

June 28, 1949.

A. SIMMON

2,474,380

DEVICE FOR MODIFYING ELECTRICAL SIGNALS

Filed Dec. 12, 1947

3 Sheets-Sheet 1

Fig. 1

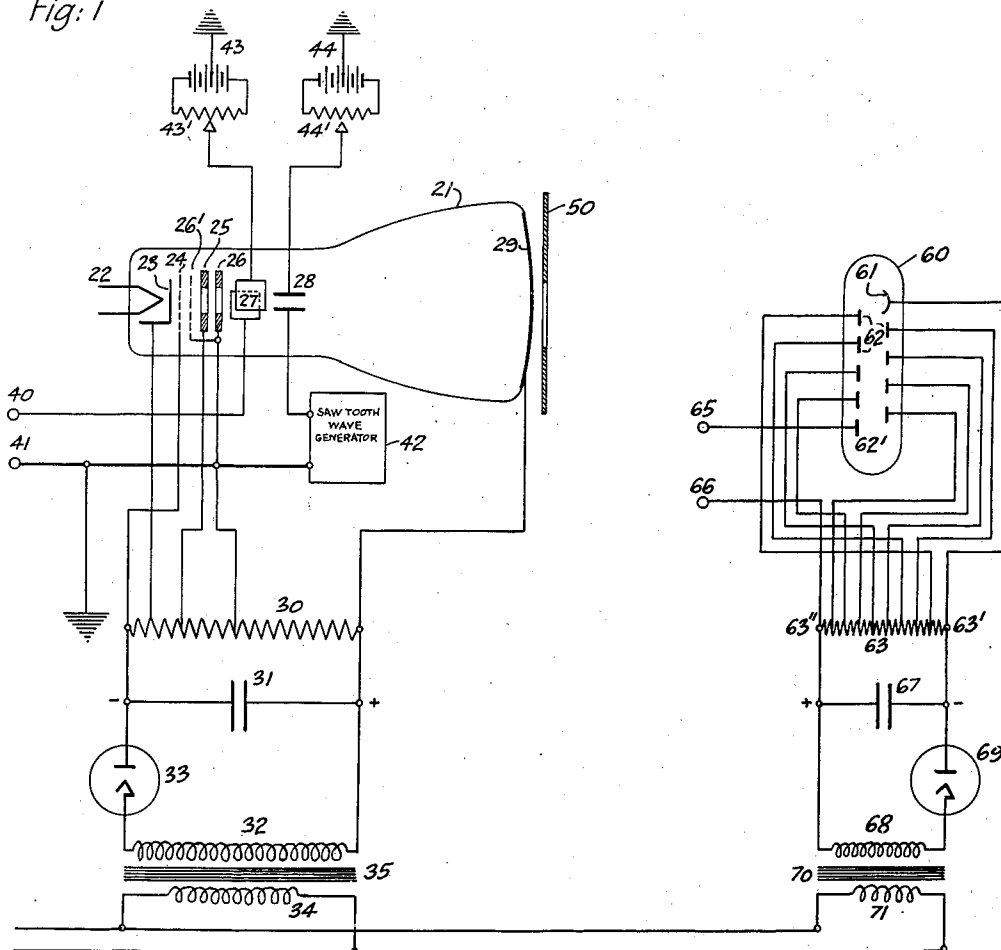
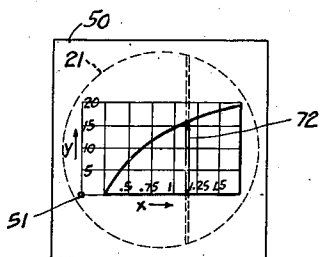


Fig. 2



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Fig: 4

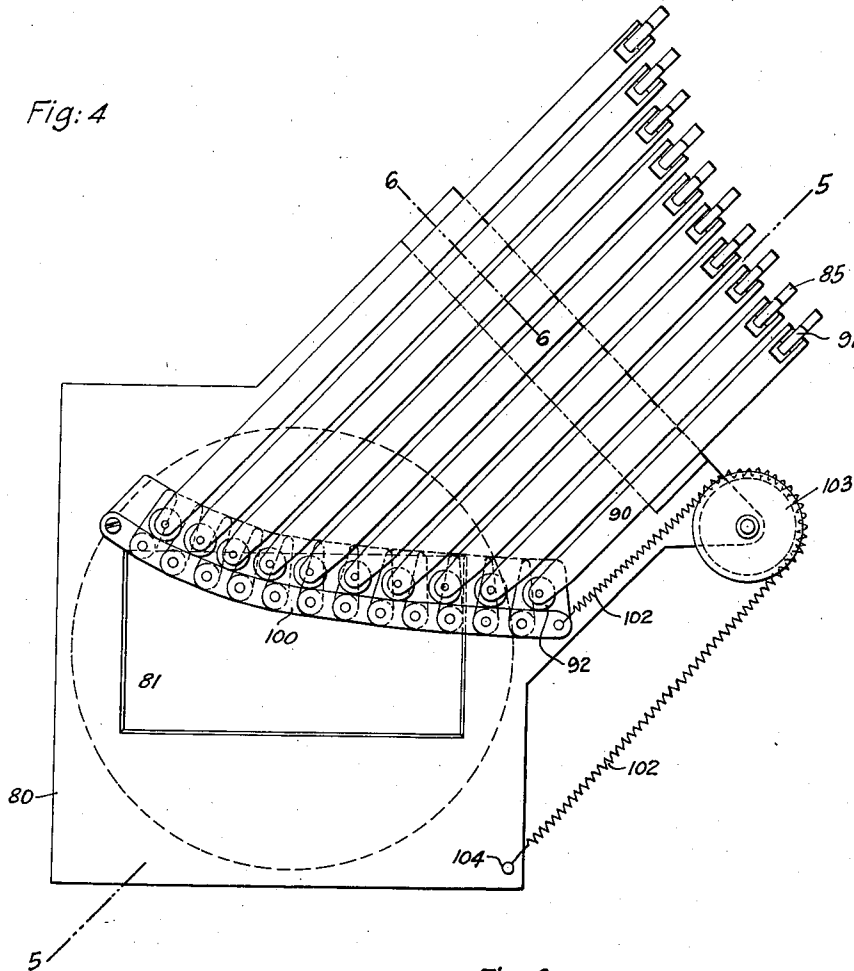


Fig: 3

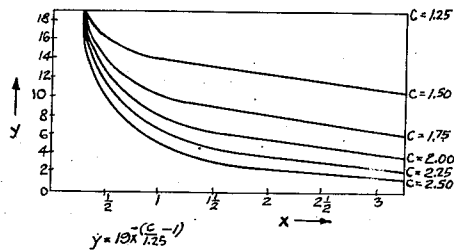
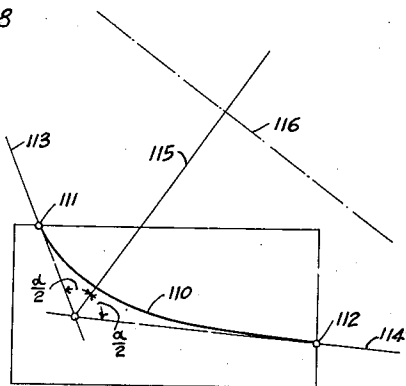


Fig: 8



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Fig: 6

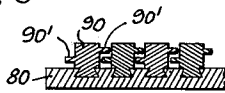


Fig: 7

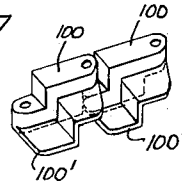
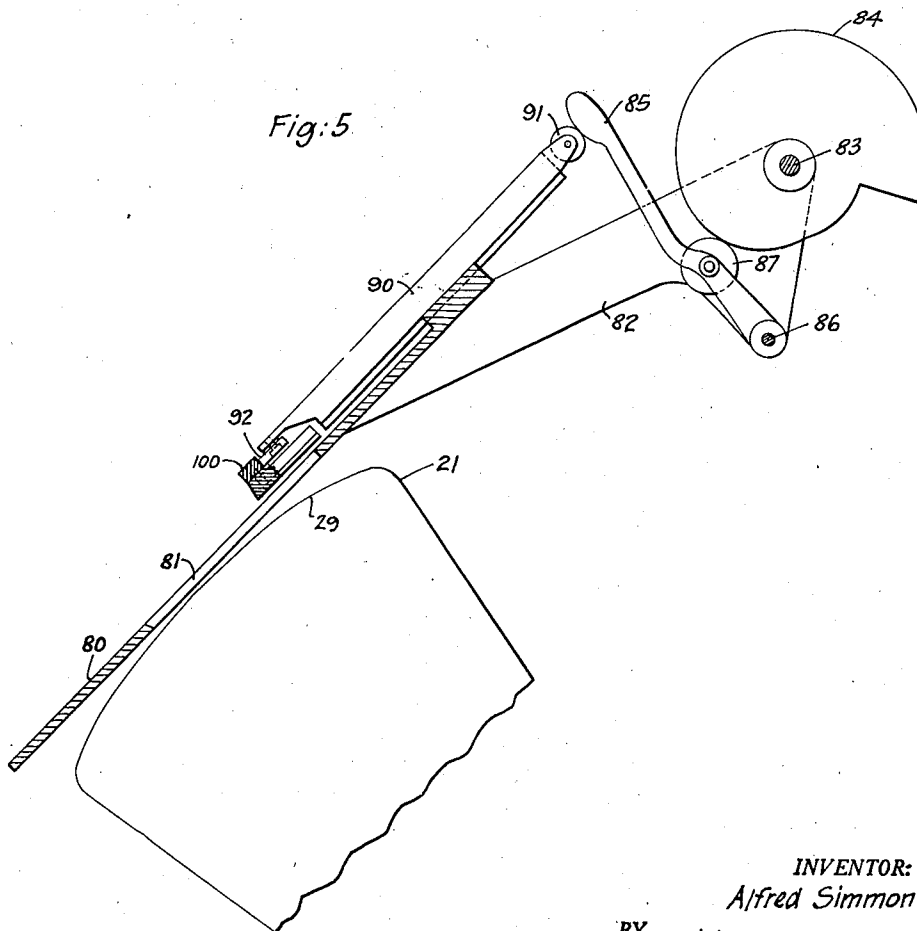


Fig: 5



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UNITED STATES PATENT OFFICE

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DEVICE FOR MODIFYING ELECTRICAL SIGNALS

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2 Claims: (Cl. 250—41.5)

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The objects of this invention is a device for modifying electrical signals according to a selected mathematical function, i. e. if the strength of an incoming signal is proportional to X , the strength of the outgoing or modified signal shall be proportional to $f(X)$. Devices suitable for this purpose known in the prior art usually comprise networks built around at least one non-linear conductor. A large variety of non-linear conductors was used, such as non-metallic so called semi-conductors, devices comprising saturated iron cores, gaseous conductors and, of course, the various types of vacuum tubes. None of these devices is entirely satisfactory because the choice of functions which can be reproduced thereby is limited; the functions are not reproduced with a high degree of accuracy, and it is difficult to duplicate results since characteristics of individual non-linear members of these types may vary widely.

It is the object of this invention to provide a device of this character which permits the modification of electrical signals according to an almost unlimited variety of selected functions with a high degree of accuracy, rendering results which can be duplicated and which are independent of the characteristics of any individual circuit element.

The invention is illustrated by the following figures embodying a preferred application of the invention:

Fig. 1 is a circuit diagram and shows also broadly the arrangement of the component parts;

Fig. 2 is a plan view of a mask forming a component part of the arrangement shown in Fig. 1;

Fig. 3 is a graphical representation of a number of functions which can be utilized in this device;

Fig. 4 is a mechanism forming an adjustable mask which may take the place of the fixed mask shown in Fig. 2;

Fig. 5 is a longitudinal sectional view along the plane of line 5—5 in Fig. 4;

Fig. 6 is a fragmentary cross-sectional view along the plane of line 6—6 in Fig. 4;

Fig. 7 shows in a three-dimensional view a number of elements used in the adjustable mask shown in Fig. 4; and

Fig. 8 is a diagram explaining the preferred disposition of certain movable elements in Fig. 4.

The device comprises three principal parts, a cathode ray tube, a mask, and a photoelectric cell.

The cathode ray tube may be of any desirable

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type and the only prerequisite is that means must be provided to focus the electrons in such a way that a deflectable luminous line is formed on the screen of the cathode ray tube. This may be done in a number of ways, for example, by surrounding the source of electrons with electrostatic shields of suitable shape and by dimensioning the focusing members usually disposed between the source of electrons and the screen in a suitable manner. Line focusing devices of this character have, for example, been used in X-ray tube design for many years with success.

Another possibility is to use a standard tube with two sets of deflection plates and to connect a sweep circuit with the well known saw tooth wave form, and with a fairly high frequency and constant amplitude, to one set of these deflection plates. The electrons are in the conventional manner focused to a point upon the screen, but due to the action of the sweep circuit, this point moves rapidly with constant velocity across the screen, forming the equivalent of an evenly illuminated thin straight line thereupon. Since the latter system can be used with cathode ray tubes which are now commercially available, it may be preferred, and it is, therefore, shown in the diagram in Fig. 1.

The cathode ray tube comprises a glass vessel containing all the other elements such as a filament 22, the cathode 23 which is indirectly heated by said filament, the control grid 24, and the focusing members 25 and 26. 26 may in a well known manner be connected to another control grid 26'. Two sets of deflection plates 27 and 28 are provided and the front of the tube is, of course, equipped with a screen 29 which is adapted to emit light when struck by electrons. The elements 23, 24, 25, 26 and 29 are connected to corresponding points of a potentiometer 30 upon which a suitable direct voltage is impressed by any desired means. These means may, for example, be a battery, but as a preferred example I have shown a condenser 31 which is charged by a transformer secondary 32 through a rectifying tube 33, the left end of the potentiometer 30 receiving negative, and the right end receiving positive potential. The transformer secondary 32 is wound on an iron core 35 which also carries a primary coil 34 connected to the line. In the interest of simplicity, I have not shown the current supplies for the filament of the rectifier 33 or the filament 22 of the cathode ray tube. These filaments are supplied either by batteries or small filament transformers in the usual manner.

The control grid 24 must always have a negative potential with respect to the cathode 23 since correct focusing of the electron stream is otherwise impossible. By varying this potential, the brightness of the spot can be adjusted, but in the example shown in Fig. 1, I have assumed that the spot is adjusted to a constant brightness and, therefore, control grid 24 is fixedly connected to a suitable point of the potentiometer 30. One of the elements of the cathode ray tube, for example, the focusing member 26, is preferably grounded.

Of the deflection plates, the first pair 27 is connected to the incoming signal which is fed into terminals 40 and 41. The other pair 28 is connected to a saw tooth wave generator 42 which is only shown diagrammatically since its detailed circuit is well known and forms no part of this invention. The only condition is that the voltage delivered by the saw tooth wave generator is constant and that its frequency is reasonably high as compared to the frequency of the incoming signal.

Both deflection plate circuits can be biased, for example, by means of small batteries 43 and 44 which cooperate with potentiometers 43' and 44'. The purpose of this biasing is to adjust the starting point of the movements to which the luminous spot on the screen will be subjected, respectively, by the action of the two circuits connected to the pairs of deflection plates 27 and 28.

In front of the screen 29, and preferably immediately adjacent thereto, is a mask 50 which can be seen cross-sectionally in Fig. 1. A plan view of this mask is shown in Fig. 2. This mask has an aperture which directly represents the mathematical function by which the incoming signal shall be modified. The mask is a thin plate made of opaque material such as black paper or sheet metal, and has an aperture of varying widths. This width is called Y in Fig. 2 and it can be seen that the vertical dimension Y is a function of the horizontal distance X from a selected point of reference, for example, from the point 51. For convenience, the lower border-line of this aperture is made a straight line, but this is not necessary and both the upper and lower borders may be curved as long as the vertical width is a function of the horizontal distance from a given point of reference. The particular function represented in Fig. 2 is

$$Y = 19 \left(1 - \frac{11X}{10^{1.7X}} \right)$$

The third element is a photoelectric cell with a suitable supply circuit which is placed in front of the masked screen of the cathode ray tube. The distance between screen and photoelectric cell must not be too small so that all points of the screen have substantially the same distance from the photosensitive cathode of the photoelectric cell. The photoelectric cell itself may be of any desired type, but the so-called electron multiplier type offers advantages because of the higher current delivered by it, which often makes additional amplifiers unnecessary. A tube of this type is, therefore, shown in Fig. 1. This tube has a glass vessel 60, a photo sensitive cathode 61 and 9 additional electrodes 62, the last of which shall be called 62'. The cathode 61 and the 9 electrodes 62 are, respectively, connected to points of a potentiometer 63 in such a manner that 61 is connected to the negative terminal 63' and the last electrode 62' is connected to the positive terminal 63'' of said potentiometer 63, said last con-

nection, however, being interrupted so that the outgoing signal can be taken off the terminals 65 and 66.

A suitable D. C. voltage must be impressed upon potentiometer 63 and, merely as an example, I have shown a condenser 67 which is charged from a transformer secondary 68 through a rectifying tube 69. The transformer secondary 68 is wound on an iron core 70 which also carries a primary coil 71 connected to an alternating current line. Since both the cathode ray tube circuit and the photoelectric multiplier tube circuit are quite sensitive to small voltage fluctuations, in practice both circuits would have to be fed from an automatic voltage regulator or stabilizer. A device of this character has not been shown in Fig. 1 since it does not form part of this invention and since devices of this type are well known in the art.

The function of the device can be fully understood from this description. By the coaction of the electron emitting cathode 23 and the various control and focusing members 24, 25, 26 and 26', a luminous spot or point is formed upon the screen 29 of the cathode ray tube. This point is deflected rapidly by the saw tooth wave voltage which is impressed by the saw tooth wave generator 42 upon the deflection plates 28. This moving point forms thereby the equivalent of a thin luminous line which appears upon the screen 29 and, with the arrangement shown in Fig. 1, this luminous line assumes a vertical position such as shown in Fig. 2 by 72. An incoming signal is impressed upon the deflection plates 27 and the luminous line 72 is thereby deflected in a horizontal direction, the magnitude of this deflection depending upon the strength of the incoming signal.

Light of this luminous line impinges upon the photo sensitive cathode of the photoelectric cell 61 causing, in a manner well known, currents to circulate in the various loops formed between corresponding points of the potentiometer 63 and the various electrodes 62. This circulating current is, of course, largest in the last loop, i. e., between terminals 65 and 66 which can be connected to any utilization circuit which may appear desirable. From the plan view in Fig. 2, it can be seen that only part of the light emitted by the luminous line can reach the photoelectric cell or, more precisely, only that part which appears behind the aperture. In other words, the effective length of the line depends upon the vertical width of the aperture and since the horizontal position of the line depends upon the strength of the incoming signal, the intensity of the light impinging upon the photoelectric cell and, therefore, the intensity of the outgoing signal itself becomes directly a function of the width of the aperture at the place to which the incoming signal has, at any given instance, deflected the luminous line on the cathode ray tube screen. It is obvious that by merely changing the shape of the aperture, an almost unlimited variety of functions can be impressed upon the outgoing signal in this manner.

It is sometimes desirable to modify an electric signal in the manner described, but not according to one single function, but according to a family of similar functions which differ from each other merely by the choice of a parameter. Such a family of functions is shown in Fig. 3, representing

$$Y = 19X^{-\left(\frac{C}{1.25} - 1\right)}$$

Where C shall be adjustable by the operator between the limits $C=1.25$ to $C=2.50$. Once adjusted by the operator, the parameter C , of course, remains constant for the duration of the operation. For this purpose, the fixed mask 50 shown in Figs. 1 and 2 is replaced by an adjustable mechanism shown in Figs. 4 and 5.

All parts of the mechanism are mounted on a supporting plate 80 which has a preferably rectangular aperture 81 which is again placed directly in front of the fluorescent screen 29 of the cathode ray tube. As can be seen in Fig. 5, two brackets 82 are attached to the frame 80 supporting a shaft 83 to which a number of generally spiral shaped cams 84 are attached. In the example shown, ten of these cams would be attached to shaft 83, but only one has been shown in Fig. 5 for the sake of clarity, and, while the shape of all cams will be generally spiral shaped, they will not all have precisely the same shape, depending upon the nature of the function which it is desired to impress upon the electrical circuit. Each cam is in series with a lever 85 which swivels around a fixed pivot 86 carrying a cam following roller 87. The front end of this lever is in operative contact with the upper end of a slidable member 90. Ten of these members are provided in the example shown in Fig. 4. In order to reduce friction, the upper ends of these members 90 carry rollers 91 and the lower ends carry other rollers 92. The two axes of rollers 91 and 92, respectively, are perpendicular to each other as seen in Fig. 5. Rollers 92, in turn, are in contact with members 100 which are linked together in a chainlike manner. One end of the chain formed by these links 100 is fixedly but rotatably attached to a pivot 101, and the other end is biased by a relatively long spring 102 which is led around a roller 103 and finally fixedly attached at a point 104 to frame 80. The manner in which slidable members 90 are supported by frame 80 can be seen in Fig. 6 which shows a cross-sectional view along the plane of line 6—6 in Fig. 4. The shape of the links 100 is again shown in a three dimensional representation in Fig. 7. Both slidable members 90 and chain links 100 are equipped with certain fins 90' and 100', respectively, which make it possible to move these elements relative to each other and still block the passage of light between them. The result of this arrangement is that the lower border of chain 100 in Fig. 4 becomes the upper boundary of the aperture of frame 80, replacing thereby the aperture of the fixed mask shown in Fig. 2.

By rotating cam shaft 83 with the ten cams 84, the operator can cause the ten slidable members 90 to assume higher or lower positions within their respective tracks and thereby the links of chain 100 to assume correspondingly different positions. If the configurations of the various cams 84 are chosen properly, the chain 100 will assume, depending upon the rotation of cam shaft 83, all possible shapes as shown in Fig. 3, i. e., for $C=1.25$ the upper boundary of the aperture in frame 80 is represented by a straight horizontal line and any increase in C will simultaneously curve this line and move it in a downward direction until for $C=2.50$ the upper boundary of the aperture is given by the lowest curve shown in Fig. 3. The operator thereby has it in his power to adjust the function by which the incoming signal shall be modified within wide limits, depending upon the choice of the parameter C .

All curves shown in Fig. 3 are concave and it is thereby possible to bias the chain links 100 with

respect to the ten slidable members 90 by means of a single spring 102. If any of the functions, however, should call for convex rather than concave curvatures, this arrangement must be slightly modified and individual bias springs must be attached to the individual chain links 100 so that they can follow the movement of the slides 90 even for convex curvatures.

From a mechanical point of view, and in order to have the least amount of friction, it is obviously desirable to design the mechanism in such a way that the angle between any link 100 and its contacting member 90 is as small as possible. This can be done by choosing the direction of the tracks in which members 90 slide in such a way that they are parallel to a line which bisects the largest angle formed by the tangents which are drawn to the extreme points of that curve of the family which has the smallest radius of curvature. In the example shown in Fig. 3, this would be the curve drawn for $C=2.50$. The diagram shown in Fig. 8 will help to explain this situation. The curve 110 terminates in the two extreme points 111 and 112. Tangents drawn to the curve at these points are 113, 114, respectively. The angle formed by these tangents, 113, 114 is called α , and a line 115 is drawn which bisects this angle. This gives the preferred direction of the tracks in which members 90 shall slide. The direction of the cam shaft 83 is, of course, at right angles to this line as represented by line 116 in Fig. 8.

It is obvious that the arrangement described above can be modified in certain ways. For example, by changing the bias of the control grid 24 relative to the cathode 23, the brightness of the light emitted by the cathode ray tube can be adjusted, which is the same as the multiplication of the incoming function with a constant or the incoming function would then be ax and the outgoing function would then be $f(ax)$. It would also be possible to impress a second incoming signal upon this control grid in which case the outgoing function would represent the product of two functions or $f(Z) \times f(X)$. Last, the sensitivity of the photoelectric cell could be adjusted in several ways, for example, by adjusting the voltage impressed upon the potentiometer 63. This would be the same as multiplying the outgoing function with a constant or the outgoing function would then be $b \times f(X)$.

While I have described one form of apparatus, this has been done by way of illustration only, and many changes may be made in its details.

What I claim as new, is:

1. A mask with an adjustable aperture, adapted to be placed between the screen of a cathode ray tube and a photoelectric cell in a device for modifying electrical signals, said mask having an apertured frame, and the following elements supported by said frame, a plurality of movable cams, including means to move them in unison, a plurality of elongated members, each with a first and a second end, said members adapted to slide in parallel tracks, a plurality of links, attached to each other and forming a chain adjacent to said aperture and covering part of it, and means, including spring biasing means operating on said links, adapted to establish operative contact between said chain and the first ends of said slidable members, and between the second ends of said slidable members and said cams, whereby more or less of the light passing width of said aperture is covered by said links and said members in accordance with the positions into which said cams

are placed by the operator relative to said members.

2. A mask with an adjustable aperture, adapted to be placed between the screen of a cathode ray tube and a photoelectric cell in a device for modifying electrical signals, said mask having an apertured frame, and the following elements supported by said frame, a plurality of movable cams, including means to move them in unison, a plurality of elongated members, each with a first and a second end, said members adapted to slide in parallel tracks, a plurality of links, attached to each other and forming a chain adjacent to said aperture and covering part of it, and means, including spring biasing means operating on said links, adapted to establish operative contact between said chain and the first ends of said slidable members, and between the second ends of said slidable members and said cams, the direction of

movement of said slidable members being parallel to the direction of a line which bisects the smallest angle formed by the tangents drawn, respectively, at the starting and terminating points of any of the curves which said chain may assume.

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REFERENCES CITED

- 10 The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
15 1,937,654	Gieskieng	Dec. 5, 1933
2,144,337	Koch	Jan. 17, 1939
2,183,717	Keall	Dec. 19, 1939
2,408,023	Kruper	Sept. 24, 1946