350-392 SR OR 2,163,550 1025W W/ Search Roo

June 20, 1939. S. L. CLOTHIER ET AL 2,163,550

MULTIPLE CELL LIGHT MODULATOR

Filed Oct. 15, 1936 3 Sheets-Sheet 1

T257

Fig. 1.

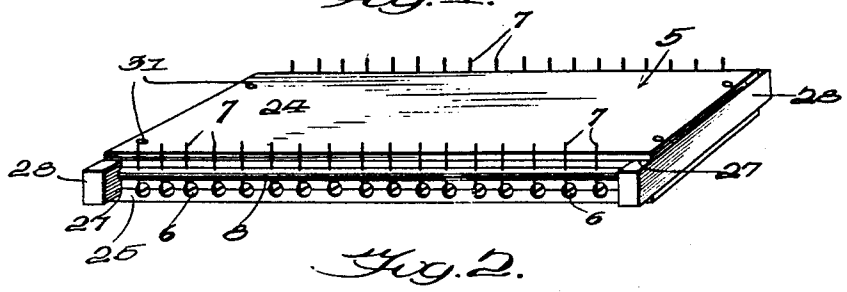


Fig. 2.

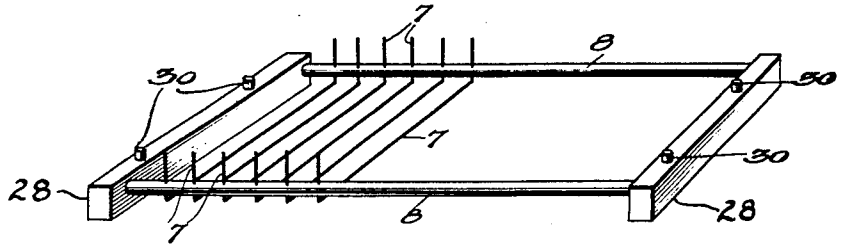


Fig. 3.

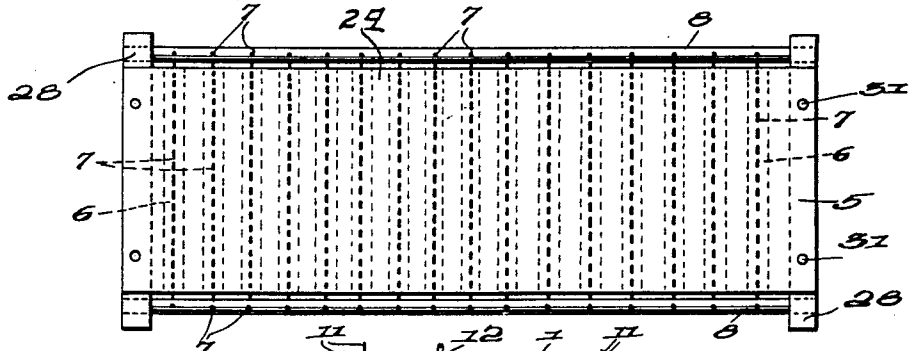
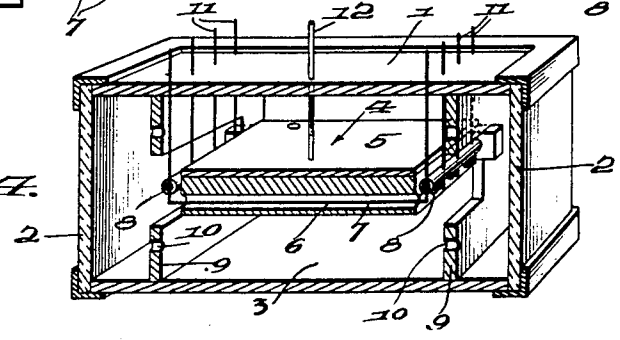


Fig. 4.



Inventors

Stewart L. Clothier

Harold C. Hogencamp

By

Attorneys

3. OPTICS
51
Search No

June 20, 1939. S. L. CLOTHIER ET AL 2,163,550

MULTIPLE CELL LIGHT MODULATOR

Filed Oct. 15, 1936 3 Sheets-Sheet 2

Fig. 5

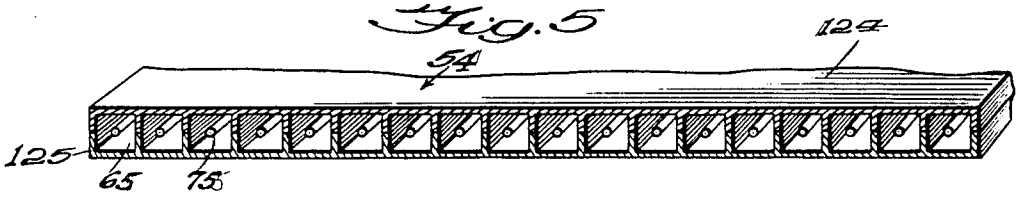


Fig. 6.

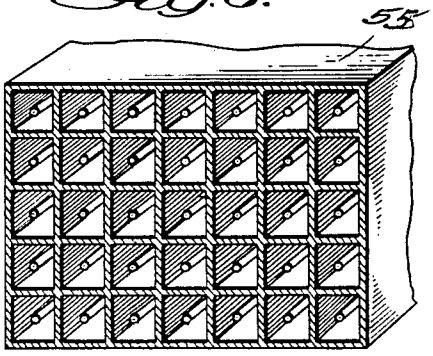


Fig. 7.

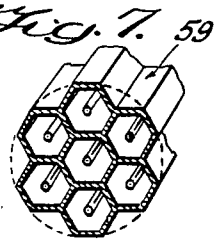


Fig. 8.

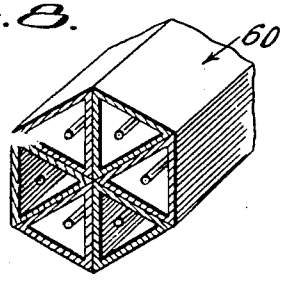


Fig. 9.

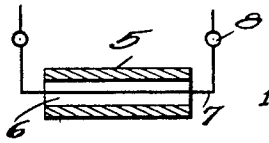


Fig. 10

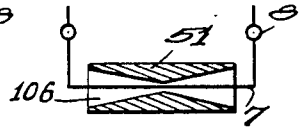


Fig. 11.

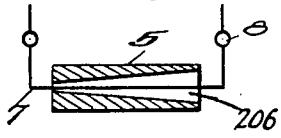


Fig. 12.

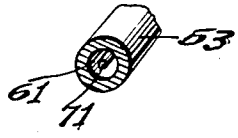


Fig. 13.

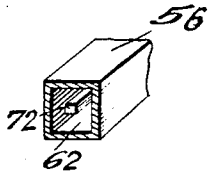


Fig. 14.

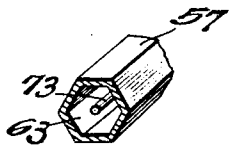
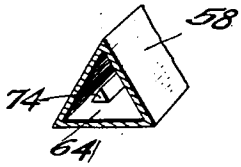


Fig. 15.



Inventors

Stewart L. Clothier

Harold C. Hogencamp

By

Attorney

Search Roo

June 20, 1939. S. L. CLOTHIER ET AL 2,163,550

MULTIPLE CELL LIGHT MODULATOR

Filed Oct. 15, 1936 3 Sheets-Sheet 3

Fig. 16.

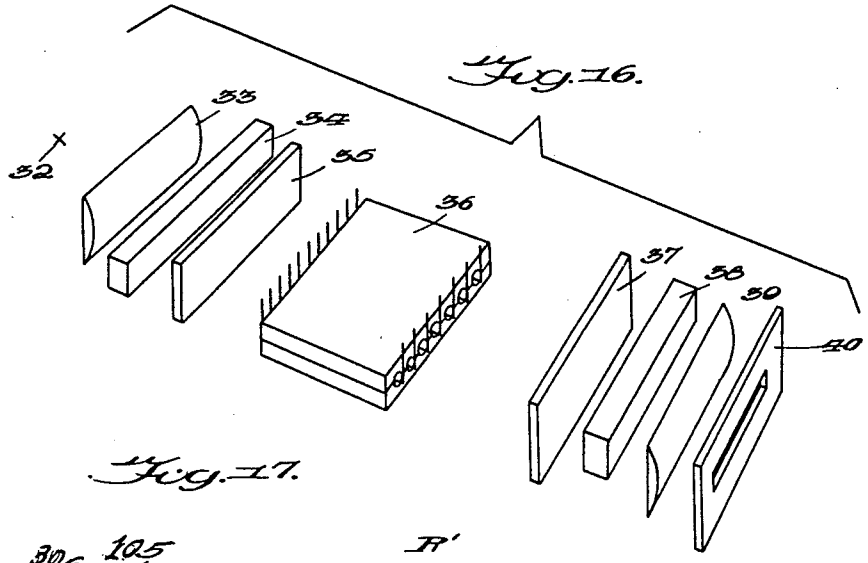
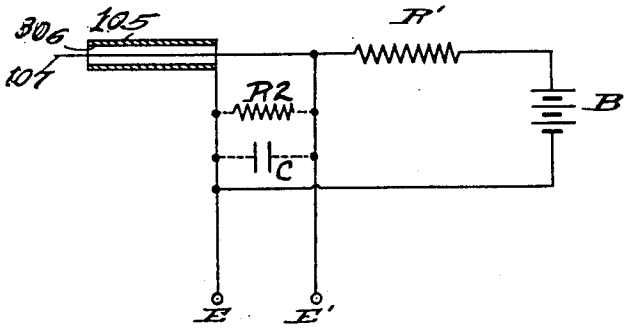


Fig. 17.



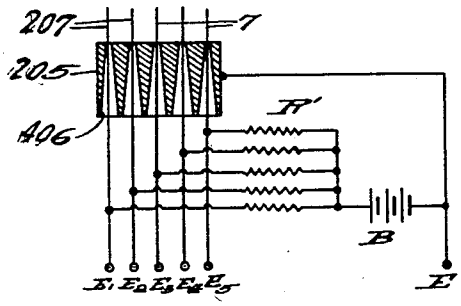
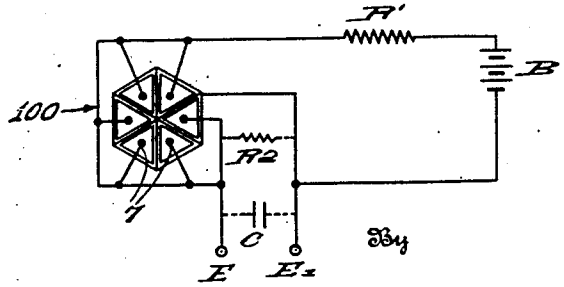


Fig. 18.

Fig. 19.



Inventors

Stewart L. Clothier

Harold C. Hogencamp

By

Attorney

88 Search Roc
61

Patented June 20, 1939 2,163,550

UNITED STATES PATENT OFFICE

2,163,550

MULTIPLE CELL LIGHT MODULATOR

Stewart L. Clothier, East Orange, and Harold C. Hogencamp, Irvington, N. J., assignors to Kolorama Laboratories, Inc., Newark, N. J., a corporation of New Jersey

Application October 15, 1936, Serial No. 105,649

2 Claims. (Cl. 88—61)

This invention relates generally to light modulating cells capable of exhibiting the Kerr effect when placed under suitable electric potential. More particularly, the invention is concerned with multiple Kerr cell units of the type disclosed in our copending application Serial No. 84,252 filed June 9, 1936 and of which this application is a continuation-in-part.

It has been found desirable for certain purposes to combine a plurality of Kerr cells into multiple cell units, the arrangement of the individual cells defining units of various configuration depending upon the particular use to which the unit is placed. One instance in which multiple cell units of this type might be advantageously used is in television systems wherein circularly polarized beams of light are arranged to be passed through the cells which have impressed thereon the desired modulating or signal potential. Kerr cells of the type disclosed in our copending application Ser. No. 83,588 filed June 4, 1936, now United States Patent No. 2,100,836, are ideally constructed for use as the individual cells of the multiple cell units here referred to, in that they are characterized by an outer electrode having a longitudinal bore within which is coaxially disposed a second electrode, the longitudinal bore of the cell defining the light path thereof. It is readily appreciated that cells of this type may be conveniently arranged in any desired grouping and that by proper arrangement of external biasing and modulating circuits, each cell of the unit may be controlled individually or, if desired, all of the cells or certain desired groups of cells of a unit may be jointly controlled from a single biasing and modulating or signal circuit.

In our copending application filed Oct. 15, 1936 and bearing Serial No. 105,648 we have shown various modifications of electrode structure which facilitates grouping of the cells such as shown and previously referred to in application Ser. No. 83,588, with a view to minimizing the loss of light from a beam passing through the multiple cell unit.

With these facts in mind the present invention has as its object the provision of a multiple cell unit of the Kerr type comprising a plurality of light modulating cells, the respective light axes of which are disposed in general parallelism.

A further object of the invention is to provide in a multiple Kerr cell unit of the type indicated, means for selectively and independently controlling all or any particular fractional part of the individual cells of a multiple cell unit.

A further object of the invention is to provide means for controlling a light modulating cell of the Kerr type in a manner to insure a desired degree of retentivity and residual modulation within the cell so that the period of modulation may be prolonged beyond the time during which the modulating impulse continues.

A further object of the invention is to provide a multiple Kerr cell unit wherein all like electrodes are connected to a common controlling circuit whereby a beam of large cross-sectional area can be instantaneously modulated.

In the accompanying drawings we have illustrated certain preferred forms of the invention, but it is to be understood that these illustrations are but for the purpose of example only and not as defining the limits of our invention, which are set forth more particularly in the appended claims.

In the accompanying drawings:

Fig. 1 is a perspective view showing the electrode construction of the multiple cell of Fig. 4.

Fig. 2 is a perspective detail view showing the manner in which the inner electrodes are mounted on the electrode supports.

Fig. 3 is a plan view of the construction shown in Fig. 1.

Fig. 4 shows a perspective view partly in section of a light modulating cell unit comprising a plurality of Kerr cells.

Figs. 5, 6, 7 and 8 are perspective views partly in section showing other forms of multiple cell units having slightly different forms of cell groupings.

Figs. 9, 10 and 11 are longitudinal sectional views showing modified forms of configurations for the bore of the outer electrode.

Figs. 12, 13, 14 and 15 are perspective views partly in section showing modified forms of the electrode construction suitable for use in cells of the present invention.

Fig. 16 is a diagrammatic view of a multiple cell unit of this invention shown associated with a circular polariscope.

Figs. 17, 18 and 19 are diagrammatic views showing different modes of controlling the modulating effect of the cells.

As hereinbefore indicated, the present invention contemplates combining a plurality of light modulating cells of the Kerr type and such as illustrated in our copending application Ser. No. 83,588 filed June 4, 1936, in certain specified groups to form multiple cell light modulating units. Thus, in Fig. 4 we have shown one form in which a multiple cell light modulating unit

may be arranged. 1 designates a suitable container provided with transparent window members 2, 2, said windows being aligned with reference to the light axis of the cell. The container 1 is filled with a suitable birefringent medium 3 such as nitrobenzene and the like, and immersed within said fluid is a multiple cell unit indicated generally by the reference character 4. The cell unit 4 comprises an outer electrode 5 having a plurality of parallelly disposed bores 6 extending therethrough and disposed in general alignment with the transparent windows 2, 2. Disposed coaxially within each of the bores 6 is an electrode 7 suitably supported by rods of insulating material 8, 8. The electrodes 7 may be supported and properly positioned within the container 1 by any suitable means such as the supporting diaphragms 9, which diaphragms may be suitably perforated as at 10 to provide for circulation of the birefringent medium around the electrodes and bores thereof. The electrodes 7 extend through the upper wall of the container 1 and are provided with exterior terminal portions 11. The electrode 5 is similarly provided with a connection 12 extending exteriorly of the casing 1 whereby a suitable biasing potential may be applied to said electrodes 11 and 12, if desred. It will be understood that upon the application of a suitable potential to said electrodes, said cell will function to modulate a beam of light passing therethrough in accordance with variations in potential applied to said electrodes.

In Figs. 1, 2 and 3 we have shown more in detail one form of construction for making the electrodes of a multiple cell unit such as shown in Fig. 4. Referring to Figs. 1, 2 and 3, the outer electrode 5 of Fig. 1 is shown as comprising a pair of plate members 24, 25 arranged in superposed relation and each being provided with complemental semi-cylindrical recesses which, when the plates are assembled as shown, cooperate to form the longitudinal bores 6. The plates 24 and 25 are each provided at adjacent ends thereof with a rabbett 27, said rabbetts cooperating when the plates are associated in superposed relation, to form a recess within which is housed an end block or frame member 28. The opposite end blocks 28 are connected by suitable rods 8 of glass or other insulating material, which also function to support the inner electrodes 7 in position such that when the outer electrode plates 24 and 25 are assembled therewith, said inner electrodes are disposed coaxially within the bores 6 of said plates. As shown in Fig. 3, the end blocks 28 are dimensioned to dispose the rods 8 slightly beyond the faces of the plates 24 and 25 which are penetrated by the bores 6 and above the axes of said bores so as to dispose the rods 8 out of line of the path of light passing through the respective bores of the cells. The plates 24 and 25 are preferably made of nickel and the electrodes 7 may conveniently be made of tungsten wire. However, any suitable conducting material may be employed for either or both electrodes, but it is desirable to maintain the strand-like or filamentary form of the inner electrode in order to keep the inherent capacity of the cell to a negligible minimum.

For the purpose of facilitating alignment of the electrodes 7 with their respective bores 6 in the plates comprising the outer electrode 5, the end plates 28 may be suitably provided with positioning pins 30 which cooperate with suitably provided apertures 31 in the plates 24, 25.

It will be understood that the form of the invention illustrated in Figs. 1 to 4 inclusive is merely representative of many possible constructions, all of which are characterized by a desired grouping of individual light modulating cells having coaxially disposed electrodes, the light axes of the respective cells being arranged substantially parallel to the beam of light to be passed through said unit. It will also be understood that whereas in Figs. 1 to 4 inclusive the outer electrode 5 is shown provided with a substantially cylindrical bore, this bore may have any desired configuration, some of the preferred forms of which are shown in Figs. 9 to 15 inclusive. Thus, in Fig. 9 the arrangement corresponds generally to that of Figs. 1 to 4 inclusive. In Fig. 10 the bore 106 comprises conical recesses extending inwardly from the ends of the electrode 51 with their apices meeting at a plane substantially midway between the ends of the electrode and defining at that plane a restricted aperture or constriction within the bore, whereas in Fig. 11 the bore 206 is tapered from a maximum at one end of the electrode 52 to a minimum at the opposite end thereof. It will be noted that in all of these figures the inner electrode 7 is disposed coaxially with respect to the bores of the respective outer electrodes.

In the constructions shown in Figs. 12 to 15 inclusive, the electrodes are all characterized by a coaxial disposition of the inner and outer electrodes. In Fig. 12 the outer electrode 53 is substantially cylindrical and is provided with a substantially cylindrical bore 61 having a strand-like electrode 71 disposed coaxially within the bore. In Figs. 13, 14 and 15, the outer electrode in each instance is shown provided with a bore which in cross-sectional configuration corresponds to regular geometrical figures. Thus, in Fig. 13 the bore 62 is substantially square in cross-sectional configuration. In Fig. 14 the bore 63 is substantially in the form of a hexagon and in Fig. 15 the bore 64 is shown in the form of a triangle in cross-sectional contour. It is also to be noted that in Figs. 12 and 15 the configuration of the inner electrodes 71, 72, 73 and 74 conforms respectively, to that of the bores 61, 62, 63 and 64, the opposed surfaces of the respective inner and outer electrodes being generally parallel to each other. The novel formation of the outer exterior surface of the electrodes 56, 57 and 58 of Figs. 13, 14 and 15 will be hereinafter referred to.

In Fig. 5 we have shown one modification of the multiple cell unit shown in Figs. 1 to 4 inclusive, the construction in Fig. 5 comprehending an outer electrode 54 having multiple bores 65 therethrough, which bores are shown rectangular in cross-sectional configuration. The plates 124 and 125 comprising the outer electrode 54 may be formed with complemental rectangular recesses similar to the manner in which the plates 24 and 25 of the construction shown in Figs. 1 to 4 are fashioned. The inner electrodes 75 in Fig. 5 may be supported in the same general manner as indicated in the construction in Figs. 1 to 4 and the combined electrode structure including the outer electrode 54 and the inner electrodes 75 may be supported within a container such as 1 of Fig. 4 in any desired manner.

It is further to be understood that wherein we have shown in Figs. 1 to 5 inclusive the relatively small number of individual cells grouped to form a multiple cell unit, conditions in actual practice may be such that it is found desirable to unite large numbers of the cells to form multiple cell units of greater magnitude than those

here shown. Thus, it is conceivable that under certain conditions it may be desirable to combine in a desired grouping 100 or more such cells.

It is to be noted that the disposition and arrangement of the individual cells of the unit shown in Figs. 1 to 5 inclusive is such as to comprehend a single line of cells, or in other words, the grouping of the cells is such that the light axes of the several cells comprising the unit are disposed in a common plane. It is conceivable that in actual practice it may be found desirable to arrange the cells comprising the unit in a manner such that the general configuration of the resulting multiple cell unit has a radically different form than that shown in Figs. 1 to 5.

Thus, in Fig. 6 we have illustrated a construction which would result from the superposition of five such units as shown in Fig. 5. In the form of the invention shown in Fig. 6 the multiple cell unit may comprise superposed units such as shown in Fig. 5, or the outer electrode **55** may be formed from sheet metal after the general manner in which honey-comb radiators are made.

In Figs. 7 and 8 are shown further modified forms of external electrode construction **59** and **60**, respectively, both of which are susceptible to the honey-comb construction referred to above in connection with Fig. 6. However, the individual cells of units such as shown in Figs. 6, 7 and 8 may comprise cells having exterior electrodes corresponding to those of Figs. 13, 14 and 15, respectively, wherein the exterior electrodes are formed from regular solid geometrical figures, the flat, symmetrically disposed sides of which facilitate grouping of the individual cells in the manner suggested in Figs. 6, 7 and 8. Thus in Fig. 13 the outer electrode **56** is rectangular in cross-section, the electrode **57** of Fig. 14 is hexagonal in cross-section, and the electrode **58** of Fig. 15 is triangular in cross-section.

In Fig. 16 is diagrammatically shown a multiple cell unit of the type disclosed in Figs. 1 to 5 inclusive, operatively associated with an optical system in the form of a circular polariscope. The optical system includes a source of light **32** which may be in the form of an illuminated incandescent filament, a quartz mercury glow tube, a plurality of arcs or any other suitable source. Light from the source **32** is arranged to enter a cylindrical lens **33** from which it passes through a calcite block **34** and thence through a one-quarter wave plate **35**. At this point there is interposed in the optical system a multiple cell unit **36** of the type previously described. Light passing through the cell unit **36** passes successively through the one-quarter wave plate **37**, the calcite block **38** and the cylindrical lens **39**. **40** represents a slotted aperture plate through which the modulated light passes.

In the arrangement shown in Fig. 16 it will become readily apparent that the light beam will in effect be divided into fractional parts by the electrode walls separating the individual cells and that one fractional part of the beam will pass through each cell of the unit. Thus, with proper external electrical circuits such as shown in the drawings and hereinafter more fully described, it becomes a simple matter to separately modulate each fractional part of the beam.

With multiple cell units of other configurations such as those shown in Figs. 5 to 8, optical systems employing light beams of other cross-section can be employed. For example, the more common beam of circular cross-section could be more advantageously used in some instances, thus permitting the use of circular lenses instead of the cylindrical lenses employed in Fig. 16.

Figs. 17, 18, and 19 show preferred forms of circuit arrangements for controlling the modulating effect of the cells or cell units of the present invention. In Fig. 17, for the sake of simplicity, a single light modulating cell is shown comprising outer electrode **105** having longitudinal bore **306** within which is coaxially disposed the inner electrode **107**. The inner electrode **107** is connected to a control circuit including a resistance R′ and a source of potential B. The opposite terminals of the potential source B are connected to the outer electrode **105**. It will be understood that the circuit thus far described is utilized to place a suitable biasing potential upon the electrode of the cell. The modulating or signal energy is applied to the cell through the terminal leads E, E′. We have found that by choosing a resistance R′ of suitable value and connecting the same between the source of potential B and the inner electrode **107**, a certain degree of modulation retentivity is imparted to the cell. In other words, the period of modulation in response to a given modulating impulse may be prolonged beyond the time during which the modulating impulse prevails. This residual modulation inertia or retentivity may be further accentuated by a second resistance R^2 shunted between the terminals E, E′. In like manner a condenser C of proper capacity might be shunted between the terminals E, E′ to accentuate this retentivity. If desirable, the condenser C may be connected in parallel with the resistance R^2. However, it will be understood that the use of the resistance R^2 and the condenser C is optional and that in most instances the single resistance R′ functions to produce the desired results.

In Fig. 18 we have shown for the purpose of example, a multiple cell unit wherein the bore **406** of the outer electrode **205** conforms to the form shown in Fig. 11 of the drawings. In the circuit arrangement here shown the outer electrode **205** common to all of the cells, is connected to one side of the potential source B, whereas the respective inner electrodes **207** of the cells are connected through resistance elements R′ to the opposite side of the potential source B. By this arrangement each cell acts individually to modulate the fractional part of the light beam which passes therethrough in accordance with the potential applied thereto through terminals E′, E^2, E^3, etc.

In Fig. 19 we have shown for the purpose of example a multiple cell unit **100** such as shown in Fig. 8 of the drawings connected to the potential source B in a manner such that like electrodes of all of the cells have the same potential. In this arrangement it will be understood that the individual cells of the unit all combine to form a unitary multiple cell and that all portions of light passing through the respective bores of the individual cells are similarly and concurrently modulated.

From the foregoing specification it is apparent that we have provided means for forming and constructing multiple Kerr cell light modulating units of any desired configuration, the individual cells of which may, by properly designing the control circuits therefor, be made to fractionally modulate a beam of light passing through such multiple cell unit, or all of the cells may be controlled to concurrently and similarly modulate the respective portions of the

light beam traversing the cells. It will also be understood that by reason of the particular control circuits disclosed, we are able to impart to the units, or to selective groups of cells comprising said units, a desirable degree of residual modulation inertia or retentivity so that the modulating ability of a cell responsive to a given modulating impulse may be prolonged beyond the period during which said modulating impulse prevails.

In conclusion, it is to be noted that the particular electrode forms shown in Figs. 9 to 15 inclusive comprise part of our copending application Serial No. 105,648 filed Oct. 15, 1936, hereinbefore referred to.

It will be understood that while we have chosen to illustrate and describe certain preferred embodiments of our invention, changes in form and minor details of construction thereof may be made without departing from the spirit of the invention and as fairly fall within the scope of the appended claims wherein we have set forth more in detail the novel and important features of our invention.

Having thus described our invention, what we claim as new is:

1. A multiple cell unit of the Kerr type comprising a body of conductive material provided with a plurality of substantially parallel bores extending therethrough, a pair of insulating bars mounted one on each side of said body and out of line with said bores, electrode supports secured to said bars and terminating substantially in the axis of said bores, and electrodes connected to said supports and extending through said bores substantially coaxially thereof.

2. A multiple cell unit of the Kerr type comprising a pair of conducting bodies, each of said bodies having a face provided with a series of substantially parallel complemental bore cavities, means for securing the plates together with the complemental bore cavities in registration, an elongated electrode extending through each bore defined by said registering cavities, and means for supporting the elongated electrodes coaxially within said bores and insulated from said conducting bodies.

STEWART L. CLOTHIER.
HAROLD C. HOGENCAMP.