

July 10, 1934.

C. R. HANNA ET AL

1,966,243

ENERGY TRANSLATING APPARATUS

Filed Nov. 11, 1931

2 Sheets-Sheet 1

Fig. 1.

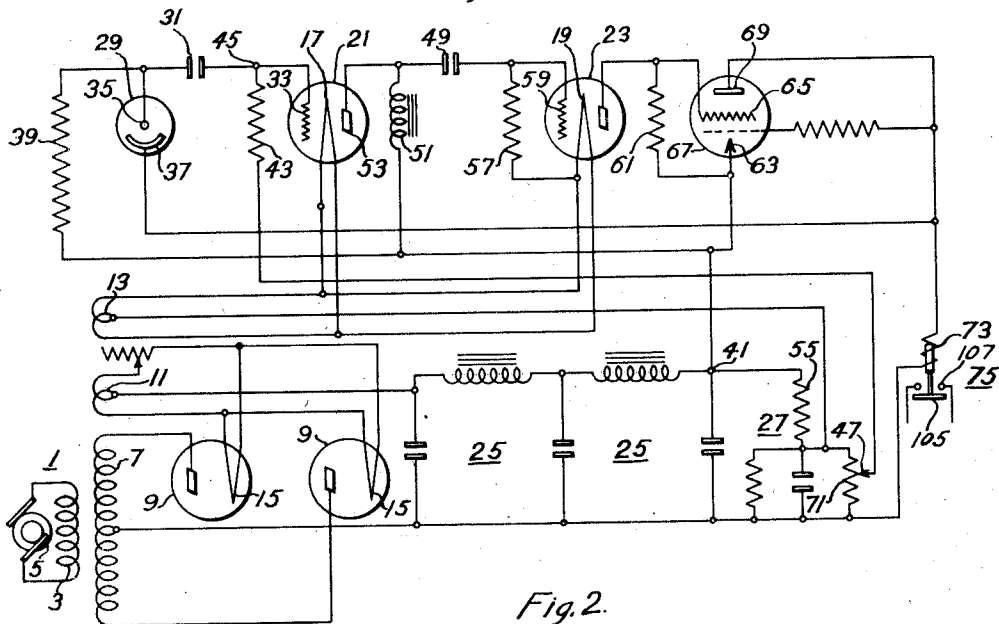
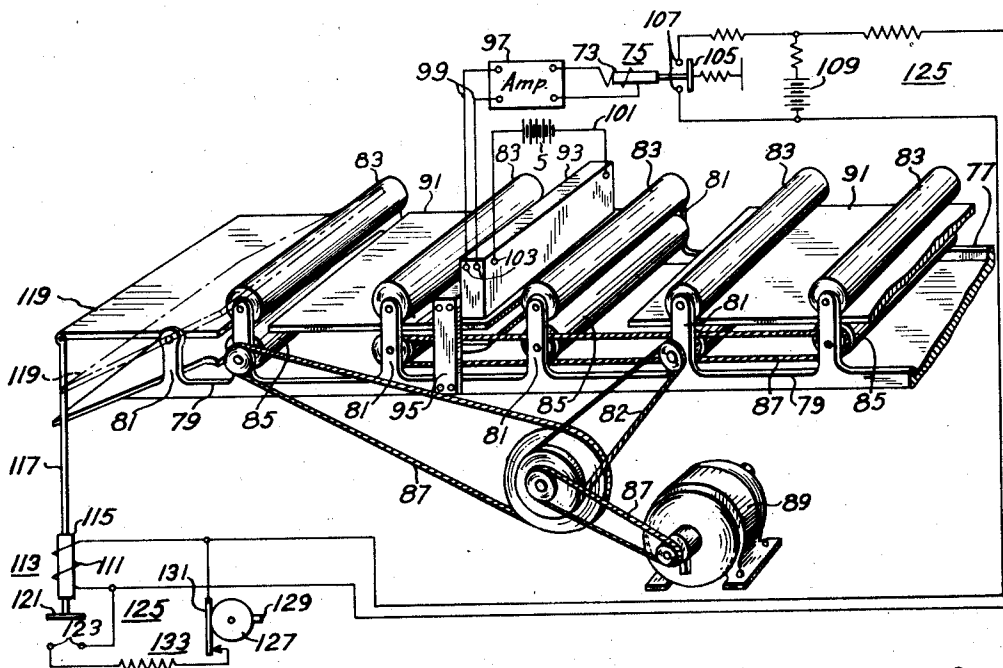


Fig. 2.



WITNESSES:

Arthur J. W. Mahon
Hymen Diamond

INVENTORS.
Clinton R. Hanna &
Ezra F. Critchlow.
BY
F. W. Lyle
ATTORNEY

July 10, 1934.

C. R. HANNA ET AL

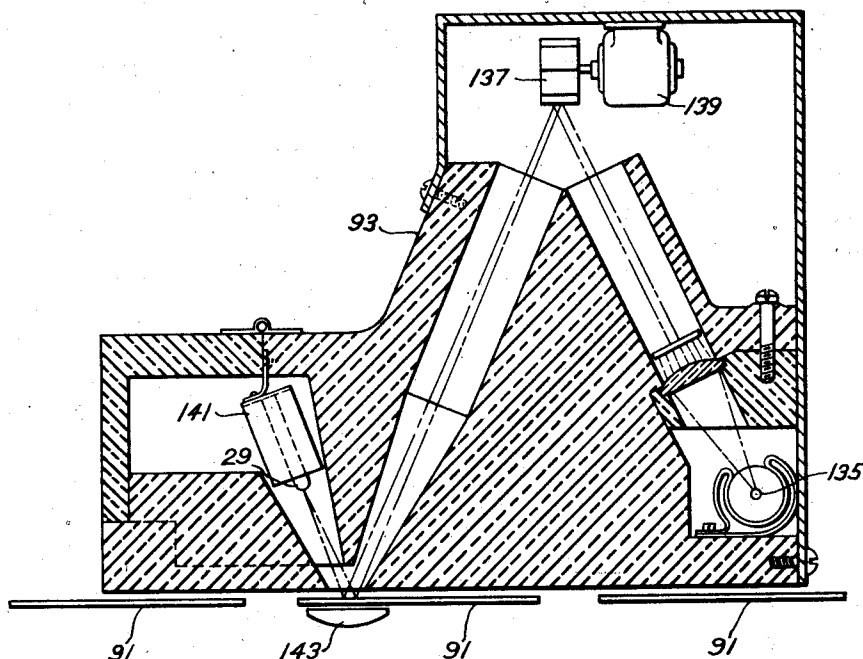
1,966,243

ENERGY TRANSLATING APPARATUS

Filed Nov. 11, 1931

2 Sheets-Sheet 2

Fig. 3.



WITNESSES:

Arthur J. W. Mahon

Hyman Diamond

INVENTORS.

Clinton R. Hanna &

Ezra F. Critchlow.

BY

F. W. Seyle

ATTORNEY

UNITED STATES PATENT OFFICE

1,966,243

ENERGY TRANSLATING APPARATUS

Clinton R. Hanna, Pittsburgh, and Ezra F. Critchlow, Munhall, Pa., assignors to Westinghouse Electric and Manufacturing Company, a corporation of Pennsylvania

Application November 11, 1931, Serial No. 574,338

1 Claim. (Cl. 250—41.5)

Our invention relates to energy-translating apparatus and has particular relation to energy-translating apparatus incorporating photo-sensitive trigger elements.

5 According to the teachings of the prior art of which we are aware, photo-sensitive translating apparatus commonly comprises a photo-sensitive device, such as an ordinary photo-cell and an amplifier of one type or another. The amplifier is ordinarily of such structure as to respond to variations in the radiations impinging on the photo-sensitive device. Such a system has, of course, a number of uses and has been known for a long time.

15 In working with article sorting apparatus, we have conceived the thought of providing an amplifier which is not responsive to the changes in the illumination directly, but is responsive substantially to the time derivatives of the illumination impressed on the photo-sensitive device. In particular, we have found that an energy-translating system, which responds to the rate of change of the illumination impressed on the photo-sensitive device, might be of particular use and we have applied such a device with considerable success in particular to article sorting apparatus with which it cooperates in such manner as to produce a new and highly useful result.

20 In article sorting apparatus, the principal problem is to provide a system which responds to heterogeneities of a predetermined intensity in the surface of the articles to be sorted. The articles to be sorted might be of any character and, in our particular application, happen to be tin plates used principally in the manufacture of cans.

25 For a considerable period of time we were engaged in endeavoring to produce a satisfactory system in which the articles to be sorted are subjected to the influence of a radiant beam and in which the radiant beam, after being reflected from or transmitted through the articles to be sorted, impinges on a photo-sensitive device. The heterogeneities appearing in the surface of the articles to be sorted produce variations in the photo-sensitive device, and the articles are classified in accordance with the influence of their surfaces on the photo-sensitive device.

30 However, in working out the solution of the problem, we have been confronted with a second problem which, on first sight, might appear of minor interest, but which is of considerable importance when the purpose of the whole investigation is to produce a commercial machine. We found that with the highly sensitive relays which

are utilized in producing the necessary results, the system not only responds to heterogeneities in the surfaces of the articles to which it should respond, but it responded also to heterogeneities of small intensity in which there is no interest. Thus, the tin plate sorting machine with which we are experimenting when equipped with a photo-sensitive relay constructed according to the teaching of the prior art responds not only to spotted areas in the surface of the tin, but responds also to such heterogeneities as finger prints, which are, of course, unavoidably present in the surface of nearly all tin plates.

35 It is accordingly an object of our invention to provide a photosensitive relay that shall respond to variations of a predetermined character in the radiations impinging on the photo-sensitive trigger element thereof and that shall not respond to variations which do not have the character in question.

40 Another object of our invention is to provide a photo-sensitive translating system that shall respond substantially to the derivatives with respect to a time variable of the illumination impinging on the photo-sensitive device.

45 Still another object of our invention is to provide a photo-sensitive translating system that shall respond substantially to the rate of change of the illumination impinging on the photo-sensitive device incorporated in the system.

50 A further object of our invention is to provide for a relay system of the type incorporating a photo-sensitive device an amplifier coupled to the output of the photo-sensitive device such that the system shall respond not to direct changes of the illumination impinging on the photo-sensitive device, but to the rate of change of the illumination impinging on the photo-sensitive device.

55 A still further object of our invention is to provide a photo-sensitive relay system that shall not respond to gradual changes in the intensity of the radiation impinging on the photo-sensitive device, but shall respond to changes that occur with considerable abruptness.

60 A more specific object of our invention is to provide a tin plate sorting system of the type incorporating a photo-sensitive element in which the classifying relays shall respond only to heterogeneities in the tins to be sorted which are of a predetermined intensity.

65 A further specific object of our invention is to provide for an article sorting system an inspection device that shall not respond to unavoidable heterogeneities, produced by the handling of the articles, in the surfaces of the articles to be sorted

but shall respond to the heterogeneities in accordance with which the classification is to occur.

More concisely stated, it is an object of our invention to provide a general purpose relay of the photo-sensitive type that shall respond to a predetermined time rate of change of variation of the radiations impinging on the photo-sensitive element of the relay and to specifically apply the relay to an article sorting system.

In accordance with our invention, we provide an amplifier that is responsive to the time rate of change of the voltage impressed on its input circuit. The amplifier may incorporate a number of tubes and the tubes that it incorporates may have any well-known structure. However, the essential element of the amplifier is a filter system disposed at some point therein and having the character of providing a plurality of paths whereby the low-frequency energy is dissipated, while the high-frequency energy is transmitted.

It should be apparent from physical considerations that such an arrangement will lead to the attainment of the objects of our invention. A Fourier Integral analysis however, will show that even from a mathematical standpoint, an amplifier of the type described hereinabove should yield the proper results.

We have further incorporated the amplifier in an article sorting system in such manner that, it responds to light reflected from the surfaces of the articles to be sorted, to trip off the necessary relays when the heterogeneities in the articles are of the proper character. It is to be noted that in combining the amplifier with the article sorting system, we have not provided a simple aggregation devoid of patentability, but have so associated the two systems as to produce a machine which yields an entirely new and useful result.

The novel features that we consider characteristic of our invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof will best be understood from the following description of a specific embodiment when read in connection with the accompanying drawings, in which

Figure 1 is a diagrammatic view showing the circuit of an energy-translating system constructed in accordance with our invention;

Fig. 2 is a view partly in perspective and partly diagrammatic showing the essential elements of an article sorting machine with which the system shown in Figure 1 cooperates to produce a photo-sensitive sorting system, and

Fig. 3 is a view in section showing the principal elements of the photo-sensitive eye that is utilized in scrutinizing the articles to be sorted.

The apparatus shown in Fig. 1 comprises a transformer the primary 3 of which is fed from a power supply source 5 and a secondary 7 of which is connected to a plurality of rectifiers 9 through which direct-current power is supplied to the system.

A plurality of auxiliary secondaries 11 and 13 are also provided. The secondaries 11 and 13 feed the filaments 15 of the rectifiers 9 and the filaments 17 and 19 of the amplifier tubes 21 and 23 utilized in the system respectively.

The power is supplied to the system through a plurality of filters 25 of proper character which are well known in the art and need not be described herein. The output of the filters feeds

into a potentiometer 27 of proper character from which the electro-motive forces necessary for the operation of the photo-sensitive elements and the amplifying elements of the system are tapped.

As shown in the drawings, the photo-sensitive device 29 is coupled through a capacitor 31 between the control electrode 33 and the cathode 17 of the first tube 21 of the amplifying system. The capacitor 31 should be of comparatively low magnitude since one of its principal functions is to block the low-frequency components and to permit the passage of high-frequency components of the disturbance impressed on the photo-sensitive device 29.

However, its actual magnitude is predetermined by the other elements associated with it specifically the magnitude of the grid resistor associated with the capacitor has a considerable bearing on the magnitude of the capacitor since in general these two elements are to be so related as to yield the proper time constant.

The necessary electromotive force is impressed across the electrodes 35 and 37 of the photo-sensitive device 29 from the potentiometer 27 through a resistor 39, one terminal of which is connected to the anode 35 of the photo-cell 29 and the other terminal of which is connected to the positive terminal 41 of the potentiometer 27. The grid bias for the first amplifier tube 21 is provided through a second resistor 43 that is connected to the common junction 45 of the grid 33 and the capacitor 31 and to a movable tap 47 on the potentiometer 27.

The plate circuit of the first amplifier tube 21 is coupled to the grid circuit of the second amplifier tube 23 through a capacitor 49 of suitable character. The capacitor 49 has substantially the same function as the coupling capacitor 31 between the first tube 21 and photo-cell 29 and is, therefore, also of comparatively small magnitude although it is of considerably larger magnitude than the first capacitor. For the purpose of further eliminating any low-frequency components which may have been transmitted through the capacitor 31, an inductor 51 is connected between the plate 53 and the cathode 17 of the first tube 21 through the resistor element 55 of the potentiometer 27 whereby the necessary electromotive force is provided for the plate circuit of the amplifier tubes 21 and 23 of the system. Low-frequency components of current transmitted through the tube 21 are dissipated in the inductor circuit and thus only high-frequency components are transmitted to the control circuit of the second tube 23.

The total grid voltage for the second tube 23 is provided by the plate current of the first tube 21 which is impressed through the capacitor 49 across the terminals of a resistor 57 that is connected between the cathode 19 and the control electrode 59 of the second tube 23. The plate current produced in the second tube 23 is fed through a resistor 61 connected between the anode 63 and the control electrode 65 of a grid-controlled electric-discharge device 67 of the gaseous type. A voltage dependent on the plate current in the tube 23 is thus impressed between the anode 63 and the control electrode 65 of the electric-discharge device 67.

The electric-discharge device 67 has the property of responding abruptly to proper distribution in electromotive forces impressed between its control electrode 65 and its other electrodes 63 and 69. When the voltage impressed between the

control electrode 65 and the anode 63 is sufficiently decreased and the voltage between the cathode 69 and the control electrode 65 is correspondingly increased, a condition is attained such that the control electrode 65 loses its property of blocking a current between the cathode 69 and the anode 63 and the tube 67 becomes energized, permitting a current of considerable magnitude to flow between its principal electrodes.

As will be noted from the drawings, in the preferred embodiment of our invention, the cathode 69 and the anode 63 of the electric-discharge device 67 are connected to each other through the necessary resistor elements 55 and 71 of the potentiometer 27 and through the exciting coil 73 of an electromagnetic relay 75 whereby the necessary response to the conditions of the photo-sensitive device 29 is produced.

While we have incorporated, in the preferred embodiment of our invention, an electric-discharge device 67 of the gas-filled type which is moreover equipped with cold electrodes 63 and 69, other electric-discharge devices are equally as well applicable in the practice of our invention, and under certain conditions, we have found they may be utilized with success. Thus, if an abrupt response is not desirable, the gas-filled electric-discharge device 69 may be replaced by a high-vacuum device. Moreover, the gas-filled electric-discharge device need not be of the type incorporating an unexcited cathode, as is shown in the drawings, but may be of the hot-cathode type or of the mercury cathode type or may incorporate any other well-known excitable cathode.

It is, furthermore, to be noted that an amplifier of the exact type described hereinabove is not sine qua non of our invention. The amplifier may be modified in a number of ways and the necessary filtering elements, for example, may be inserted in a number of different positions from those in which they are inserted in the amplifier shown. Our invention should, therefore, not be restricted to the specific amplifier illustrated.

The elements and the constants of an amplifier which we have found to be of considerable use in the present connection and particularly in connection with article sorting are as follows. The rectifying tubes 9 are of the ordinary high-vacuum hot-cathode type capable of supplying a normal quantity of rectified power. The amplifier tubes 21 and 23 are high μ tubes of the type similar to the radiatron UX250. The electric-discharge device 67 is of the type known as the cold-cathode grid-glow tube in which an electromotive force of 440 volts is impressed between the principal electrodes when the tube is deenergized and through which a current of several milliamperes is ordinarily transmitted when the tube is energized.

The resistor 39 connected between the anode 35 of the photo-sensitive device 29 and the positive terminal 41 of the potentiometer 27 is of the order of 50 megohms. The other resistor 43 associated with the photo-sensitive device 29 and with the first tube 21 of the amplifier is of the order of 5 megohms and the capacitor 31 coupling the photo-sensitive device 29 to the control circuit of the first tube 21 is of the order of .0005 microfarads. The inductor 51 connected in the plate circuit of the first tube 21 is of the order of .6 henries and the capacitor 49 coupling the first tube 21 to the second tube 23 is of the order of .01 microfarads, while the resistor 57 associated with the grid circuit of the second tube 23 is of the order of 5 megohms.

The resistor 61 connected between anode and the control electrode of the electric-discharge device is of the order of 50,000 ohms. The other elements of the system are not essential to the amplifier and should be given the proper values to provide the necessary electromotive force for the tubes of the system.

In Figs. 2 and 3, a tin plate sorting system incorporating the essential elements of our invention is shown. The apparatus shown in Figs. 2 and 3 comprises essentially a base plate 77 of substantially transverse C-section from the flanges 79 of which a plurality of ears 81 project. The ears 81 project in pairs from the flanges 79 and between pairs of certain of the ears a plurality of rollers 83 and 85 are mounted. The lower rollers 85 in each group are driven through a system of belts 87 through a motor 89 and in rotating advance the slabs 91 to be tested which are disposed between the rollers and the idling upper rollers 83.

An enclosure 93 is supported on a plurality of brackets 95 fastened to the flanges 79 of the base plate 77, and has disposed therein the essential elements of the photo-sensitive inspection device which are shown in detail in Fig. 3 and which will be described hereinafter. An amplifying system 97 of the type described hereinabove and a power supply source 5 of suitable character are disposed at some convenient point in the vicinity of the enclosure 93 and are connected to the elements within the enclosure by a plurality of leads 99 and 101 that enter the enclosure through a plurality of openings 103.

The relay 75, the exciting coil 73 of which is in the output circuit of the electric-discharge device 67 of the amplifier 97, is equipped with a movable contactor 105 which is capable of engaging a plurality of corresponding fixed contactors 107 when the relay becomes energized. When the movable contactor engages the fixed contactors, a battery 109 provided for the purpose of exciting the coil 111 of a second relay 113 is short-circuited and the second relay 113 is deenergized. The core 115 of the second relay 113 has secured thereto a bar 117 that is, in turn, secured to a guide plate 119 which is capable of being pivoted under the action of the bar 117 and which is pivoted to an oblique position when the exciting coil 111 of the relay 113 is deenergized and the core 115 drops to its lowermost position.

The character of the amplifier 97 is such that, when a heterogeneity of predetermined character appears in the surface of a slab 91 to be tested under the eye of the inspection device, the first relay 75 becomes energized, the battery 109 is short-circuited and the second relay 113 is deenergized. The guide plate 119 is then pivoted to its oblique position (as is shown in Fig. 2 in broken lines) by the movement of the relay core 115.

On the other hand, the relay core 115 is equipped at its lower end with a movable contactor 121 which engages a plurality of fixed contacts 123 when the core 115 drops and provides a short-circuiting path for the battery 109 after the spot on the slab passes out of the influence of the photo-sensitive eye 29 and the first relay becomes deenergized. The second relay 113 remains deenergized for a period of time predetermined by the rate of rotation of a cam 127 which is equipped with a pin 129 that, after the predetermined time, engages the movable element 131 of a switch 133 and opens the circuit 125 through the battery 109.

While the relay 113 is in its deenergized con-

dition and the guide plate 119 of the sorting machine is in its oblique position, the particular slab 91, which has caused the relay 75 associated with the amplifier 97 to become energized, passes under the oblique guide 119 and into a container (not shown) provided for the defective plates. On the other hand, if the plate 91 should not be defective, the relay 113 regulating the position of the guide plate 119 would not be deenergized and the slab 91 under consideration would be moved over the guide plate 119 (now horizontal) into the proper container provided for it.

The inspecting system, which we have found to be of considerable utility in the present connection, is shown in detail in Fig. 3.

A radiant beam emitted by a suitable source of radiation 135 and suitably collimated and masked is projected on a plurality of reflectors 137 peripherally disposed and rotated by a motor 139 of suitable character. The rotating reflectors 137 are equipped with plane surfaces and swing the beam reflected from their surfaces through an angle predetermined by their width. The reflectors 137 may be so wide that the width of a predetermined plate 91 is completely scanned as the plate moves under the swinging beam.

The scanning beam reflected from the plates 91 impinges on the surface of a cylindrical reflector 141 and on the cathode 37 of the photo-sensitive device 29. The photo-sensitive device 29 is thus affected by the rays impinging thereon directly from the surface of the plates 91 and by the rays reflected from the cylindrical mirror 141. It is, moreover, connected in an amplifier system 97 of the type shown in Fig. 1, and as the slabs 91 to be tested move under the scanning beam, the amplifier 97 responds to heterogeneities in the surface of the slabs and the slabs are sorted as has been explained in connection with the apparatus shown in Fig. 2.

It is to be noted that a reflector 143 is provided for the purpose of maintaining the photo-sensitive device energized during the interval that the radiations are not reflected from the slabs. Provisions must also be made for taking care of the variations which might be introduced into the photo-cell when the scanning beam moves in the vicinity of either end of the plate. Such provisions may be made simply by restricting the swinging of the scanning beam to within the area of the plate and by providing a trimming opera-

tion after the plates have been classified, whereby the ends of the plates which have not been under the influence of the scanning beam are removed.

On the other hand, suitable reflectors may be disposed below the position at which the slabs, to be tested, pass and adjacent to the ends of the slabs. As the scanning beam approaches the end of the slab, the light from the reflectors at the ends is reflected into the photo-cell 29 and the relay system associated with the photo-cell is not tripped off.

It will be noted that, in accordance with a preferred embodiment of our invention, we provide a system which is particularly applicable to the sorting of articles having specular surfaces or having purely transparent surfaces. It is to be noted that with a few modifications, our system may be equally as well applied to articles having diffuse surfaces, either opaque or translucent.

Although we have shown and described a certain specific embodiment of our invention, we are fully aware that many modifications thereof are possible. Our invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claim.

We claim as our invention:

Apparatus for sorting articles of the type that may be marked with sharply-defined heterogeneities and with diffusely defined heterogeneities, such as finger prints, to separate the articles marked with sharply-defined heterogeneities from the other articles; comprising means for projecting a beam of light, means for subjecting successive areas of an article to be sorted to said beam of light, light sensitive means responsive to the resultant light emitted by said article for converting the light into electrical currents, amplifying means adapted to dissipate the low-frequency components of said currents, caused by diffusely defined heterogeneities, such as finger-prints, and for amplifying the high-frequency components of said currents caused by sharply-defined heterogeneities, and means to be actuated by the output of said amplifying means when the totality of the high-frequency components of said currents have such a magnitude as to correspond to the influence of a sharply-defined heterogeneity in said article on said light beam.

CLINTON R. HANNA.
EZRA F. CRITCHLOW.