F.I.A.T. FINAL REPORT No. 1027

THE KRAWINKEL IMAGE-STORING CATHODE RAY TUBE

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THE KRAWINKEL IMAGE-STORING CATHODE RAY TUBE

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A B S T R A C T

This report covers a new type of cathode ray tube which is capable of storing images over long periods of time. The tube was developed by Dr. Krawinkel with the idea of eliminating flicker in television pictures. This tube may also be used for recording and storing impulses of short duration for comparison purposes. The writing time is about 1 mm. in 5×10^{-8} seconds and it is believed that this can be increased to 1 mm. in 5×10^{-10} seconds. The first laboratory samples of this new type of cathode ray tube were completed in 1944.

INTRODUCTION

Objective

Work on the Krawinkel tube was begun in 1938 with the view to overcoming technical difficulties in the television field.

It is well known that a flicker exists in television pictures due to the fact that the light spot which produces the picture must traverse the whole screen and that a complete picture is produced only due to the inertia of the eye and the persistance of the screen. In order to avoid this flicker it would be necessary to design a cathode ray tube so that it would store each portion of the picture produced by the point of light as it passes over the screen until the screen has been completely covered. This could not be accomplished by the fluorescent screen because the fluorescent screen loses its brilliance too fast.

With this in view in 1938 Dr. Krawinkel proceeded to develop a cathode ray tube on the principle that by an accumulation of electrical charges produced by the signal current, other electric currents could be modulated so as to produce the desired picture on the screen. In 1944 he completed the first laboratory samples of such an image-storing tube.

Evaluation

This report covers the general principles of construction of an image tube, which is at present only in the experimental stage. It is believed, however, that this tube may become of great value in television and many other fields for recording, storing, and comparing impulses of very short duration. The information in this report is prepared from information obtained from Dr. Krawinkel. The author has not seen the tube in operation, as facilities for a demonstration were not available, but he has, however, inspected samples of both the semi-completed tube and the completed tube.

DESCRIPTION

The present Krawinkel tube is constructed along the lines outlined in Figure 1. In this figure, (T) is a glass tube which contains an electronic system (G) to produce, concentrate, and deflect a cathode ray (B) onto the plate (P) which has the storage qualities desired.

This plate has on its surface a sensitive photoelectric layer (C) (Figure 2), which is connected to a potential outside of the tube, and on this layer (C) are many small quartz insulating islands (J) (Figure 2). When the cathode ray (B) comes in contact with the plate (P), the electrons of the cathode ray produce a secondary electron emission. When the cathode ray comes in contact with the photoelectric layer (C), it makes no change in the surface potential of this layer, but when the ray comes in contact with the islands (J), by its secondary emission, it produces a charge on the surface of this island the value of which is dependent on the secondary emission factor. Figure 3 shows the normal secondary emission factor curve.

This illustrates the proportion (s) of secondary emitted electrons (i_s) to the primary electrons of the cathode ray (i_p) plotted against the velocity of the electrons of the cathode ray measured in electron-volts. The value $s = \frac{i_s}{i_p} = 1$ is very important and therefore has been indicated with a dotted line in Figure 3.

When the surface of an insulating island (J) (Figure 2) comes into contact with the cathode ray (B) (Figure 1) with a velocity of (E) (Figure 3), at which the secondary emission factor is less than one, the insulating island (J) (Figure 2) will become charged with a negative charge which is proportional to the value of (d) (Figure 3), to the duration of the cathode ray's contact with the insulated island, and to the intensity of the cathode ray. Since the charge on the insulating island is negative with respect to the photoelectric layer (C)(Figure 2), electrons emitted by this photoelectric layer cannot reach the surface of the insulating island and the insulating island retains its charge. In this manner a trace of the desired electrical signal is produced on the plate (P) (Figure 1) by the modulated and deflected cathode ray.

The insulating islands of a diameter of from 50 μ to 100 μ, in samples of this tube, have retained their charges for a period of three weeks, and it is believed that they would retain their charges still longer; however, no samples have been subjected to a test for a longer period of time.

When the surface (P) (Figure 1) is illuminated by a light source (L), which has been filtered so that only the invisible part reaches the surface of (P), the photoelectric layer emits electrons which are guided to the fluorescent screen (H) (Figure 1) by the magnetic lens (O) (Figure 1). The entire screen is thereby illuminated except for that portion which corresponds to that part of the plate (P), where the insulating islands are negatively charged. Therefore the negative charges on the plate produce dark spots or lines on the screen (H)(Figure 1) which represent the electrical signals which modulate or deflect the cathode ray.

Since the efficiency of the tube is dependent on the retention of negative charges on the insulating islands, it is necessary to reduce the number of positive ions within the tube to as few as possible. Such ions produce a faster discharge of the insulating islands than the islands' conductivity. The positive ions are produced by the residue of gas in the tube during the illumination of the screen. With a residual gas pressure of about 5.10^{-7} mm. mercury, a discharge of the insulating islands occurred in about 10 to 15 minutes. When it is desired to erase this picture, it is only necessary to pass the cathode ray over the entire plate but with its electron velocity so charged that the factor of secondary emission of the insulating islands is greater than one. This can be accomplished with a voltage E_2 (Figure 3). Contacting the islands with the cathode ray with such an electron velocity produces positive changes on the islands.

Figure 4 is a picture of the first laboratory sample of the Krawinkel tube.

Figure 5 is one of the first pictures recorded on the above-mentioned tube and represents a signal whose duration was 10^{-6} seconds. On the baseline of this oscillogram can be noticed the effect of amplification noise. The speed of writing, in this instance, was about one millimeter in 5.10^{-8} sec. It is expected that the writing time can be increased to one millimeter in 5.10^{-11} sec., enabling research to be performed on signals of a duration of about 10^{-11}.

PLATE CONSTRUCTION

Originally the plate was made (as described) of a photoelectric layer with insulating islands inserted in it, but this did not produce uniform layers so the process was reversed and the photoelectric layer was placed on the quartz in such a manner that insulating islands were left in the photoelectric layer in the following manner.

A quartz plate (Figure A) approximately 2½ x 2¼ inches, on the border of which a small metal strip (R) (Figure A) about one-eighth inch wide has been vaporized, is now vaporized with diagonal metal strips of silver or aluminum (S) (Figure B). Both the strips and the spacing between them are about 100 or 150μ in width. These strips are the leads for the photoelectric layer, and part of the space between them will become the insulating islands. This is then fastened in the center of a thin metal saucer about 4.5 inches in diameter. A very fine mesh net, the width of the quartz plate, is then fastened to and rolled on a roller of the variety used for ordinary household window blinds. This roller must have a spring for rewinding the net. The mesh of this net must be of such a size that the diagonal of the opening is as large as the width of the insulating strips between the silver strips (S) (Figure B). This roller is then fastened to the back of the metal saucer, and the net is pulled through a large slit in the saucer above the quartz plate. It is then pulled over the plate and through another slit at the bottom and fastened with two small wires to a terminal. This is arranged so that when the net is no longer needed, the wires may be electrically burned in two and the net will rewind itself on the roller and be out of the way. This is necessary as the photoelectric layer must be vaporized on the plate under vacuum while the plate is in the tube.

The screen allows the photoelectric layer to be vaporized on the plate where the openings are but not where the wires are, thus making tiny insulating islands (J) (Figure C) between the photoelectric layers (C) (Figure C). Since the diagonals of the openings in the net are as large as the width of the insulating strips between the metal strips (S) (Figure C), each photoelectric square will touch one of the diagonal metal strips, which will serve as a conductor to the outside.

For the vaporization of the photoelectric layer on the plate, it is necessary to have an electric source in front of the screen, which also must be removed after the vaporization is completed. This is accomplished in a somewhat similar manner as follows.

The electrical element is fastened to a stiff wire which has been bent in a 90° arc with a radius of approximately four inches. At the opposite end from the element the wire is bent to a radial position and is passed through two holes in two small pieces of metal. These have been fastened to the edge of the flat part of the back of the metal saucer perpendicular to the bottom of the saucer at a point opposite to the middle of one of the sides of the quartz plate. These two pieces of metal serve as a pivot for the entire unit. After passing the wire through them, it is bent again at right angles to itself and at an angle of 45° to the plane of the arc. A spring is fastened to this end so as to hold the mechanism in place and pull the parts back into place after vaporization is completed. The element is then pulled through a slit cut in the side of the saucer to its position in front of the plate and fastened there with another small wire which will be burned through when the vaporization is completed. The above assembly is now placed in the tube and after the tube is sealed and gittering is completed, the photoelectric layer is vaporized in a normal manner through the net on the plate. Then the vaporizing equipment is removed as explained above and the tube is complete.

Pictures 1, 2, and 3 show the Krawinkel tube assembled before the plate has been vaporized with the photoelectric layer. In Pictures 1 and 2 the net and electric source can be seen in front of the quartz plate. In Picture 3 the empty curtain roller, on which the net will be rolled, can be seen clearly on the left, and above this the taut spring to the end of the wire which supports the electric source for vaporizing the photoelectric layer on the plate. This wire can also be seen passing upward through the metal plates that support it and then bending forward directly away from the camera. The taut spring will pull the wire and electrical source away from in front of the plate when the thin wire (which cannot be seen in any of the pictures) is electrically burnt in two.

Picture 4 shows the completed tube with the net and electrical source for vaporizing the photoelectric layer removed and should be compared with Picture 2, which is the corresponding view of the unfinished tube.

Pictures 2 and 4 also show a good view of the metal saucer, to which the quartz plate is fastened.

Picture 5 shows the completed tube with the net wound up on the roller on the left (being pointed to with the light pencil). This should be compared with the empty roller in Picture 3. Above this roller in Picture 5 the spring can be seen in its normal position, the electrical source having been drawn (being pointed to with the dark pencil) behind the metal saucer. This should also be compared with Picture 3. Between the two pencils in Picture 5 can be seen the gittering device. This is also visible in Picture 3.

Picture 6 shows a good view of the fluorescent screen.

Picture 7 shows the inventor, Dr. Krawinkel, holding a completed model of his tube.

GITTERING

The usual method of "gittering" of melt-off tubes, which consists of depositing a barium or strontium layer on a part of the tube, is usually unsatisfactory; therefore a gittering method was developed and used as follows.

This gittering device was built similar to a three-electrode-tube (amplifier-tube), as is shown in Figure D, and consists of an electron emitting heating filament (k), around which is a coarse meshed grid (g), which is connected to a positive voltage (approximately 200 volts). The whole thing is surrounded by a metal casing (a), on the inside of which is a "gitter" layer (b), which is connected to the negative voltage.

The electrons emerging from (k) (Figure D) are accelerated by the positive voltage on the grid (g) (Figure D) and on their way from (k) to (g) ionize the residual gas molocules. The resulting positive ions are accelerated to (a) by the potential drop between (k) and (a) and are shot into the gitter layer (b) at a much higher velocity than normal.

This gittering device is installed in a convenient place in the tube in order to produce the necessary vacuum.

APPENDIX I

FIGURES AND PHOTOGRAPHS

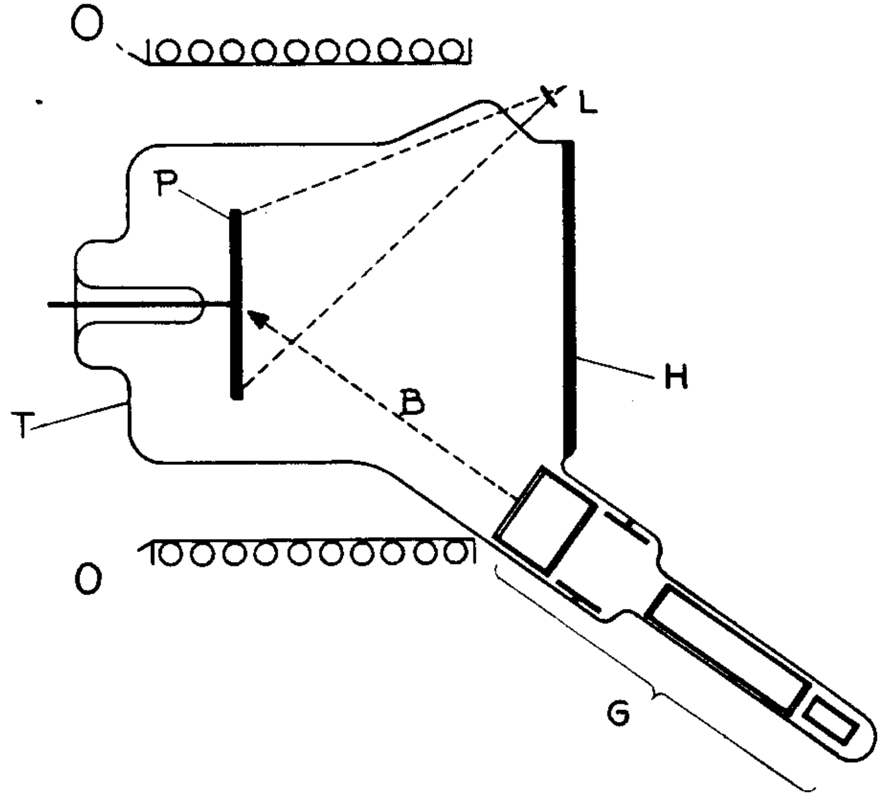

FIG. 1: THE KRAWINKEL TUBE.

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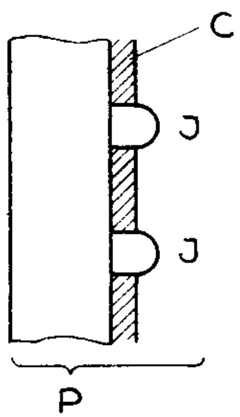

FIG.2: ENLARGEMENT OF SECTION OF THE STORAGE PLATE.

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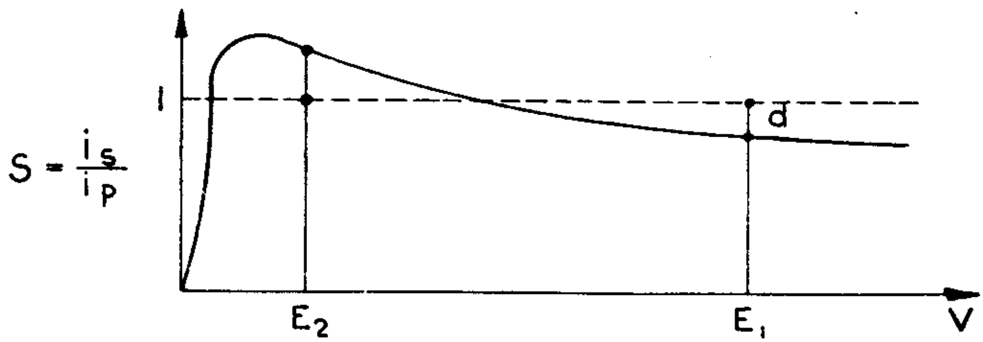

FIG 3: NORMAL SECONDARY EMISSION FACTOR CURVE.

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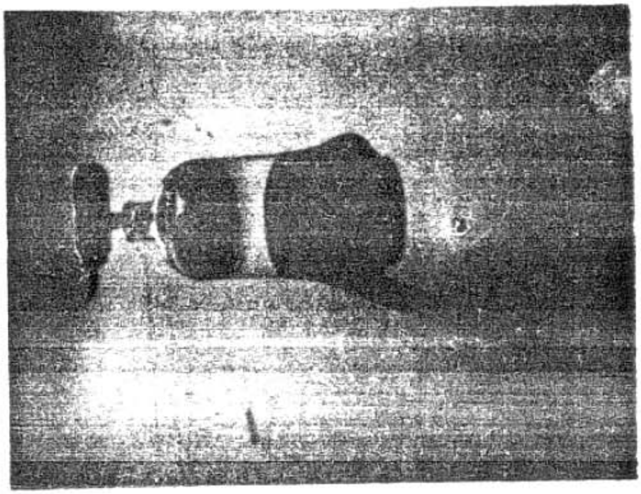

Figure 4

The First Krawinkel Tube

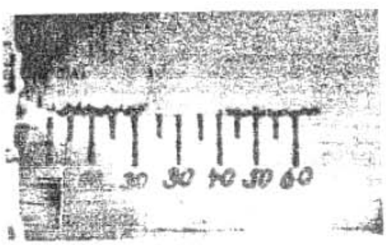

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Figure 5 - One of the First
Pictures Recorded on the Tube

FIG. A: PLATE AND METAL BORDER.

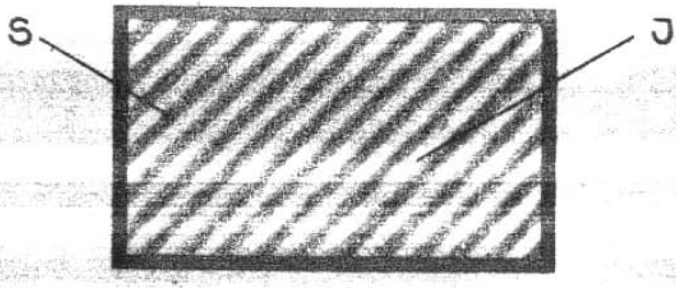

FIG. B: PLATE. BORDER. AND METAL STRIPES

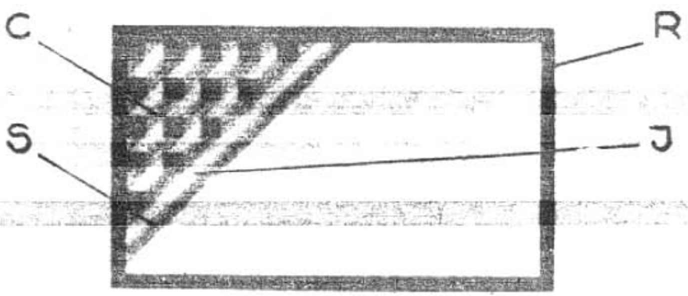

FIG. C: PLATE. BORDER. STRIPES. AND PHOTO-SENSITIVE SQARES.

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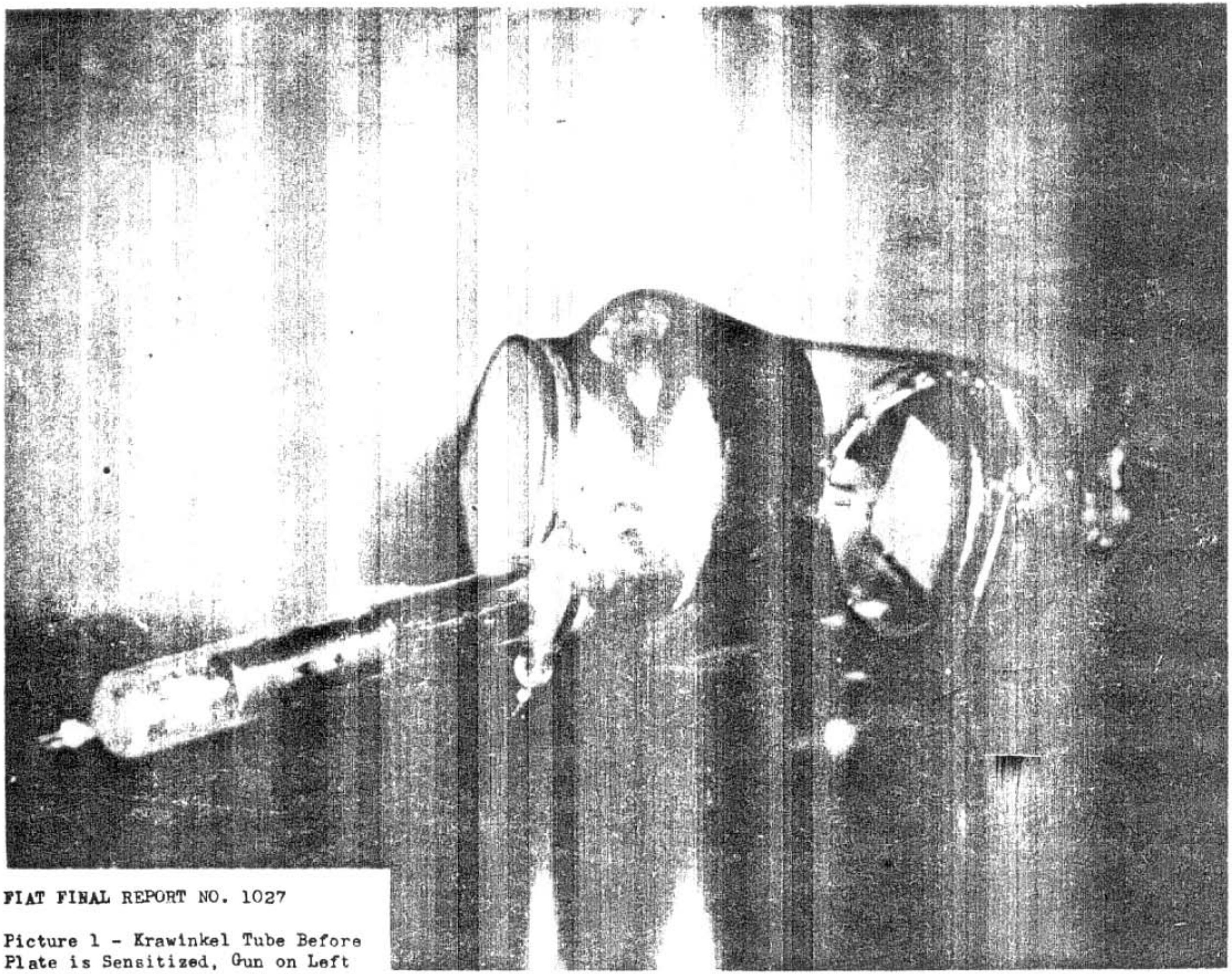

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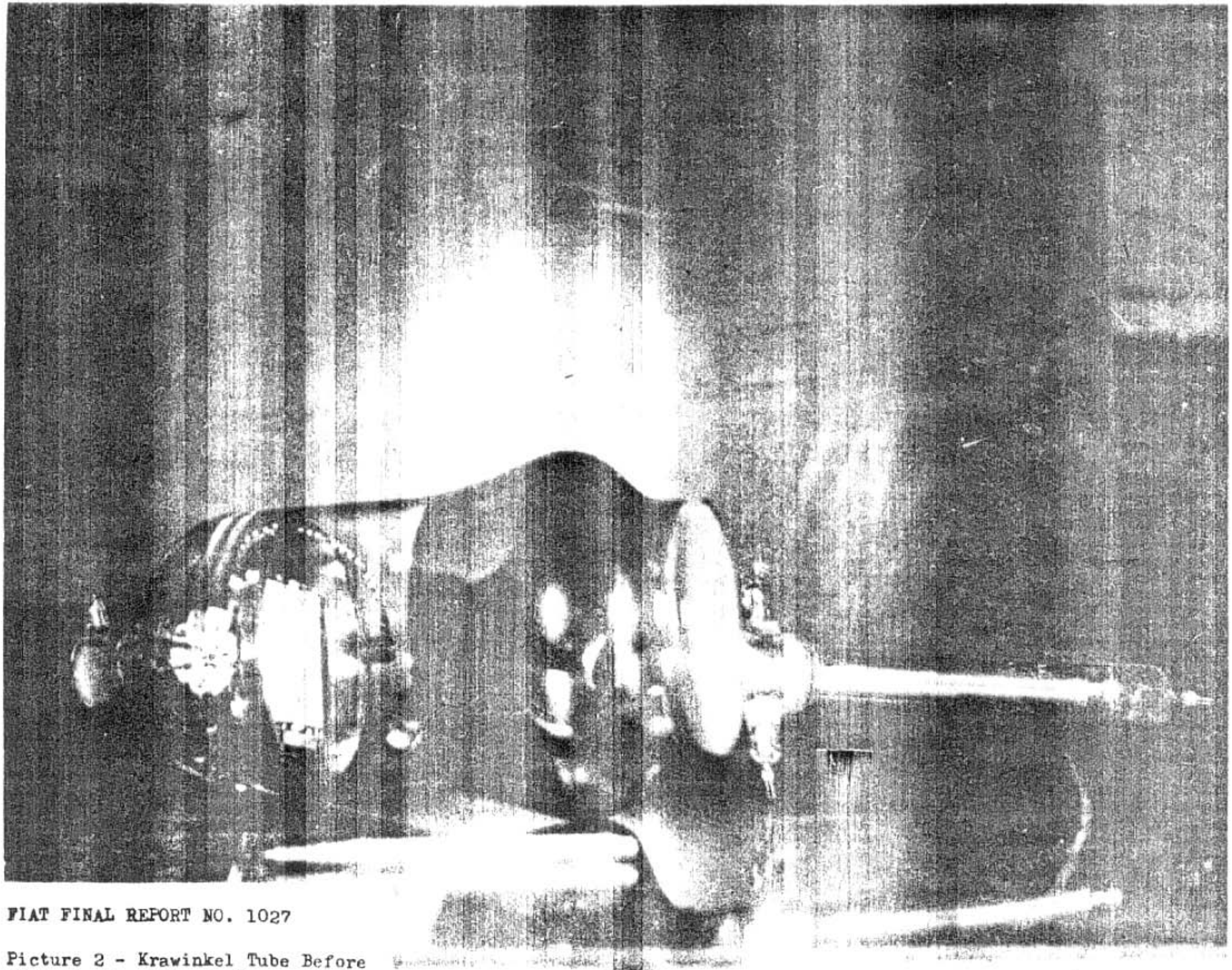
Picture 1 - Krawinkel Tube Before Plate is Sensitized, Gun on Left



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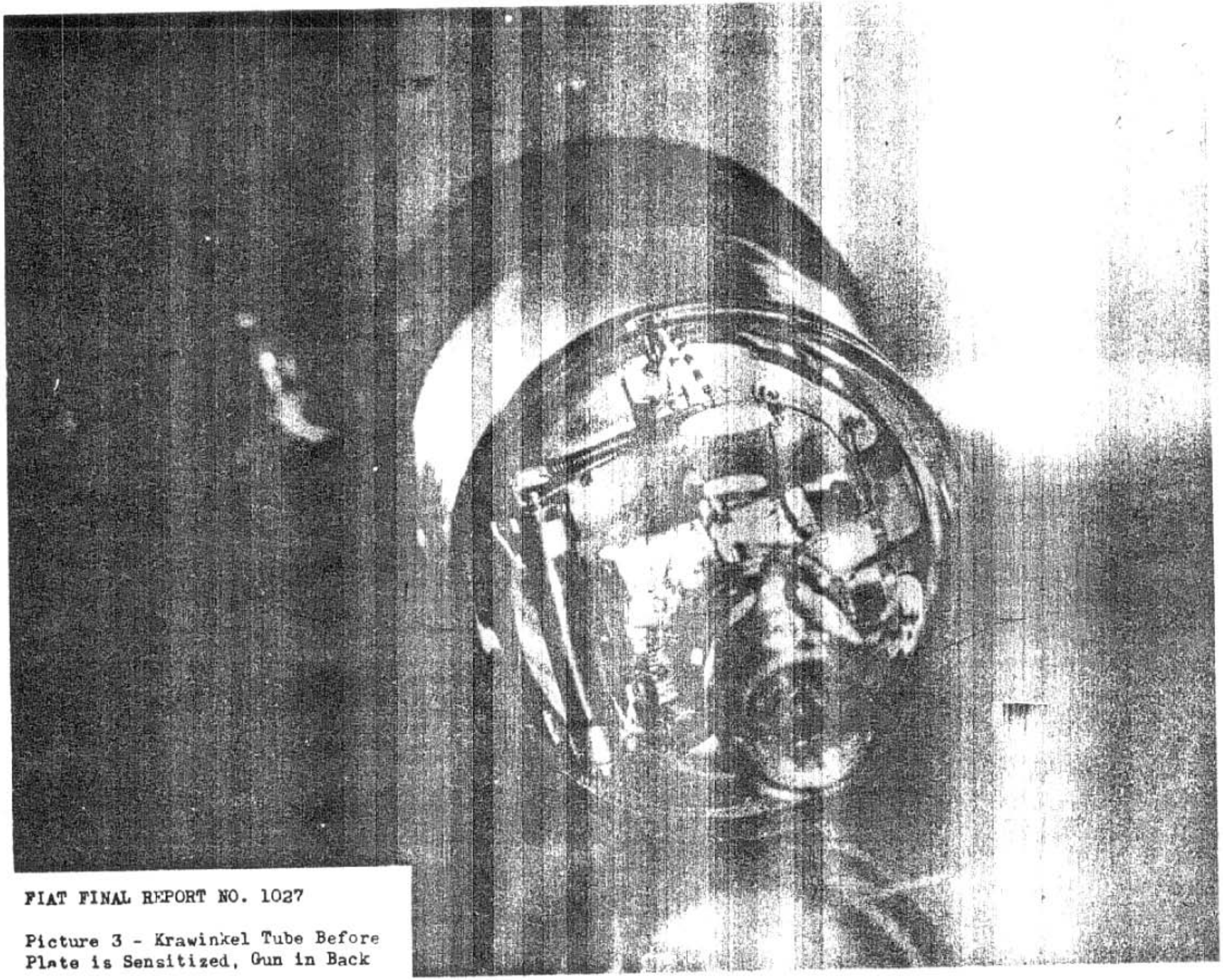
Picture 2 - Krawinkel Tube Before Plate is Sensitized, Gun on Right



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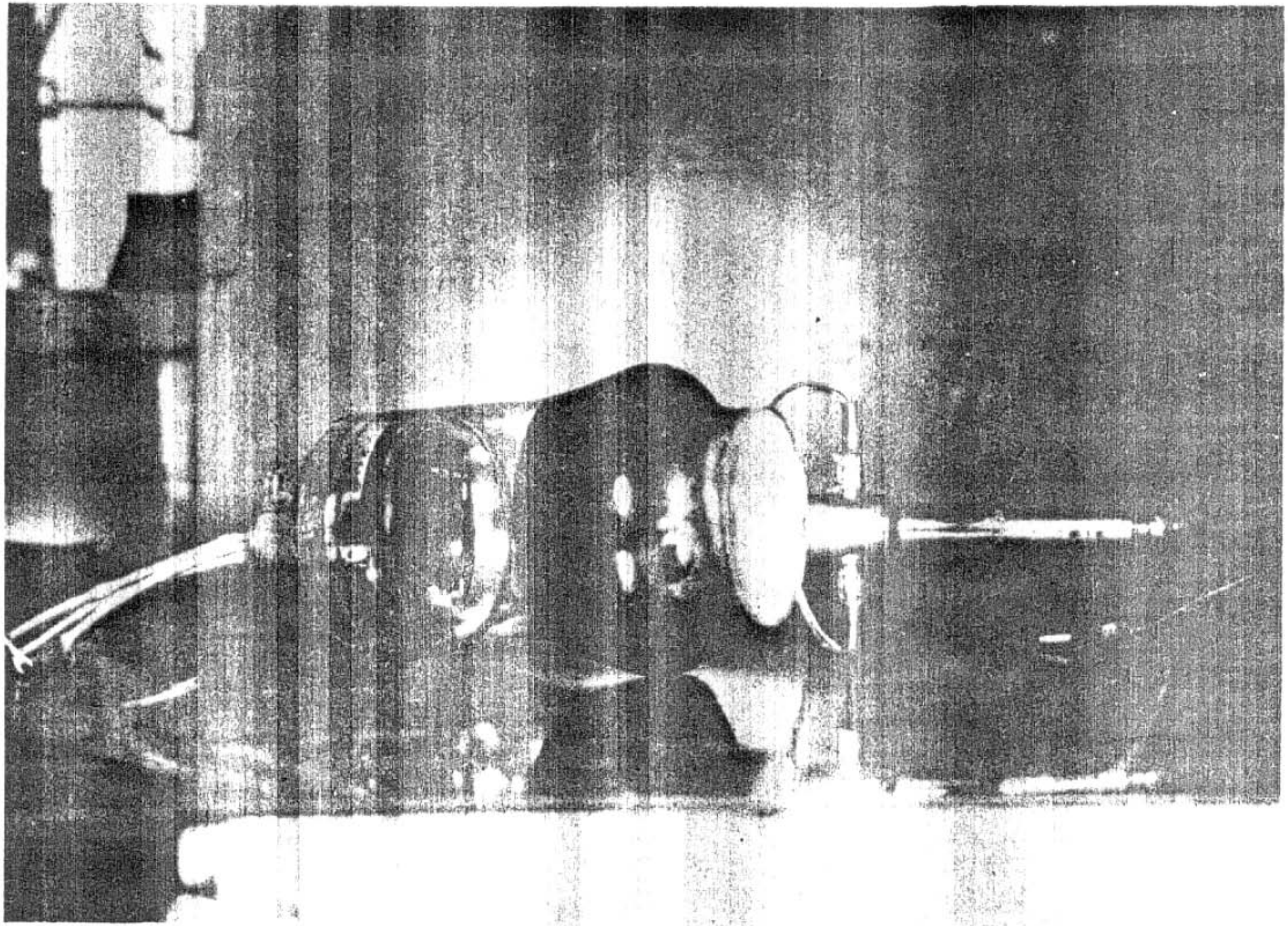
Picture 3 - Krawinkel Tube Before Plate is Sensitized, Gun in Back



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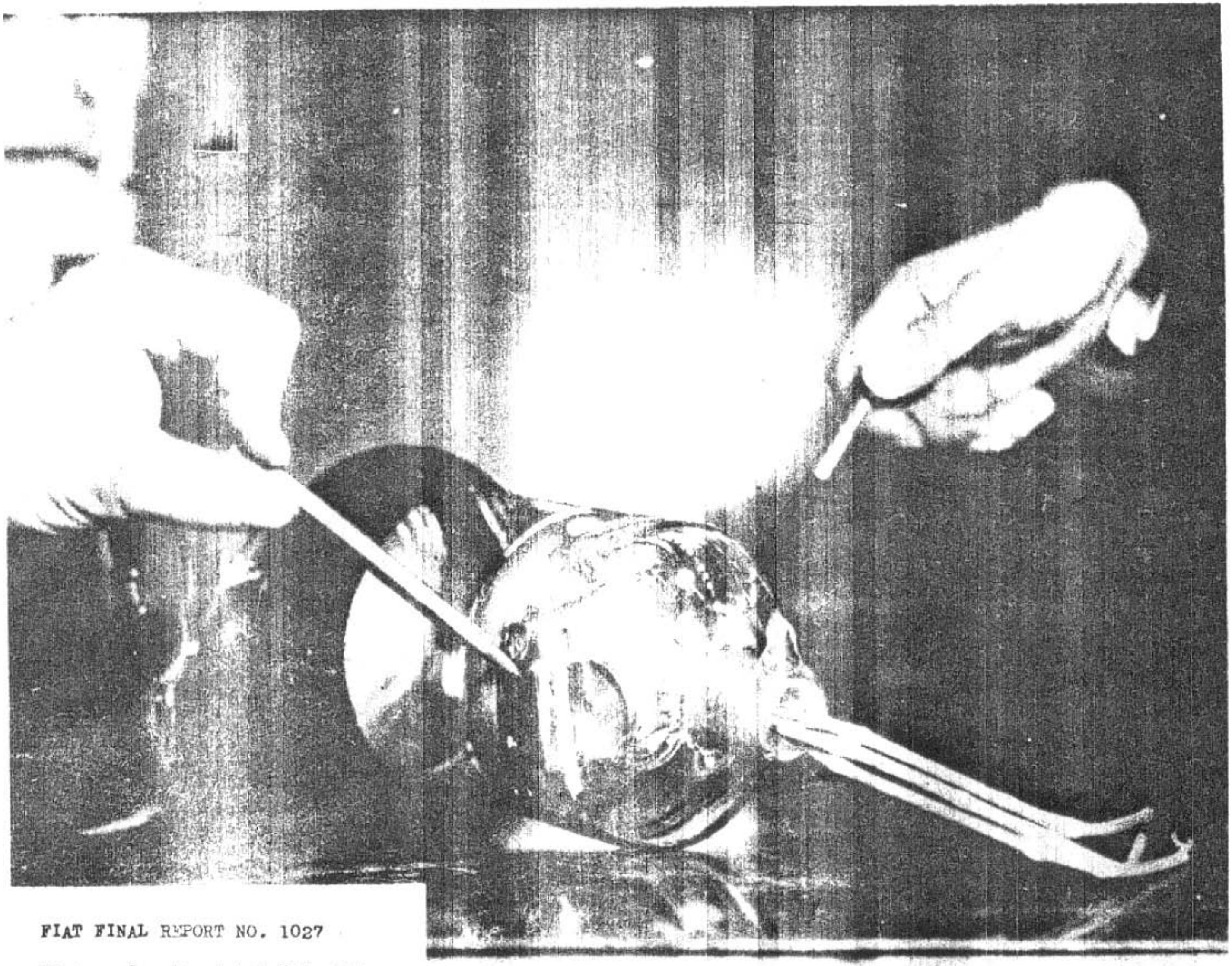
Picture 4 - Krawinkel Tube After
Plate is Sensitized, Gun on Right



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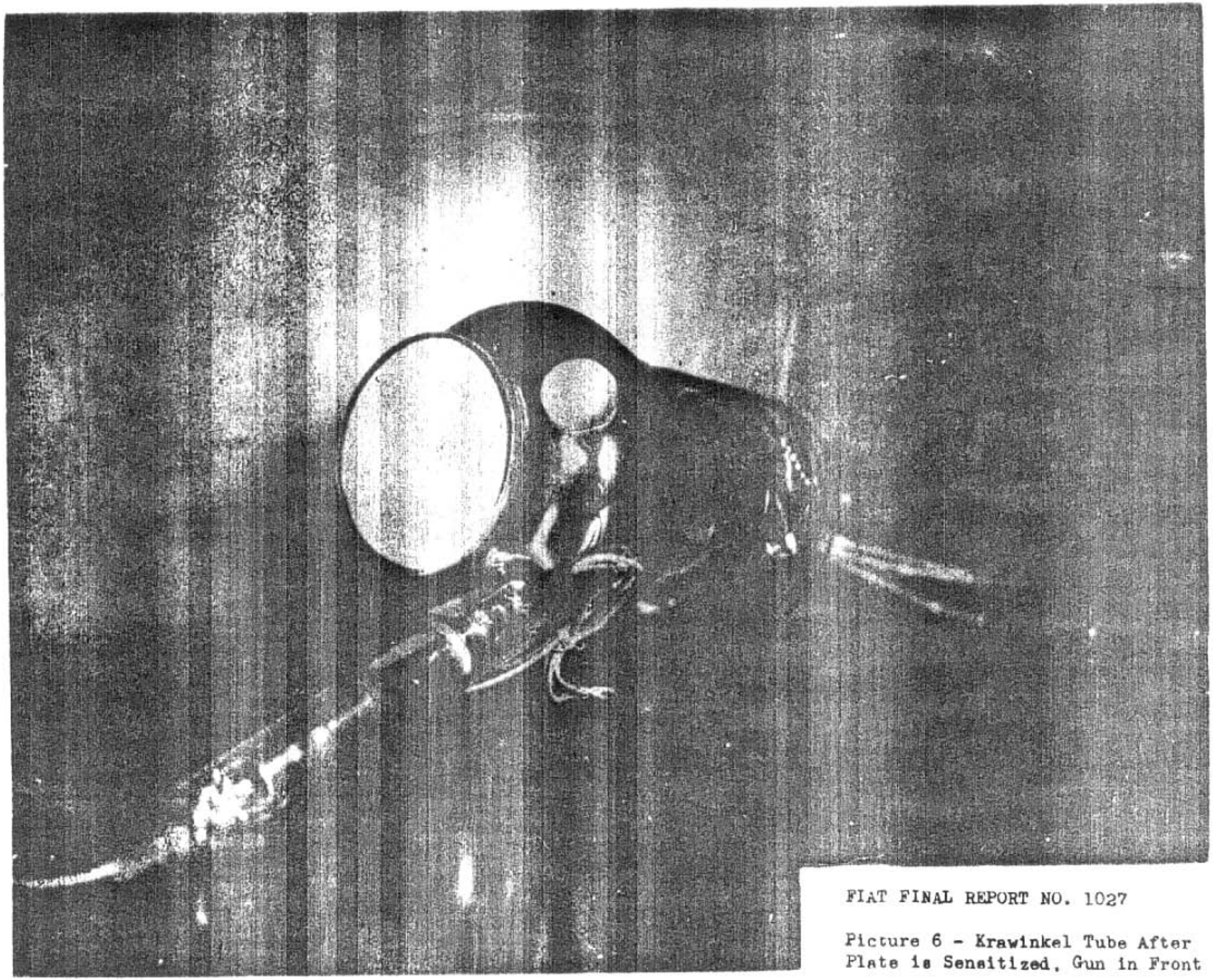
Picture 5 - Krawinkel Tube After Plate is Sensitized, Gun in Back



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Picture 6 - Krawinkel Tube After Plate is Sensitized, Gun in Front

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Picture 7 - Dr. Krawinkel
Holding one of the Krawinkel Tubes

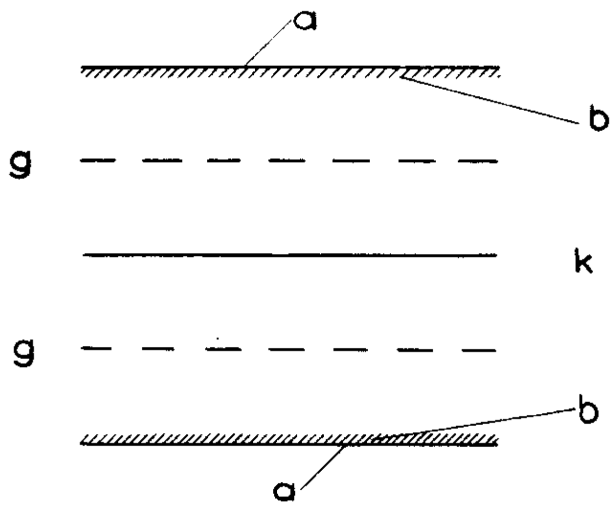

FIG. D: CROSS SECTIONAL SKETCH OF GITTERING DEVICE.

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