triode transistors, preferably as miniature or microminiature circuits capable of controlling voltage pulses in a predetermined sequential manner.

It is obvious that this type of raster can be used for many different purposes, one of them being the showing of a television picture. When a television picture is to be shown, the picture signal is fed in from a picture amplifier which is added to the voltage pulse. Each electrode receives a voltage pulse in a timed sequence which starts from the left-hand edge and moves to the right-hand edge in synchronism with the received television signal. During each horizontal application of pulses one of the electrodes is energized by the applied pulse plus the picture signal. During the next horizontal application of pulses, the next lower electrode is energized. As the process continues, a complete pattern of the entire raster is energized and at the end of the frame time interval, all the pin pairs, where light is to be transmitted, will then have received voltage pulses which establish an electrostatic field between them thereby aligning dipoles in those areas. The alignment varies according to the applied voltage so as to provide a light flux proportional to the voltage above a threshold voltage. The diameter of the light spot is also proportional to the applied voltage in a certain range (see FIG. 9).

As explained above, a threshold voltage is preferably maintained across opposite pin electrodes 15 by applying an alternating voltage of the order of 10 to 100 volts. This voltage is the minimum critical voltage (V/2 in FIG. 7) above which the dipoles start to align, thus forming circular dots of transmitted light between opposite pin electrodes 15. Upon the application of the additional voltage from the television picture signal, the spot diameter of aligned dipoles in the selected areas within the suspension 14 increases to form small transparent annular areas permitting light to pass through the raster at those places thus modulating the spot transmission in accordance with the signal voltage. An increase in voltage expands the annular areas and permits more light to pass. When the voltage is removed, the dipoles again are disaligned by Brownian action to form an opaque nontransmitting area.

FIG. 5 shows an alternate means of illumination of the dipole suspension from the rear to show a picture. A diffusing plate 33, which may be ground glass, diffuses the light from a plurality of gaseous discharge lamps 34, only one being shown in FIG. 5. This form of display has very little thickness and may be used as a self luminous "picture on the wall" "flat" television screen, or data display screen.

FIGS. 3, 4, and 6, each show a small round mask 35 placed at each electrode crossover. These masks cut off the light which might be transmitted by the suspension below a chosen threshold voltage. As explained above and shown graphically in FIG. 7, a voltage of about half the maximum voltage of the sum of the signal and pulse voltages produces a light cutoff. Below a given voltage (40 volts as in FIG. 9) the tendency to align the dipoles is matched by the energy of the liquid molecules to produce Brownian motion and this provides cutoff. If a greater threshold voltage is required then a circular mask of suitable diameter is used, for example, 0.3 mm. if the electrode spacing is 0.6 mm. As might be expected, this voltage is not definite and varies with electrode spacings, fluid thickness, dipole concentration, and other factors.

When the display is operated, the applied voltage is not directly proportional to the light values desired to be produced. Instead, zero light transmission is denoted by a voltage of half the maximum voltage. If the maximum voltage is set at 100 volts, then the opaque condition must occur from 0 to 50 volts, half transmission at 75 volts and full transmission at 100 volts. Such a system results in a linear correspondence between signal voltage values and light transmission as indicated by the straight portion of the curve shown in FIG. 7.

The signal voltages are applied to conductors 16A and 17A (see FIG. 6) and thereby produce a voltage on the conductors because of the potential drop across resistors 20 and 22. All those conductors which receive no signal are at ground potential because they are connected through resistors 20 and 22 to ground. Since each conductor 16A receives a positive voltage at the same time a conductor 17A receives an equal negative voltage, they are always at a voltage which is V/2 reactive to ground.

Let it be assumed that the maximum signal voltages of +50 volts are applied to vertical conductor 17B and −50 volts to horizontal conductor 16B. Then only at the cross over position 37 is there a potential difference of 100 volts, and a maximum light transmission is thereby effected in the dipole suspension at the cross over point shown as the area indicated by the circle 38. At the same time a potential difference of 50 volts is applied to the suspension at all other points on conductors 16B and 17B. This series of voltages produces no light transmission, as indicated below V/2 in FIG. 7, and in FIG. 4. The random distribution of dipoles adjoining the vertical pencil of aligned dipoles blocks light. At all other signal voltages less than the maximum value there is no tendency to produce misplaced pencils since the side voltages are always one-half the signal voltage, and elsewhere the voltages between the pins are zero, except at the cross over where the full voltage is applied, and the light spot appears.

With the device shown in FIG. 4, in which the pins contact the fluid and when a nonionic fluid is preferably used, an AC or DC voltage may be employed.

In the device shown in FIG. 3, in which the pins are insulated from the fluid, the fluid may be ionic or nonionic and an AC voltage preferably above 5 kHz. is then used to prevent ionic migration and blocking of the voltage used to align the dipoles.

Herapathite dipole suspensions generally are ionic and require the device shown in FIG. 3, while metal or other conductive materials form dipoles without ions in a nonionic fluid and may be used with the device of FIG. 4.

In the device shown in FIG. 8, a layer of transparent plastic or glass material 50 is adhered to the faces of the plates 10, 11 facing the dipole suspension 14 A plurality of electrically conductive dipoles 51 such as metal whiskers or elongated crystals are embedded in the plastic material. The dipoles 51 are permanently aligned normal to the major faces of the layer material 50 and parallel to the path of the light through the raster panel. Alignment of the dipoles 51 can be achieved while the plastic or glass is in a viscous state by the application of a suitable electric or magnetic field.

The device shown in FIG. 8 is similar to that shown in FIG. 4 in all other respects except that the pins 15 may now be omitted. Contact is made at the cross over points by the capacitive effect of the metal dipoles which is greatest where the distance between the electrode lines is least.

In the above disclosure an iris raster has been described which is operated by signal voltages applied to a series of vertical and horizontal electrodes. Pins or aligned dipoles are used to concentrate the field in the dipole fluid suspension at the cross over points of the X and Y electrodes. Vertical and horizontal electrodes are connected through resistors to ground. The dipolar suspension is of a nature to respond by transmitting light above a threshold electric field E_r. At points where light must not be transmitted an artificial threshold consisting of small masks 35 may be used over the center of the spot.

Having thus fully described the invention, what I claim as new and desire to be secured by Letters Patent of the United States, is:

1. A multiple iris raster comprising; a first transparent nonconductive plate forming one boundary of the raster, a second transparent nonconductive plate spaced from the first plate and forming the other boundary of the raster, a transparent nonconductive fluid held between said first and second plates, a plurality of dipole particles in said fluid, a plurality of spaced parallel electrodes secured to said first plate with means for connection to an external circuit, a plurality of spaced parallel electrodes secured to said second plate and positioned at right angles to the electrodes in the first plate with means for connection to an external circuit, a plurality of conductive pins secured in the first and second plates, each pin positioned along said electrodes and in contact therewith, each of said pins mounted normal to the surface of said plates and each pin in one plate mounted opposite to a pin in the other plate, and threshold means consisting of an opaque mask mounted at each of the pin positions on one of the plates to prevent the passage of light through the raster below a selected voltage.

2. A multiple iris raster as claimed in claim 1 wherein each of said conductive electrodes in the first and second plates is connected through a resistor to a common conductor to ground.

3. A raster as claimed in claim 1 wherein said conductive electrodes in the first plate are sequentially connected to a signal source of alternating current at the same time said conductive electrodes in the second plate are sequently connected to the same signal source but having a reversed polarity.

4. A raster as claimed in claim 1 wherein said dipole particles have a length which is about one-third the wavelength of visible light and a diameter which is less than one-tenth of said wavelength.

5. A raster as claimed in claim 1 wherein said pins extend only part of the distance through the plates and are not in contact with the fluid.

6. A raster as claimed in claim 1 wherein said pins extend all the way through the plates and make contact with the fluid between the plates.

7. A raster as claimed in claim 1 wherein said first and second plates are substantially flat and parallel to each other and thereby define a fluid chamber having parallel surfaces.

8. A raster as claimed in claim 1 wherein said dipole particles are elongated optically active dichroic crystals formed by precipitation from a liquid solution.

9. A raster as claimed in claim 1 wherein said dipole particles are made of Herapathite.

10. A raster as claimed in claim 1 wherein said dipole particles are made of assymetric metal particles.

11. A raster as claimed in claim 1 wherein said pins are spaced along said electrodes at a distance equal to the distance between the electrodes on the other plate.

12. A multiple iris raster comprising a first transparent nonconductive plate forming one boundary of the raster, a second transparent nonconductive plate spaced from the first plate and forming the other boundary of the raster, a transparent nonconductive fluid held between said first and second plates, a plurality of dipole particles in said fluid a layer of transparent plastic material on the fluid side of each of the transparent plates between the plates and the fluid, a plurality of electrically conductive dipoles permanently aligned normal to the plate faces and carried within the plastic layers, a plurality of spaced parallel electrodes secured to the first plate with means for connection to an external circuit, a plurality of spaced parallel electrodes secured to the second plate and positioned at right angles to the electrodes in the first plate with means for connection to an external circuit, said electrically conductive dipoles within the plastic layers providing a capacitive path to control the electric field in the dipole layer between the plates, and a threshold means to prevent passage of the light through the raster below a selected voltage.