

KIRLIAN PHOTOGRAPHY
ITS SCIENTIFIC FOUNDATIONS AND FUTURE POTENTIAL

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by
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I. INTRODUCTION

In recent years, considerable interest has developed in a type of high-voltage photography recently called Kirlian photography after its chief developer, the Soviet scientist, Semyon Kirlian, who investigated many aspects of the technique over a 30-year period^(1,2). On the photograph, one sees an image of the structure of the surface studied plus a surrounding halo. Both the dimensions of the halo and the overall brightness of glow appear to change in accordance with changes in the physiological state of the organism. Current interest in this subject is very high on the part of physicists, biologists, psychologists, psychiatrists and those involved in the healing professions who look upon the technique as a unique way of observing energy states associated with all living things. In fact, some investigators in the United States are already trying to use it as a diagnostic tool to monitor the psychological and physiological conditions of their patients.

Some rather extravagant claims have been made about the process based upon very little first-hand information and based upon experimental results by

untrained investigators. Of course, the fascinating color photographs of plant leaves⁽³⁾ and human fingertips would make anyone wax poetic. Early statements attributed to the Soviets⁽¹⁾ suggested that the aura, as seen by clairvoyants, was being photographed. From the Soviets, we also heard claims that freshly cut leaves, with significant portions removed, still exhibited the radiation pattern of the entire intact leaf⁽¹⁻³⁾ suggesting evidence for a "lost limb" type of effect. Remarkable color effects have been reported in the U.S. and ascribed by the investigators to various psychological and psychic events. Indeed, an abundance of extremely interesting and potentially exciting observations have been made that demand our careful attention.

On the one hand, if the data are taken on face value, the intensity and character of the energy emissions seem to depend strongly on the mental, emotional and physical health condition of the subject being photographed and this has prompted some people to postulate new types of energy emission from the body (called bioplasmic energy by some Soviets⁽⁴⁾). On the other hand, the process itself is clearly associated with an electrical discharge and looks, on the surface, like a corona discharge effect which has prompted other people to relegate the entire phenomenon to a category of fairly familiar and thus uninteresting electrical discharge effects. However, if it is clearly the latter, then the technique may be a convenient path to the obtaining of electrical correlates for certain physiological or biological states in living systems. If it is clearly the former, then we have indeed opened a new door to the study of Nature.

After three years of experience with Kirlian photography in the U.S., it is now time we asked ourselves some serious questions concerning the process:

(a) Can we realistically account for the observations made to date with a specific

model? (b) In what way might the changes of energy states in the living system be made manifest on the photograph? (c) Can we presently specify the weaknesses of the technique and thus delineate which observations reveal new information and which are merely artifact associated with poor technique? (d) Is this a potentially useful technique and what must be done to maximize its utility? (e) Does the evidence show that we are dealing here with physical or what we might call "nonphysical" effects?

We shall see that all questions can be answered in the affirmative and that development of the technique is worth pursuing. We shall see that there is a specific physical explanation, called the "streamer" phenomenon of corona discharge, that can account for all the observations made to date. We shall also see that the identification of a specific physical mechanism for light generation does not mean that energy interactions with nonphysical levels of the universe are not intimately involved. A brief discussion of this latter point will be made at the end of this article. We shall start with a discussion of the "streamer" work done by electrical engineers during the past 40 years as a background for viewing Kirlian photography.

II. BACKGROUND STREAMER STUDIES OF THE 1930's AND 40's

A. Basic Features

One may begin by considering a plane-parallel gap between two metal electrodes, of spacing $d = 1$ cm, in which the cathode is illuminated by ultraviolet light to such an extent that one electron per microsecond leaves one cm^2 of cathode area. Assume that the atmosphere is air at 1 atm and that the voltage between the plates is 31,600 volts (the conventionally observed sparking potential across an air gap, V_G^*). The ratio $E/p = 41.6$ volts/cm per mm Hg, where E

is field strength and p is pressure, is an important parameter of the process. A single electron starts across the gap quickly acquiring an average random energy of $\bar{\epsilon} = 3.6$ eV and a drift velocity v in the field direction of about $1.5 - 2.0 \times 10^7$ cm/sec. As this electron moves, it creates new electrons by collision at the rate of α per cm in the field direction (α depends strongly on E/p) so that, in a distance x , it and its progeny amount to $e^{\alpha x}$ electrons forming an avalanche. Therefore, $e^{\alpha x}$ positive ions have been left behind by the electron group, virtually where they were formed in the 10^{-7} sec during which the electrons travel between the plates. The mobility of the ions is 10^{-2} to 10^{-3} times that of the electrons.

As the electron avalanche advances, its tip is spreading laterally by the random diffusive movement of the electrons. The radial distance of diffusion is readily calculated to be $\bar{r} \approx \sqrt{2Dt}$ where $t = x/v$ is the time of advance of the avalanche and D is the electron diffusion coefficient. From these data, it is possible to compute the density of positive-ion space charge left behind at any point x . The value of α under these conditions is about 17 making $e^{\alpha x} = 2.4 \times 10^7$. The first ion pair is created at 0.04 cm from the cathode and there are 4.9×10^3 ions at .05 cm from the cathode, 3.7×10^5 ions at 0.75 cm, and within 0.04 cm from the anode, there are 1.2×10^7 ions. A schematic illustration of this process is given in Fig. 1. Cloud track pictures of such avalanches as they proceed across the gap with time intervals of 10^{-7} sec are shown in Fig. 2.

Most of the electrons will be drawn to the anode except for some few that are bound by the positive ions. Such a distribution of ions does not make a conducting filament of charges across the gap and hence, in itself, an avalanche

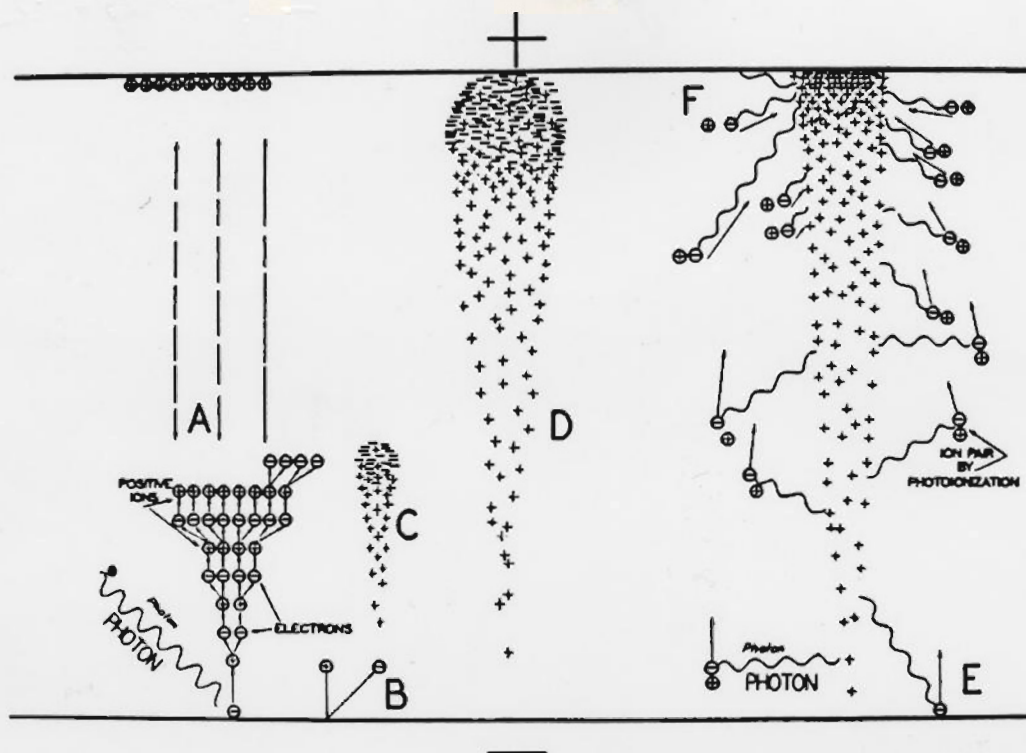


FIGURE 1

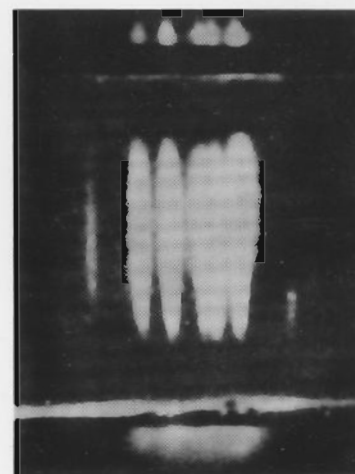
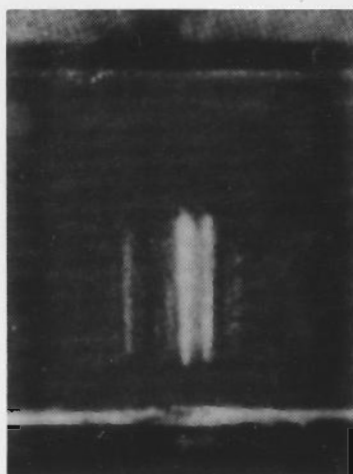
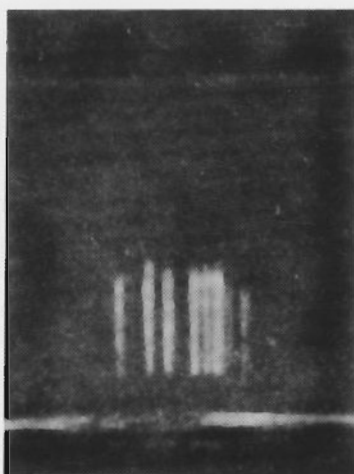


FIGURE 2

that has crossed does not constitute a breakdown of the gap. We can readily estimate the electric field, E , at the anode, due to the positive ions which are the force attracting the electrons back to the ion cloud. For the conditions chosen, it is 6000 volts/cm or $E_1/E = 0.20$. Thus, the field caused by the positive space charge is 20% of the applied field near the cathode. If the initial voltage had been increased by only 5%, E/p would have been 43.6, α would have been 20 and E_1 would have been 140,000 volts/cm. Thus, for this case, part of the electron swarm would have been held back by the dense space charge some 0.9 of the way across the gap. These electrons will recombine with ions and radiation will be emitted.

The single most important fact neglected thus far is that a number of secondary mechanisms exist for the formation of electrons in the air gap. Since α is a constant for a given value of E/p , electrical breakdown can occur only if, before disappearing, this first avalanche itself gives rise to a second avalanche at least as dense and so on. This can happen only as a result of other processes for the production of free charges:

- (1) β effects: ionization of the gas by collision with positive ions created by the initial electrons.
- (2) γ effects: emission of secondary electrons by the cathode under impact from ions in the discharge. It is this process which explains breakdown at medium pressures. It depends on the nature of the gas and the cathode and can occur only after a considerable delay.

- (3) δ effect: emission of secondary electrons by the cathode under impact from photons coming from the discharge (de-excitation or recombination). Since the photons are very fast and scarcely absorbed, this process is very fast and efficient (particularly at high pressures); it depends on the gas and the cathode.
- (4) ϵ effect: emission of secondary electrons by the cathode under impact from excited atoms in metastable states. The effect is analogous to γ and δ processes but, in this case, the delay is a great deal longer because the atoms diffuse very slowly to the cathode.
- (5) η effect: photoionization of the gas which can play a significant role at high pressures. In pure gases, it can occur only with great difficulty since the photons which arise in the gas due to recombination or de-excitation do not have sufficient energy to ionize the same gas.

For the generation of streamers, it is the η effect that is of prime importance to us. Accompanying the cumulative ionization, there is produced by the electrons, from 4 to 10 times as many excited atoms and molecules⁽⁵⁾. Some are excited to an energy exceeding the ionizing potential of some of the atoms and molecules present, either by excitation of an inner shell, by ionization and excitation, or in a mixed gas like air by the excitation of molecules of higher ionizing potential; e.g., N_2 . These atoms or molecules emit radiations of very short wavelength in $\sim 10^{-8}$ seconds. This short ultraviolet radiation is highly absorbed in the gas and leads to ionization of the gas.

The photoelectrons created at points in the gas and at the cathode at any

great radial distance from the avalanche axis will merely create more avalanches. Those photoelectrons created near the space charge channel of positive ions, and especially near the anode, will be in an enhanced field which exerts a directive action drawing them into itself.

The electrons from the intense cumulative ionization of such photoelectron avalanches in the combined fields E and E_1 which are drawn into the positive space charge feed into it, making it somewhat of a conducting plasma which starts at the anode. In this fashion, the positive space charge develops toward the cathode from the anode as a self-propagating positive space-charge streamer. The velocity of streamer propagation, dependent as it is on photoionization in the gas and photon propagation at the velocity of light as well as the short distance motion of electrons in high fields near the space charge, is rapid. It has been observed to be about 1.3×10^{-8} cm/sec by Raether⁽⁵⁾ in one case.

As the streamer advances towards the cathode, it produces a filamentary region of intense space charge distortion along a line parallel to the field. The conducting streamer of a plasma consisting of ions and electrons extending to the anode thus makes a very steep gradient at the cathode end of the streamer tip. As this advances towards the cathode, the photoelectron avalanches produced by radiation at the cathode begin to produce an intense ionization near the cathode. Thus, as the space-charge streamer approaches the cathode, a cathode spot is forming which may become a source of visible light. As the streamer tip reaches the cathode, the high field produces a rush of electrons toward the end of the streamer. This, if followed by a current of electrons, gives a high-potential wave which passes up the pre-ionized conducting channel to the anode, multiplying the electrons present by a large factor. The channel may thus be rendered

highly conducting and, unless limited by external resistance, will then develop into an arc. The velocity of propagation of the returning wave of ionization up the pre-ionized channel may be as large as 10^9 to 10^{10} cm/sec in certain instances.

Aside from all the details, the important factor for us to remember is that this is the primary source of light detected in high-voltage photography. It is found that the process does not occur in vacuum, pure, rare or atomic gases, probably because of the absence of any significant photoionization effect. In addition, the process is only possible if the magnitude of E is sufficient for the charge density of the avalanche to reach a critical density N_c [requires $N_c \sim 3 \times 10^8$ ions with $r \approx 3 \times 10^{-3}$ cm arising from $(\alpha d)_c \approx 20$].

As we look a little deeper, we find that all light-emitting streamers do not propagate completely across the interelectrode space but that some are extinguished in midgap. The streamer length depends on the applied voltage, increasing linearly with the voltage. During streamer propagation, some of the initial critical ball of positive ions are consumed by recombination events so that it becomes subcritical and ceases to propagate; i.e., the energy required to create new ion pairs and excited atoms is derived from the energy of the streamer tip.

Although the onset of breakdown may depend on the electrode material, the streamer length is not similarly affected. The streamer length is found to be proportional to the applied voltage only. If a photographic film is placed in the point-to-plane gap (see Fig. 3), either perpendicular to and a short distance from the anode point, or parallel to and in contact with the anode point, the streamers move along the surface of the film and leave a photographic record of their path (Lichtenberg figures)⁽⁵⁾. In these experiments, the film seems to act largely as a deflector for the streamer such that the path length in air plus

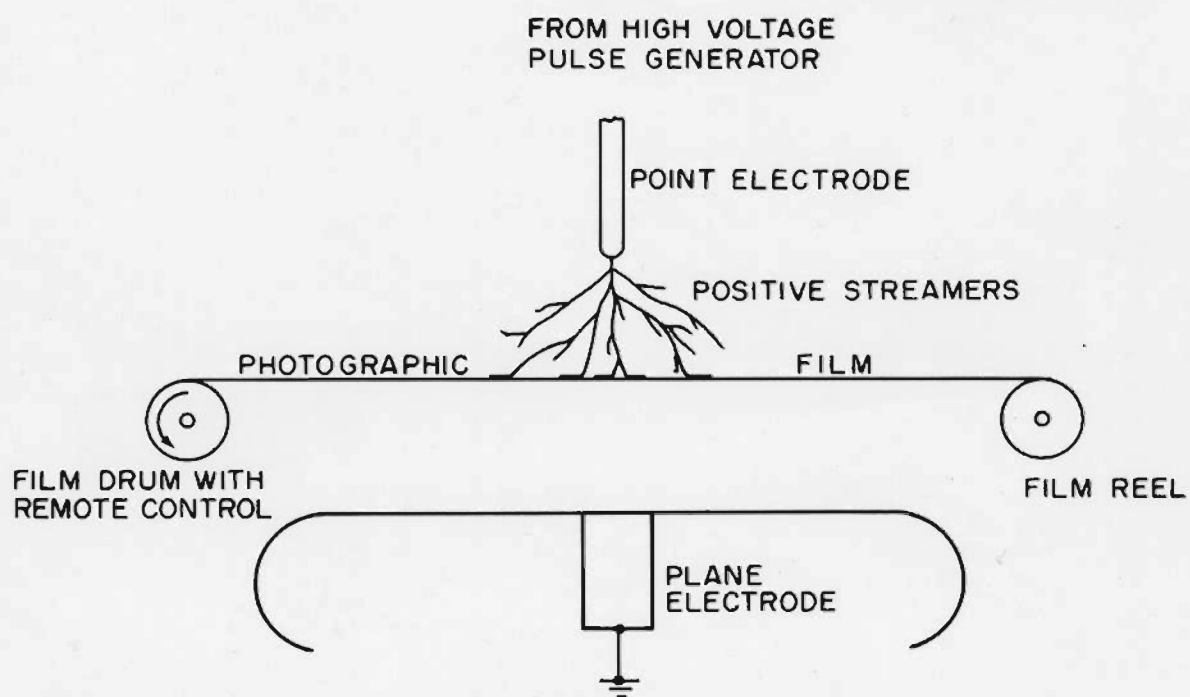


FIGURE 3

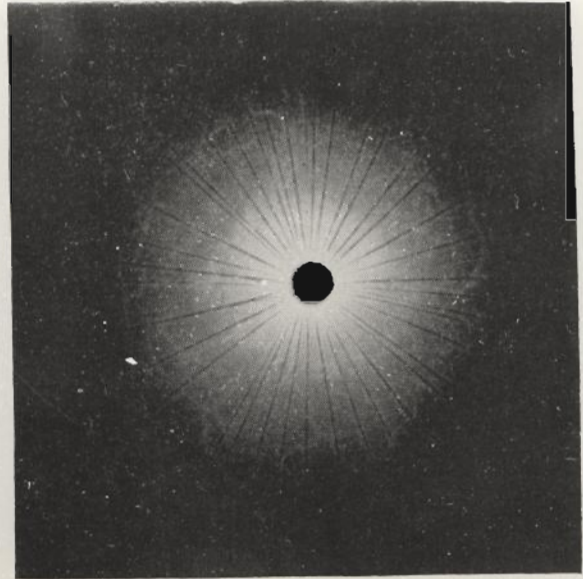
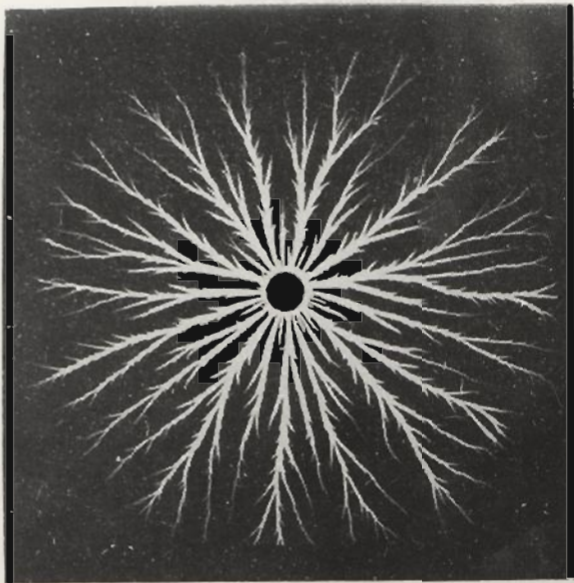
the length along the surface of the film is a constant for constant applied voltage⁽⁶⁾.

B. Electrode Polarity Effect

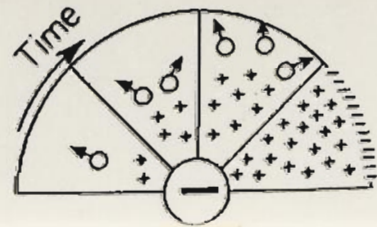
A representative experimental arrangement used for studying streamer characteristics is that of Nasser⁽⁷⁾ given in Fig. 3. The point-to-plane electrode configuration is a favored one by corona discharge researchers because it provides a uniform electric field in the vicinity of the plane electrode and a radially symmetric field in the vicinity of the point electrode having an enhanced field strength due to the reduced radius. Significantly different morphology and features of the discharge exist depending upon whether the point electrode is positive or negative.

The polarity effects recorded with a point-plane or cylindrical electrode arrangement (in Fig. 4) are the result of the different roles played by the electrons and positive ions in the discharge gap. The electrons are fast, ionize in avalanche fashion, and tend to move rapidly to the anode (+ve); the ions are slow, stay behind as positive space-charge clouds and tend to drift toward the cathode (-ve). The original electrostatic field between the electrodes is therefore greatly altered as events unfold.

When the point electrode is positive, the electrons are accelerated into a field of increasing intensity and leave behind radial channels of positive space charge, increasing steeply in charge density toward the anode. This extends the electrical character of the anode, giving it a tentacle-like character which attracts subsequent electrons. As new avalanches strike the radial channels from various directions, a system of positive space-charge branches grows from the



a



b

FIGURE 4

positive point electrode into space until, at the tips, the field becomes too weak to support further ionization.

In contrast, from a negative point electrode, the electrons speed out into fields of decreasing strength. Ionizing, they leave behind a positive charge that further weakens the radial driving field and creates tangential field components. Thus, the negative primary discharge broadens into sectors and steepens the field directly in front of the cathode. This tendency causes the primary negative Lichtenberg figure to be smaller than the positive Lichtenberg figure.

A space-charge branch of the positive figure (Fig. 5) may transform into a plasma when a succession of electrons traverse the same path. As the resistance of the branch decreases, more current concentrates in it and its field towards the outside increases. Thus, a positive spark develops as if a metal wire were pushed from the anode along a tortuous path predrawn by the primary figure. Side branches, robbed of their field by the advancing channel, die off. Since the voltage drop along the spark channel is quite small, a positive spark carries the anode potential practically on its tip. New starting electrons are created by the photo effect in the gas ahead of it. The advance continues, if overvoltage is avoided, by the creation of positive space-charge branches and the transformation of a selected few of these branches into plasma channels. Because the electron flow is a converging flow, the electron density reaches sufficient proportions that the magnetic pinch effect (Lorentz force) becomes operative, which squeezes the plasma into narrow channels.

On the other hand, the negative spark can draw on a much more copious electron source provided at the cathode by thermionic or field emissions. The



FIGURE 5

buildup of positive ions at the cathode surface enhances the magnitude of the electric field at the cathode and pulls more electrons out of the cathode. The developing plasma, however, does not find a narrow space-charge branch for intricate guidance but rather a broad sector of space charge and moves forward along a straight smooth path. Cutting radially through the primary figure, the spark may be brought to a temporary halt at its edge if overvoltage is avoided (the electrons are moving into a region of reduced field). Then the advance continues in the direction of the highest space-charge field gradient, which frequently lies tangentially to the old direction. It traverses its path in a number of discrete steps⁽⁸⁾. In this manner, the most intricate secondary Lichtenberg figures can be created. Still, the negative spark consists of smooth sections while the positive spark, in its unruly advance, reveals the guiding space-charge tracks.

With the point positive and facing the sensitive side of the film, the four autographs of Fig. 6 are typical of what is obtained as the film is moved from the point toward the plane. The autograph of Fig. 6(a) was taken with the film almost touching the point, yielding the typical positive figure. Such a figure is produced by a streamer emerging from the point and then deflected by the film. Because of the symmetry of the experimental apparatus, the streamer divides into six branches equally distributed around the circumference of the main branch. The six branches continue to branch further resulting in the pattern shown.

Moving the film 1 cm away from the point resulted in the autograph of Fig. 6(b). Here, there are a number of streamer branches, called impact points, out of which surface streamers, similar to those of Fig. 6(a) but having different lengths, grow radially outward. Such an autograph is produced by the several branches developed in the main streamer that strike the film and are then deflected into the

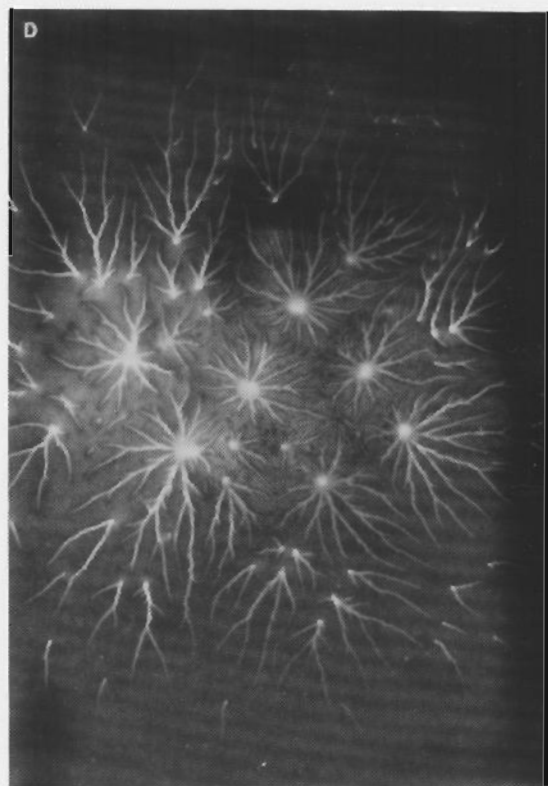
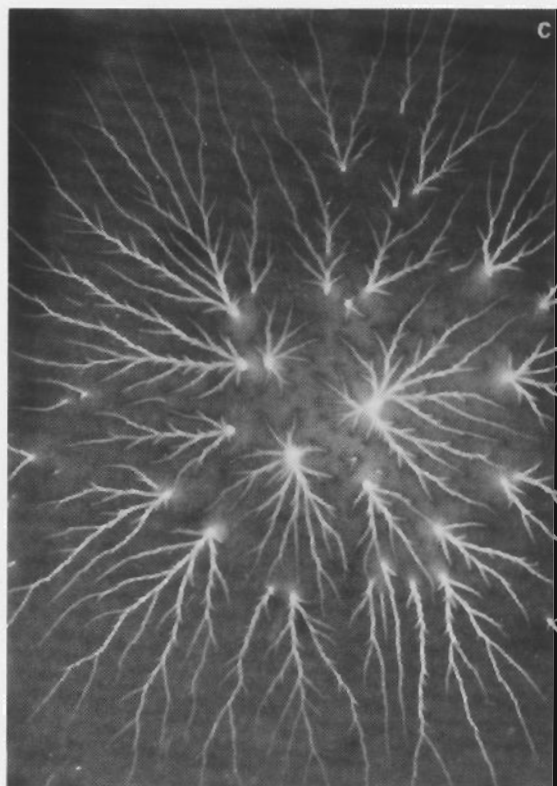
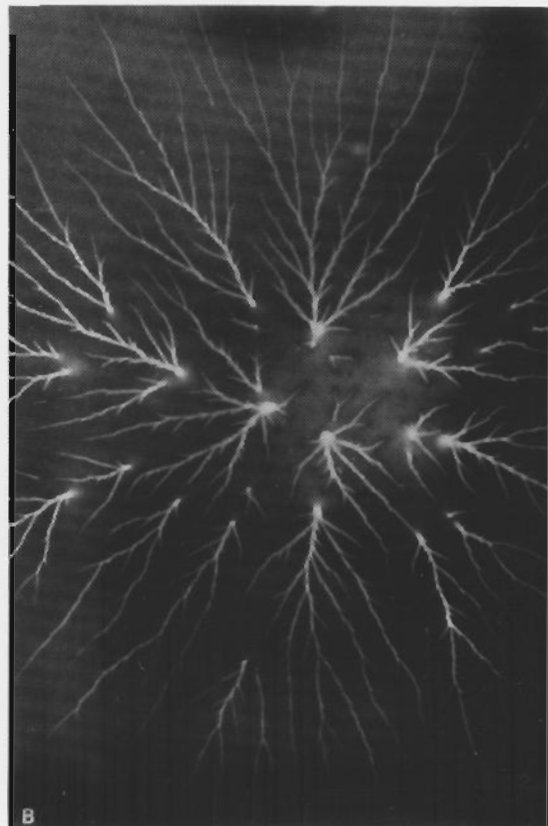
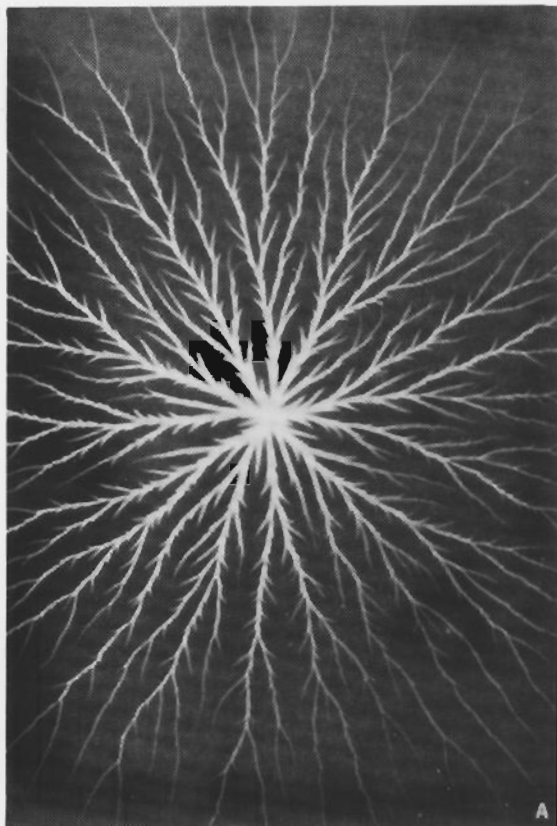
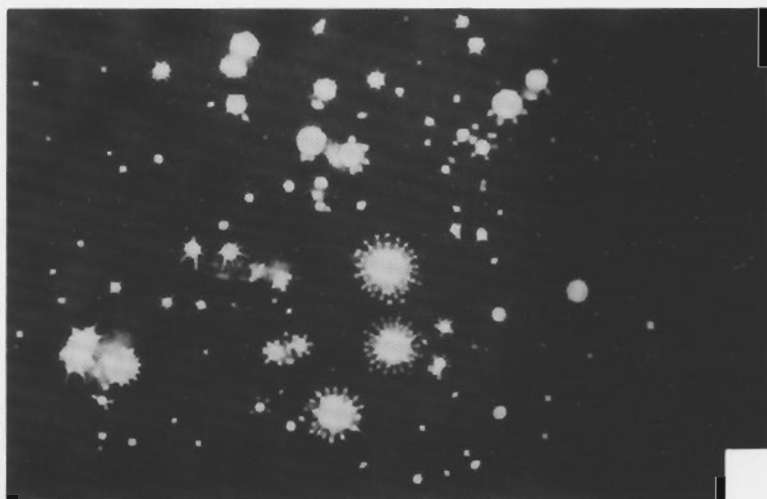


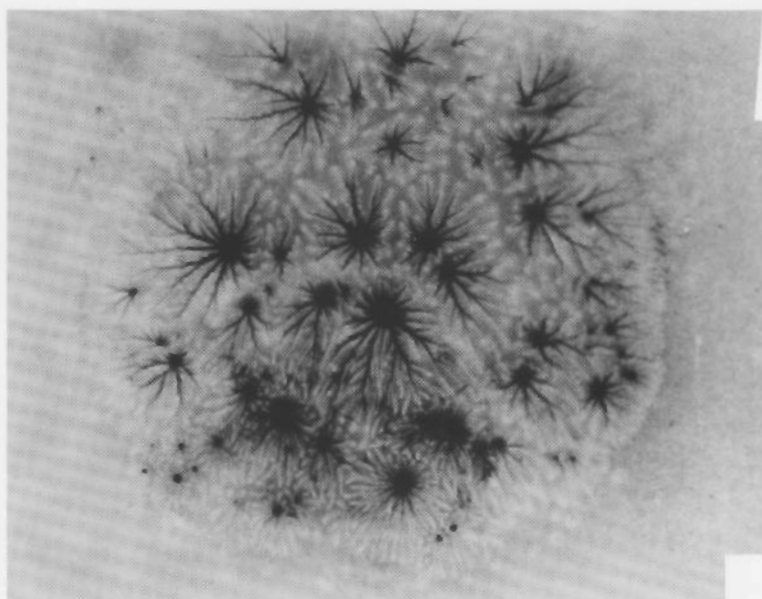
FIGURE 6

field. A single streamer starting at a point may branch into as many as 40 branches. Figure 6(c), taken 1.5 cm away from the point, shows that the number of impact points reaching the film has increased tremendously. The surface tracks (glide streamers) they produce have diminished in length however. From this fact, the electrical potential of streamer tips can be estimated. Finally, Fig. 6(d), taken 2 cm from the point, indicates the enormous number of branches present; most of them have short surface streamers that repel each other. All four autographs were taken with a 30 kV voltage pulse that was well above corona onset but below spark threshold (36 kV). At reduced voltages, the manifestations shown by the autographs become continually less pronounced, finally disappearing.

If very intensive streamers strike the cathode, electron emission is produced. This is due to the high electric field in front of the space charge of the streamer tips approaching the cathode; the emitted electrons are accelerated toward the positive wavefront. If there is ample time and distance, the electrons initiate avalanches and negative streamers. When the current is observed, a pulse is produced when the streamers reach the cathode. A flash of light was also reported when the phenomenon was viewed with the aid of sensitive photomultipliers. A film was placed on the cathode and, depending on the orientation of the emulsion side, either the ionizing processes at the cathode or those emanating from the anode, or both, were recorded. The use of color film shows both phenomena, with radiation coming through the back side exciting the red-layer emulsion and that coming from the front exciting the blue layer. Streamer impact points and tracks are seen in red, whereas cathode phenomena are seen in blue or white because of their high intensity (see Fig. 7).



a



b

FIGURE 7

C. Back Figures and Retrograde Streamers

On the negative points taken at low pressures (see Fig. 4), a ghost-like structure generally appears behind the sectors. Increase of pressure sharpens the structure of these "back figures"; they change from broad foggy trees to sparks traveling preferentially along the outer edges of the negative primary discharge figures (see Fig. 8). These sparks of pronounced positive character are soon a dominating factor in the landscape of the surface discharge (Fig. 9). They follow the negative sparks and climb like ivy over the negative tree trunks (Fig. 10). All the evidence indicates that the back figures are lightning strokes discharging the negative clouds when the transient voltage applied across the electrodes die away. Figure 11 schematically illustrates the situation in terms of surface charge and its removal for a typical case such as Fig. 9. After a rapid building up of the positive charge (cathode fall) by the primary negative figure, a negative spark develops from a preferential point, branches sharply and covers an appreciable area with a new primary figure. The external voltage starts to fall and soon the electrode becomes positive with respect to the negative parts of the cloud. At the point of highest gradient, the return flow of electrons starts with sufficiently intense ionization to create a positive spark. Using the large electron supply available in the negative surface charge, the spark grows rapidly and neutralizes the two-dimensional cloud as far as the intensity of the field allows. The final neutralization of the remaining charge is a slow process of local recombination and conduction without the formation of new traces.

D. Effect of Electronegative Gases

The influence of electronegative gases on the discharge is helpful for

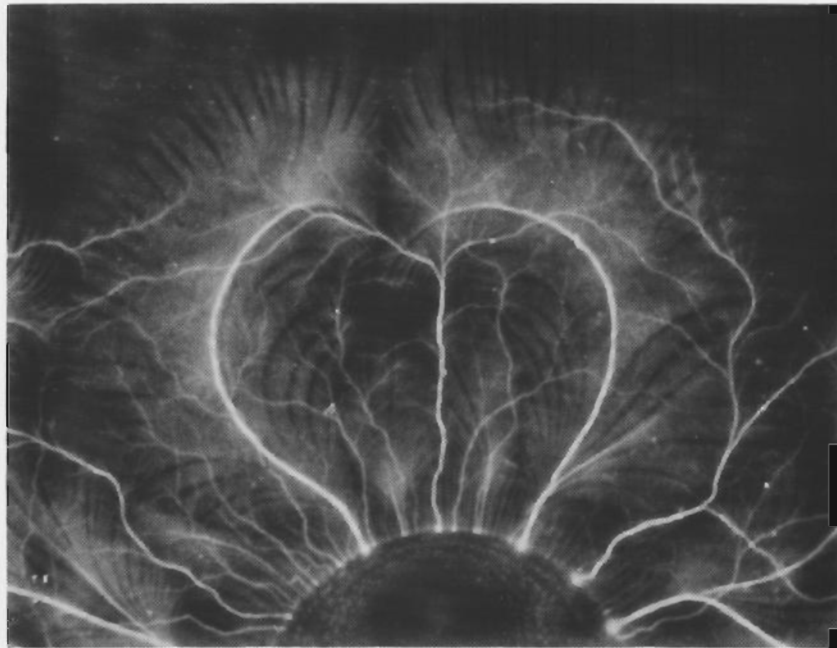


FIGURE 8

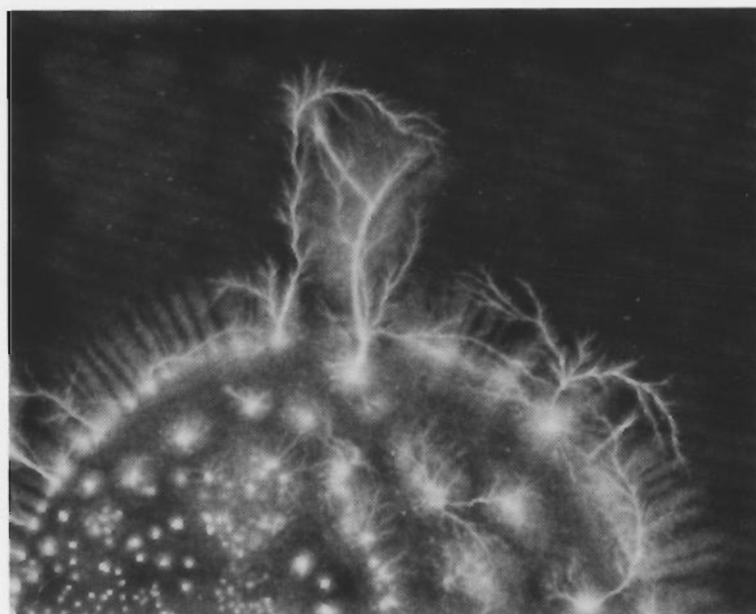


FIGURE 9

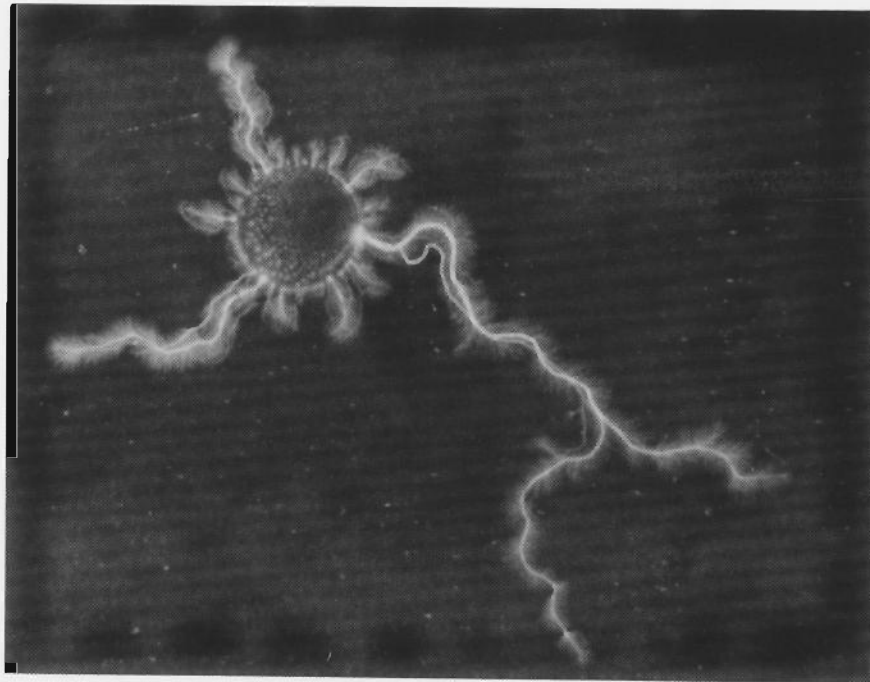


FIGURE 10

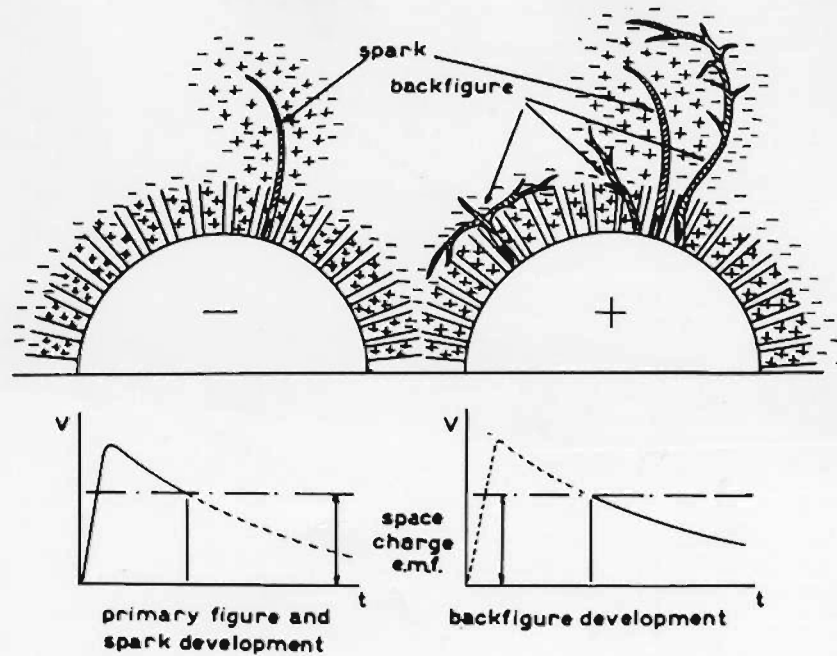
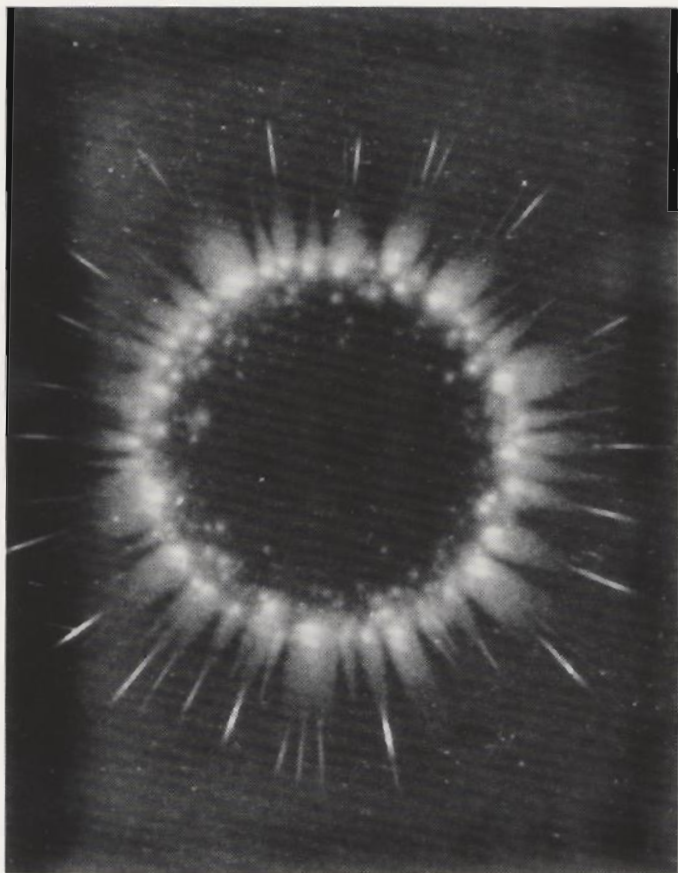


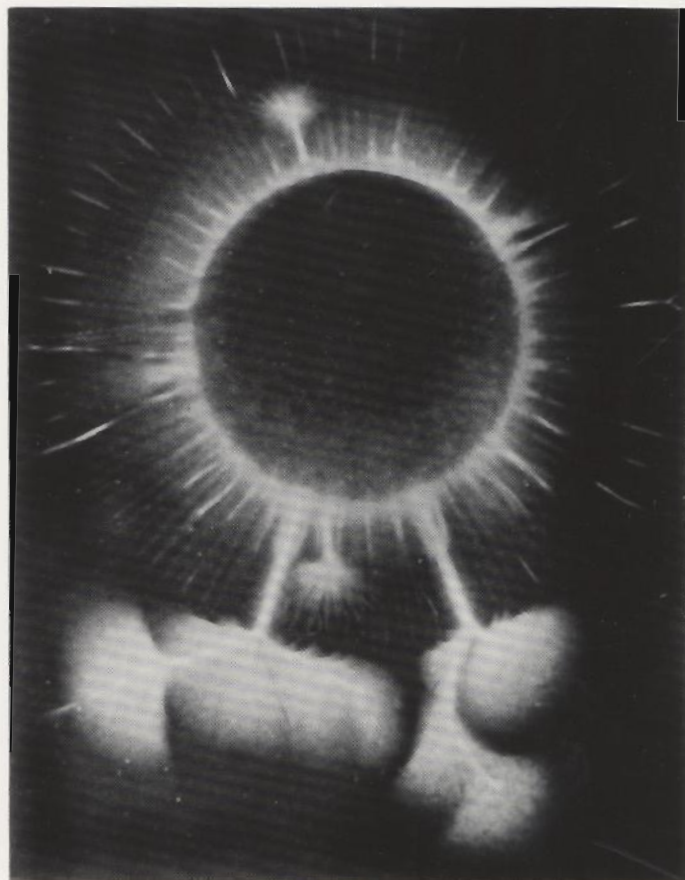
FIGURE 11

establishing the role played by the positive space charge. Addition of carbon-tetrachloride vapor to nitrogen changes the structure of the primary discharge figures completely. Not only does the diameter shrink to a small fraction of its initial size but also the fine structure of the positive branches and the sharp division of the negative sectors are lost (Fig. 12). This decisive activity of small admixtures of carbon tetrachloride is easily understood. Electron impact splits the carbon-tetrachloride molecules into two highly electro-negative components, CCl_3 and Cl . Both trap slow electrons, thus hindering the start and quenching the growth of electron avalanches. The negative ions formed drift slowly through the field like the positive ones, smoothing out the boundaries of the positive space charge. No sharp negative sectors appear and, instead of the far-reaching positive branches, only short leaves are formed.

The activity of a suppressor gas (organic vapors are found to be extremely effective) is not constant. The decomposition of the original molecule into electro-negative components, the trapping of electrons by the decomposition products and the release of electrons from negative ions by violent collisions depend on the character of the gas and the experimental conditions. Figures 13 and 14 plus Figs. 12 illustrate the altered discharge morphology due to the presence of a suppressor gas for both positive and negative points. In Figs. 12(a) and 13, we note the appearance of radial spikes of enhanced ionization. In the case of the negative figure, Merrill and Von Hippel⁽⁸⁾ assume that the negative space charge may become so dense that electrons at the outer boundary are projected outwards starting new avalanches. In some cases, periodic ring structures are formed by periodically revived ionization. These effects disappear if the electro-negative gas is highly concentrated.



a



b

FIGURE 12

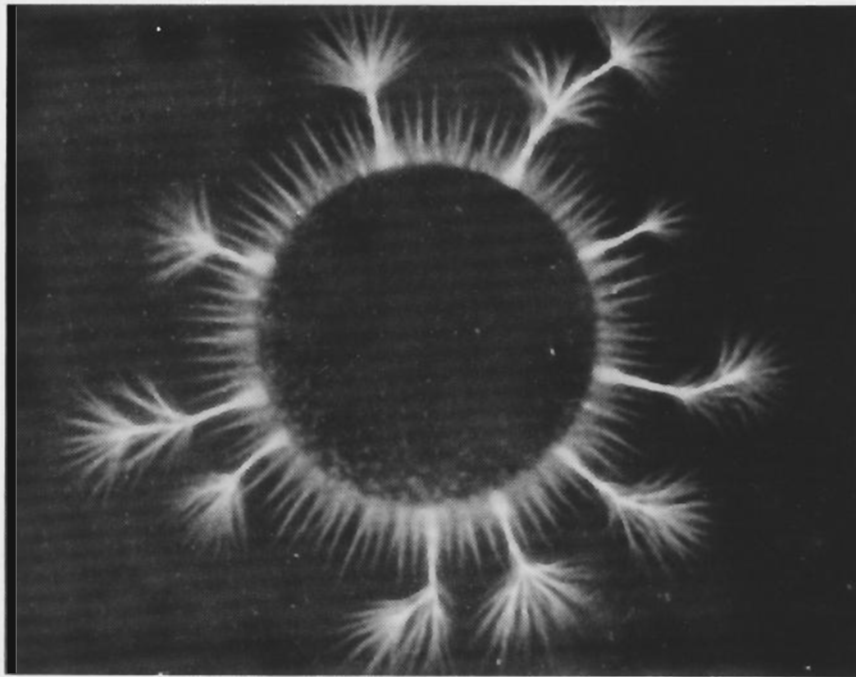


FIGURE 13

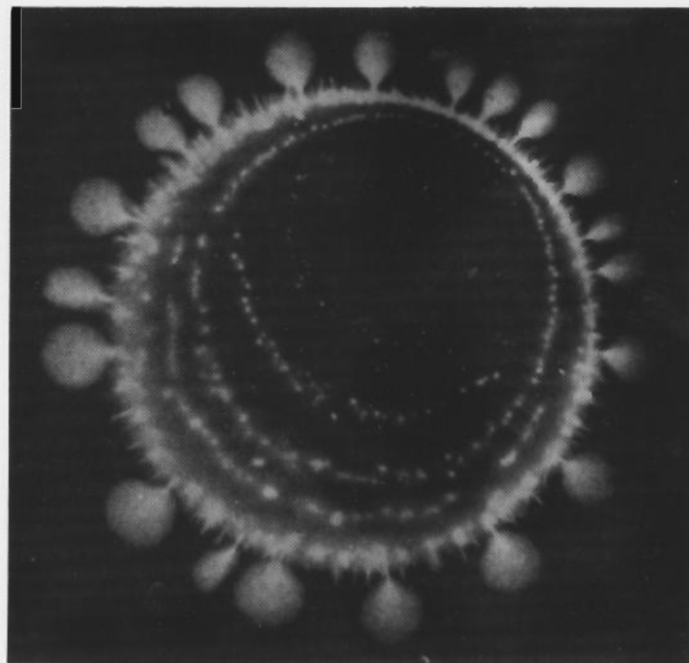


FIGURE 14

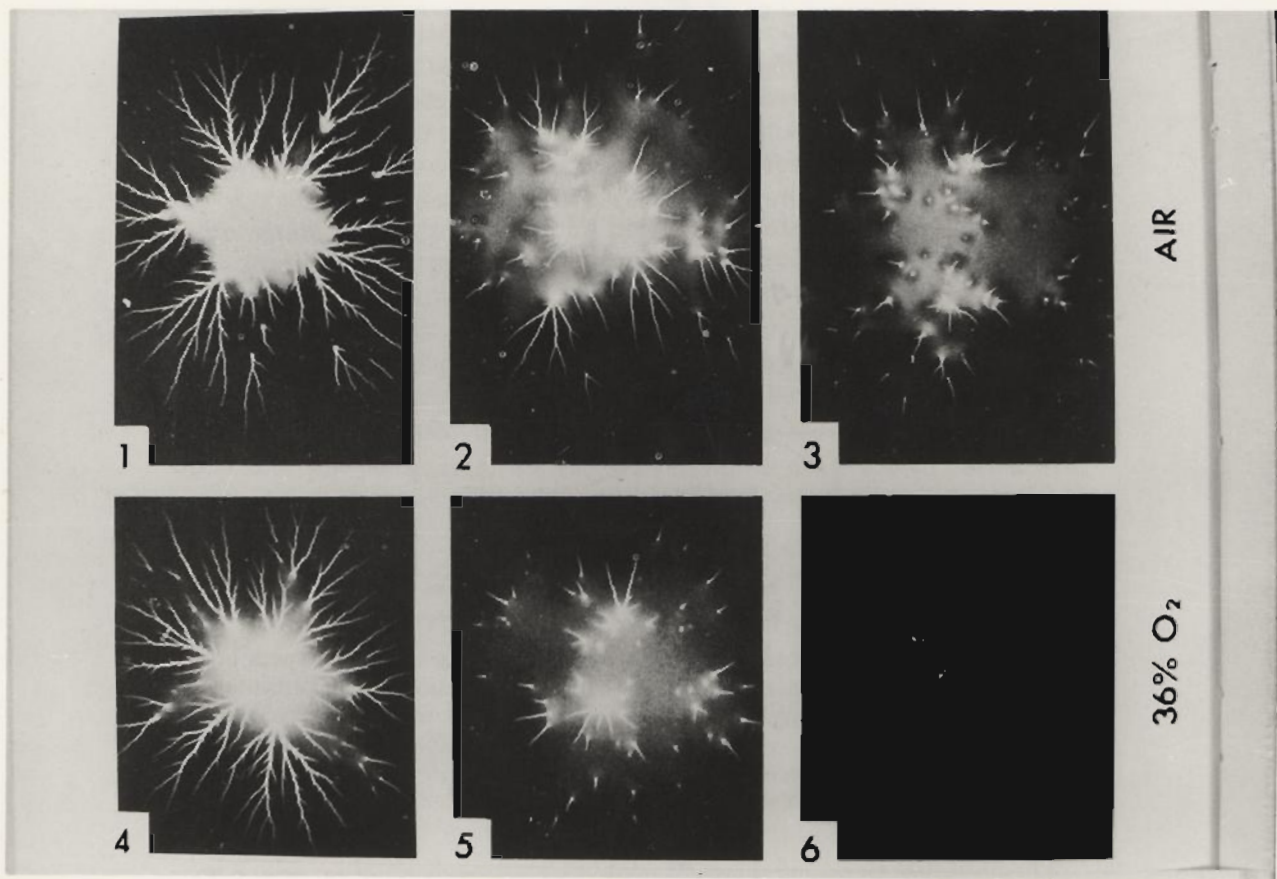


FIGURE 15

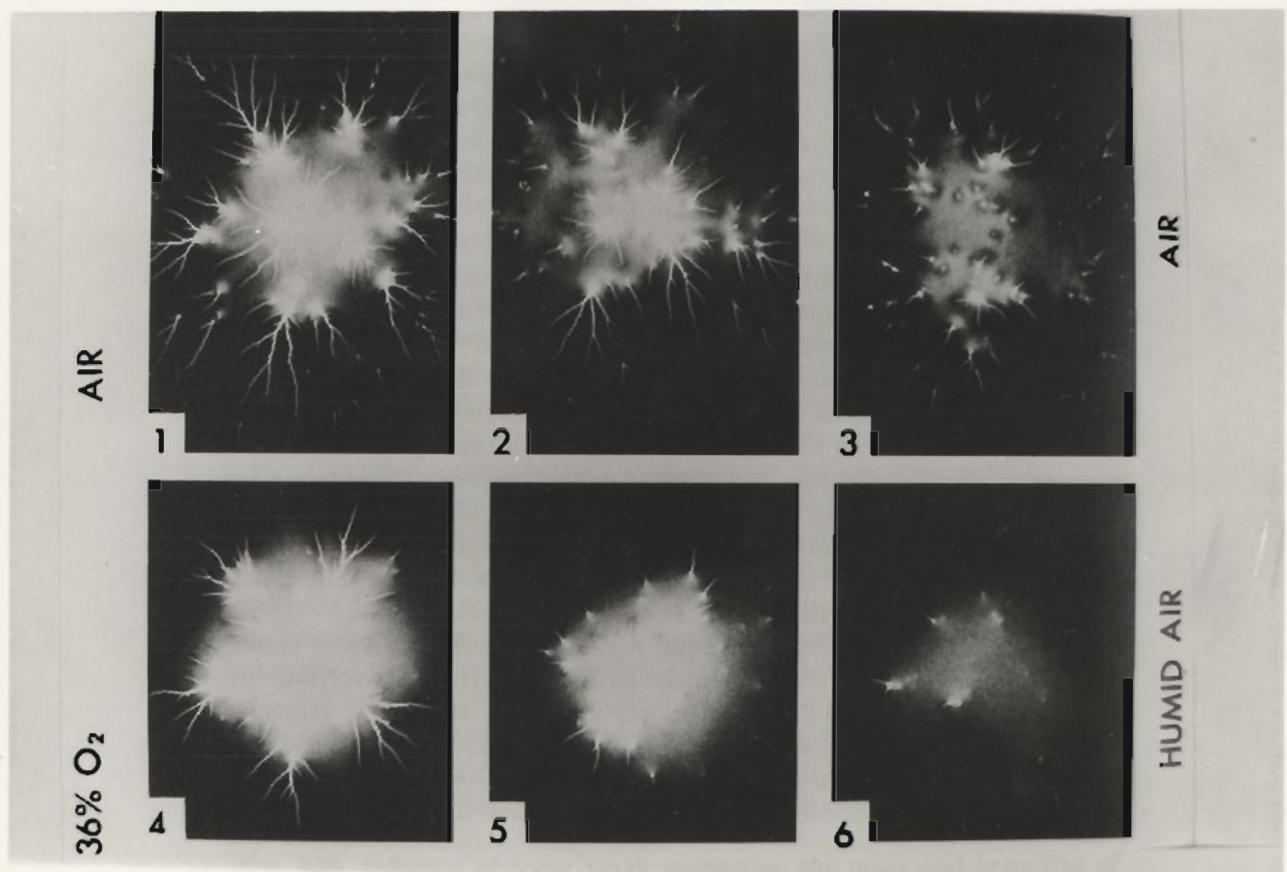


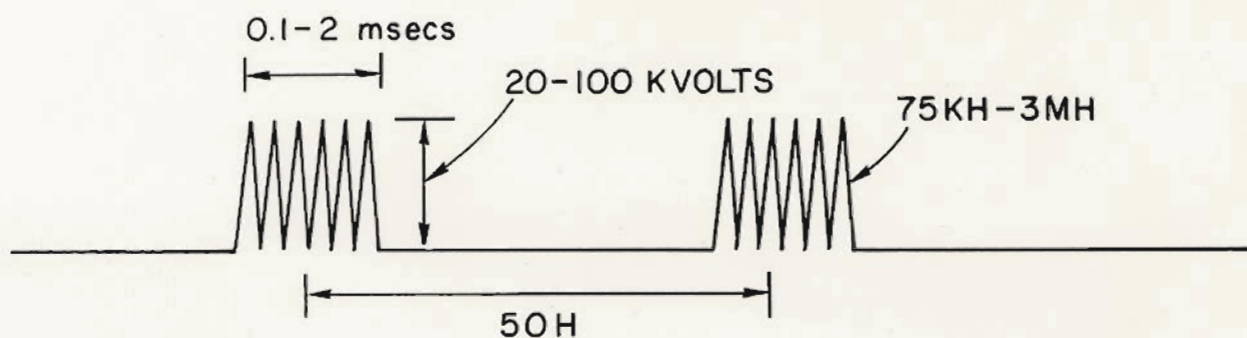
FIGURE 16

The initial breakdown condition is found to be very dependent on the surface condition of the electrodes. Roughening of one electrode, whether it is positive or negative, reduces the breakdown voltage by approximately the same amount. Self-sustaining discharge currents exist before breakdown, decreasing in magnitude with increasing smoothness of the electrode surfaces. Both observations indicate the importance of point discharges created at rough spots on the surface of the final breakdown. Figure 14 dramatically shows how, at preferential points, the primary figure changes into a spark discharge and, out of this plasma stem, electron clouds are erupted into space.

The effects of enhanced oxygen content in the air plus the effect of humidity on point-to-plane electrode discharges are shown in Figs. 15 and 16, respectively.

III. SOME SOVIET KIRLIAN STUDIES

Adamenko⁽⁹⁾ indicated to this author that the power source for Kirlian photography should be a pulsed high-frequency field, somewhat similar to a radar power source. The pulse characteristics are given in Fig. 17 and are (i) pulse height = 20 KV - 100KV, (ii) pulse width = 10^{-4} to 2×10^{-3} sec generally (as small as 10^{-6} sec in some cases), (iii) pulse repetition rate = 60 per sec and (iv) A.C. frequency of 75KHz to 3MHz. This power source is applied to a device, such as illustrated in Fig. 18. The Soviet experience was that a single D.C. pulse would not be effective in producing the desired effect and that it would be rather dangerous to use D.C. rather than high frequency A.C. inside the pulse envelope. The Soviets felt that it was necessary to have a discharge spacing between the specimen and the film in order for the proper discharge channel to form. The H.F. signal is also used in the pulse so that one can decrease the



KIRLIAN POWER SUPPLY CHARACTERISTICS

FIGURE 17

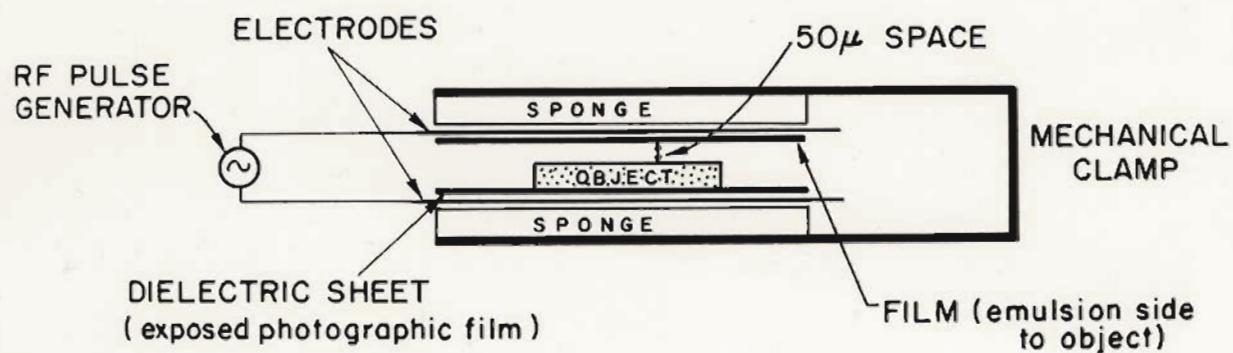


FIGURE 18

size of the equipment.

Actually, one need use only one pulse to obtain a photograph. The slow pulse repetition rate is to provide low average power. They felt that a pulse duration of about 2 msec is maximum and, if τ is much larger, the image sharpness diminished. On the other hand, if τ is too small, the channel discharge process does not have time to develop. The total current drawn from the entire surface was less than 1 μ amp so that the actual current in a single discharge channel would be much less. They suggest that this is the reason for the stability of the cold electron emission.

The average power of a generator is about 1 watt (pulse power is much larger of course). Thus, quite small generators using batteries, transformers, transistors, etc., can be built and taken out into the field. Adamenko⁽⁹⁾ was of the opinion that the film exposure occurs not only from the photons produced by electron-ion recombination events but also by the direct impingement of electrons on the photographic plates.

In their simplest Kirlian device, shaped like a sandwich or parallel plate condenser, the object is placed between the two plates to which voltage is applied (see Fig. 18). If the condenser plate is too close to the object, there will be no effect on the film [critical electron avalanche length is not present for streamer formation at that driving voltage - strongly suggests dominance of photon effect]. In order to obtain good pictures, there must be a dielectric gap between the object and the film. The exposure time depends on the film speed and on the power density of the electric field. To improve the effect and augment it, a fine screen (like a silk screen) was placed between the object

and the capacitor plate. One type of effective screen material is film itself that has been completely exposed and developed. The screen enhances the overall effect, probably by serving as a dielectric which limits the current flowing in a single discharge channel.

The device can be placed in a clamp arrangement as shown in Fig. 18, the clamp being used to apply a slight but even pressure via the sponge. The electrodes were developed x-ray film ($\text{AgBr} \rightarrow \text{Ag}$) and the leads were fastened to them as indicated. The dull matt finish of these electrodes provided poor reflection of light and thus was an aid in producing a good image. The normal spacing between object and film was about 50μ .

For taking pictures of a section of human skin or other part of the body, only one electrode is needed as illustrated in Fig. 19. In this case, the body acts as ground so that only one-half of the device presented in Fig. 18 is needed. This same electrode procedure is used for the Kirlian microscope, illustrated in Fig. 20, when it is applied to the body. Using a modification of Fig. 18, a device for taking movie pictures has been constructed and successfully utilized. In Fig. 21, an extremely useful idea is illustrated. The previous methods utilized rigid capacitor plates which did not allow one to take pictures of objects having irregular profiles. In this method⁽¹⁰⁾, the device takes the shape of the body. The transparent electrode was initially made from a type of organic film; however, many other possibilities exist. With this device, any portion of the body could be photographed directly. In fact, one could make a snug fitting vest or garment of the material which could then be monitored photographically from a distance or displayed continuously via closed circuit T.V. [However, the capacitive impedance of such a garment would be so large as to severely limit its utility.]

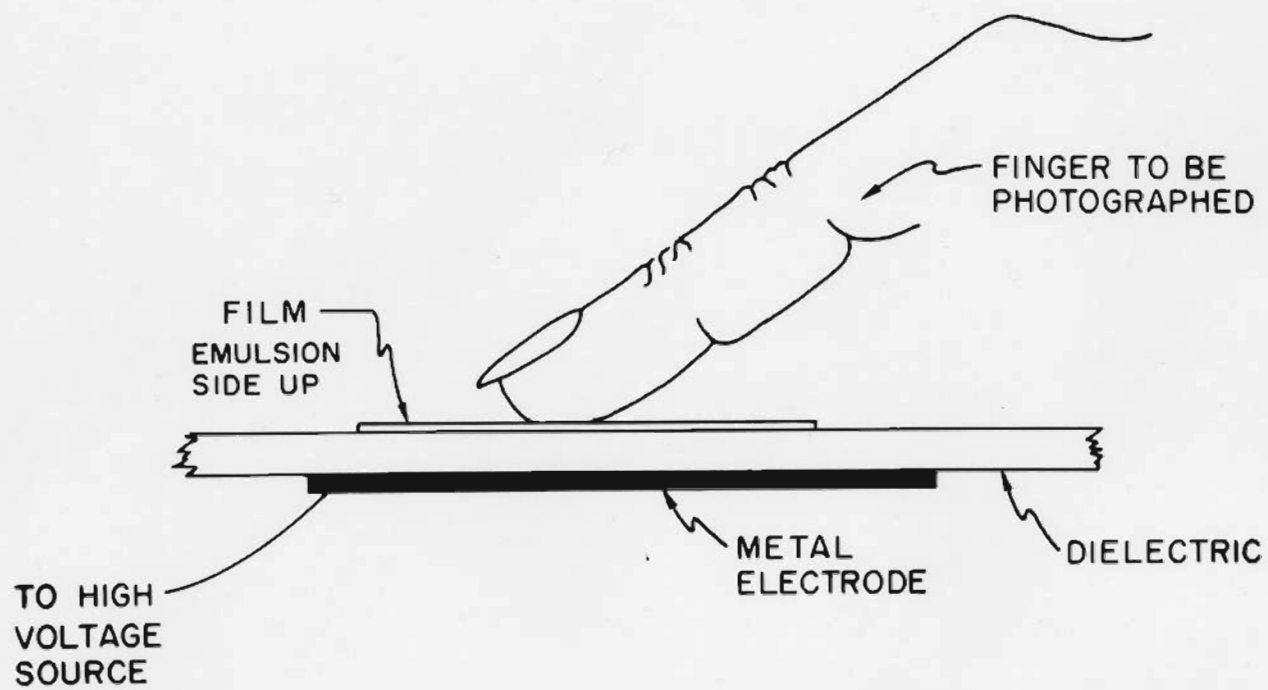
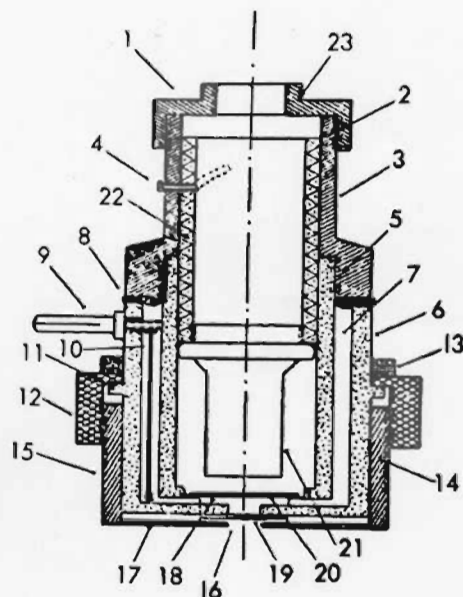
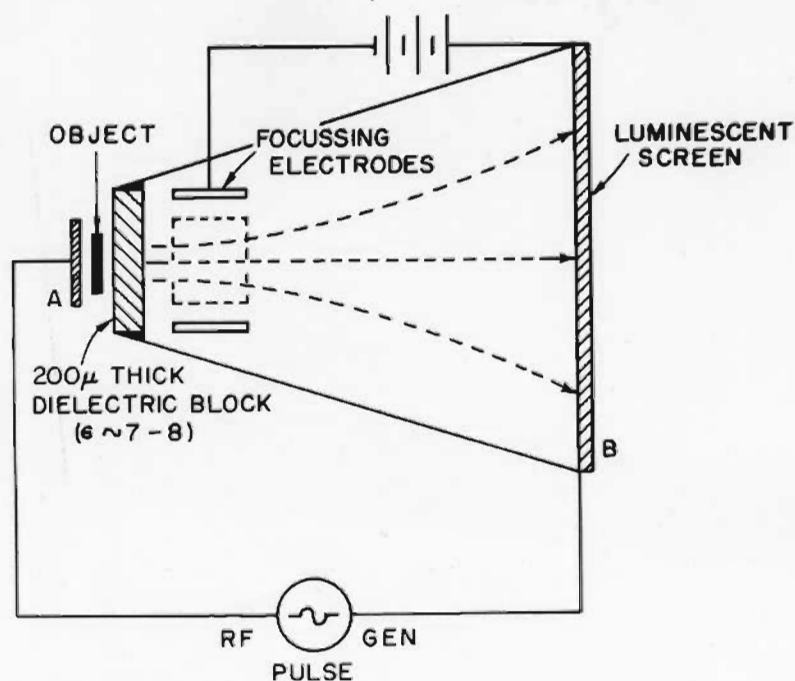


FIGURE 19



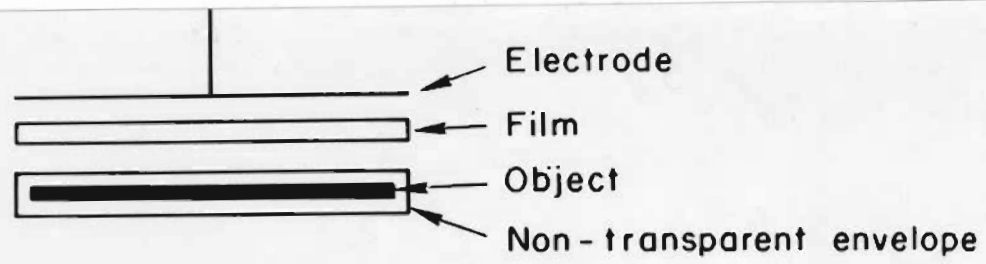
1. Transitional nut (to microscope tube)
2. Thread
3. Upper half of housing
4. Pin for focusing
5. Thread
6. Lower half of housing
7. Two orifices (ϕ 4mm) disposed one in front of the other
8. Rubber washer
9. Contact to power source
10. Metallic wire (for protection against circuit disruption because of water evaporation)
11. Thickening in form of a ring
12. Pressing nut, freely revolving
13. Collars
14. Thread
15. Traverse
16. Orifice ϕ 5mm
17. Bottom of the traverse
18. Glass with thickness 0.6-1.0mm
19. Glass with thickness 0.13-0.14mm
20. Chamber (cell), flooded by water through orifice 7
21. 8-12 times objective
22. Bushing which carries objective
23. Thread (in accordance with microscope tube thread)

FIGURE 20

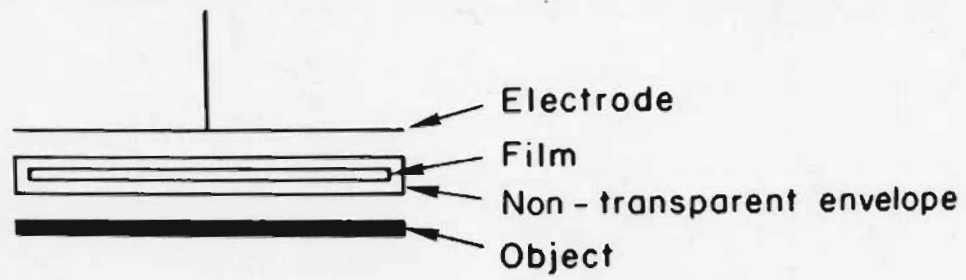


SCHEMATIC KIRLIAN CRT

FIGURE 21



(a)



(b)

FIGURE 22

The foregoing devices all operate in air at 1 atmosphere pressure. When the pressure was reduced to 10^{-5} mm Hg, the image was still retained provided the electrode separation was increased to 20-30 cm. At a pressure of 10^{-6} mm Hg, no image has been obtained. A visual display system using something like a CRT is illustrated in Fig. 21. In this device, electrons from the object impinge upon a 200 μ thick dielectric film and their charge pattern induces a polarization pattern on the other side of the film which, in turn, affects the preferential geometry of electron emission from the film. Thus, the eventual magnified image on the screen is indeed that of the object (magnifications of $\sim 350\times$ was obtained in 1971).

They found it quite inconvenient to be generally performing these experiments in a dark room and developed the technique illustrated in Fig. 22. Here, a non-transparent envelope either encloses the sample or the film. This allows the device to be utilized under normal light illumination; however, higher power supply voltages are needed and some loss of image definition occurs. Adamenko⁽⁹⁾ has also developed a variety of techniques utilizing photon and electron excited phosphors so that direct visual monitoring techniques can be employed.

On the Soviet Kirlian photographs, one sees an image of the structure of the surface plus a surrounding halo due to the high-frequency discharge. Different sections of the skin were found to yield characteristically different colors: the heart region showed as dense blue, the hip as olive and the forearm as greenish light blue. As a result of emotional excitement (fear, pain, etc.), the color of the related section was observed to change.

Using a magnification system, one saw discharge channels arranged on the background configuration of the skin. They exhibited a variety of energy emission characteristics⁽⁹⁾; they may be point-like, crown-like, flare-like or clot-like. They

may have different coloring such as sky blue, various shades of lilac or yellow and they may appear bright or faded. Some of the channels glow constantly, some are twinkling, some flare up periodically, some are stationary and some are moving, changing always from place to place [consider Fig. 14 and others of that section in the context of these observations, a great similarity exists]. In certain sections of the skin, one sees immobile flare-up points which exhibit a definite rhythm and are light blue or golden in color. Besides these points, there are faded clots of indefinite form which are constantly changing, taking from time-to-time a sphere-like form. Some clots are continually spilled out from one point on the skin onto another where they are absorbed. In certain cases, the luminous clots are not oriented in their movement. They slowly move between the flares and finally are extinguished with a little burst and seem to disappear into space [sounds like electronegative gas effects scavenging electrons]. The colors of the clots are generally milk-light blue, pale lilac or grey-orange. In many respects, these flares and clots resemble the plasma behavior noted in observations of the sun.

They found that a withered leaf showed almost no flares and that the clots barely moved. As the leaf gradually died, its self-emissions also decreased correspondingly until there was no emission from the dead leaf. Likewise, the finger of a human body, dead for several days, exhibited no distinctive self-emissions. The self-emission of living things seemed to be a direct measure of the life processes occurring within their system.

The Soviets claim^(1,4,9) that the structure and emission characteristics of these discharge channels can be utilized for an objective evaluation of the physiological state of the living organism, for diagnosis of body health or pathology,

for the registration of the emotional state and also for the control of the systems response to various radiations. For example, during the radiation of living objects with a laser ($\lambda = 6328\text{\AA}$), they observed a sharp increase in the intensity of discharge flaring. However, daylight radiation (incoherent radiation) of the same intensity did not cause any changes in the discharge process.

A spectral investigation of the high frequency discharge glow from the leaves of plants revealed the existence of a series of peaks ($4200\text{\AA}$, $4250\text{\AA}$, $4550\text{\AA}$ and $4750\text{\AA}$) and several small peaks in the red part of the spectrum. When the plants were irradiated with the laser ($\lambda = 6328\text{\AA}$), the glow spectrum of the leaves was found to be altered in the blue and green regions so that characteristic peaks appeared at $5100\text{\AA}$ and $4800\text{\AA}$ and the spectrum shifts in the range $4400\text{\AA}$ to $4500\text{\AA}$. However, the number of peaks in the blue part of the spectrum remained unchanged. With the skin of animals (rabbit, mainly), the peaks were found in the range $4950\text{\AA}$ to $5000\text{\AA}$ with the short-wavelength portion exhibiting a peak structure coinciding with that from leaves. [This sounds as if the gas discharge spectrum is shifted by local chemistry changes due to either emission from, reaction with, or vaporization from the subject being studied.]

If one photographs, on the same film at the same time, fingers from two different people, then a crown discharge is seen around each finger. As the two fingers are brought closer together, the discharge crowns deform and leave a small gap between them rather than interpenetrate. [A lateral zero field region is expected between two symmetrically located ^{uncharged} dielectric electrodes and a plane electrode. No streamers would form in this region and thus a gap would appear on a photograph.]

The Soviets observed, via Kirlian, the palm of a "healer" as he worked on a patient. When he began a healing session, they initially saw many points flaring on the palm. Later, fewer points were flaring but the area of discharge around the remaining points was larger (greater flare intensity) and eventually an area the size of a dime in the center of the palm became luminously brilliant. By careful study of the location of the major flare points on the palm, the Soviets claimed that they corresponded with the location of acupuncture points.

In concluding this section, we should mention one of the most interesting and certainly the most puzzling observation. In Fig. 23, a photograph of a whole leaf is given showing the edge halo and inner light structure. It has been claimed that if 2 to 10 percent of a leaf has been cut away from one edge, the Kirlian photograph shows not only the portion of the leaf remaining but also an energy pattern from a portion of the leaf that has been physically removed. In Fig. 24, we see such a cut-leaf photograph with the right-hand edge of the leaf removed and we note both the remaining radiation pattern and the altered contrast. [Such a result might be produced by a xerox type of effect, as will be discussed later.] Adamenko⁽⁹⁾ indicated that this effect is difficult to produce and that the protocol has not been completely worked out yet. It was also indicated that when one sands off a person's fingerprint, the Kirlian photograph clearly reveals the fingerprint perhaps because the energy flare points are located only along the dactyloscopic design of the skin.

In this section, many observations have been related with inadequate supporting data. It is unfortunate but that is the nature of our communications from our Soviet colleagues. At this point, the observations should only be taken as suggestions which need to be reproduced in our own laboratories before they can be considered as fact.

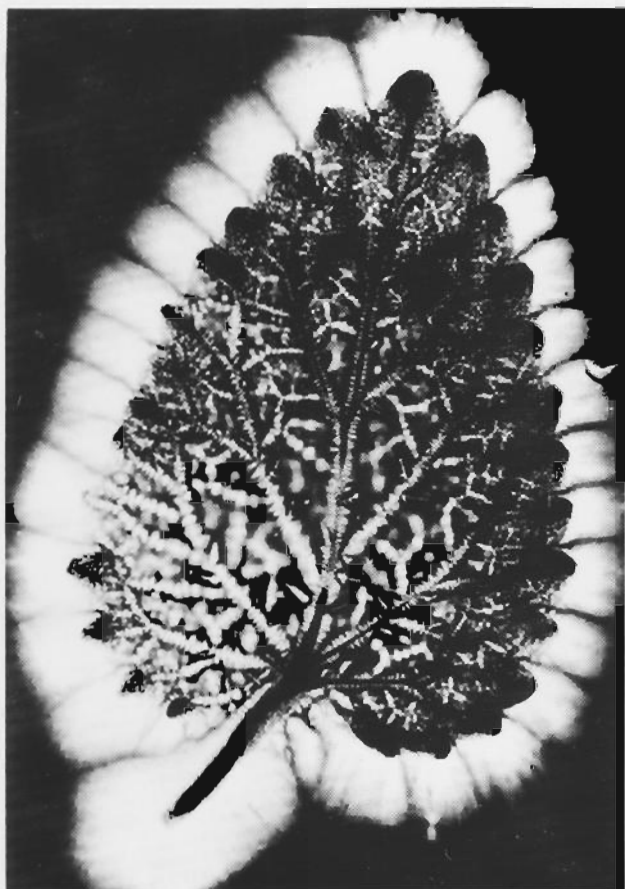


FIGURE 23

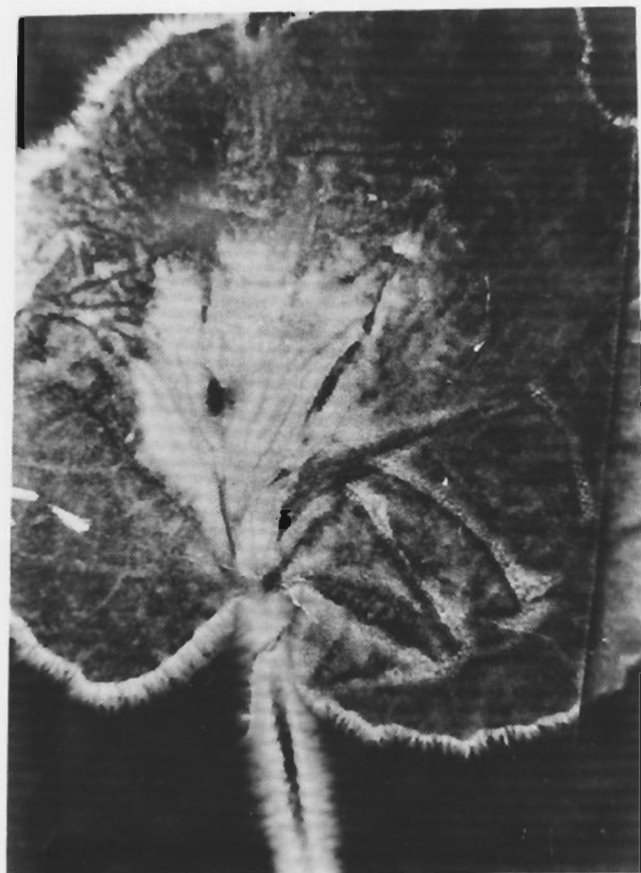


FIGURE 24

IV. SOME EUROPEAN KIRLIAN STUDIES

Milner and Smart⁽¹¹⁾ have, for some years, been experimenting with high-voltage photography using a sandwich type of device very similar to Fig. 18. However, their work differs significantly from the Soviet work in that they used a D.C. pulse technique and control process for controlling the slope of the leading and trailing edges of the pulse as illustrated in Fig. 25. They were unable to detect any energy in the visible range; however, they found abundant information in the far U.V. They used pulse voltages in the range 5 kV-20 kV and exercised great experimental caution because of the significant electrical power involved.

Using the arrangement of Fig. 25, during application of voltage across the empty cell, nothing visible occurs in the air gap to the naked eye but one finds that the photographic emulsion has been exposed on both the +ve and -ve plates as illustrated in Figs. 26a and 26b. The energy patterns on these complementary plates are quite different even though they are located only 75 μ apart [note the similarities to Fig. 4]. Steepening the rate of voltage decrease on the trailing edge of the pulse leads to Fig. 27 for the +ve plate. Figure 28 corresponds to the -ve plate with a larger air gap in the sandwich. On the opposite plate, one observes clusters of spheres (somewhat like Fig. 26a) but having the same morphological shapes as shown in Fig. 28 in an almost exact mirror image relationship. [The explanation for these strikingly different morphological features will be given later.]

Inserting a leaf or spray of leaves into the sandwich leads to Fig. 29a for the +ve plate. Here, using a rapid pulse, the leaves are hardly registered and are separated by a type of void space from the surrounding "empty sandwich" pattern. With a more prolonged pulse, areas of the leaves become luminous and bright balls of plasma gather at the tips of the leaf serrations and begin to become detached and fixed into the surrounding atmosphere (see Fig. 29b). Maintaining the voltage for increasingly longer periods of time leads to the formation and detachment of

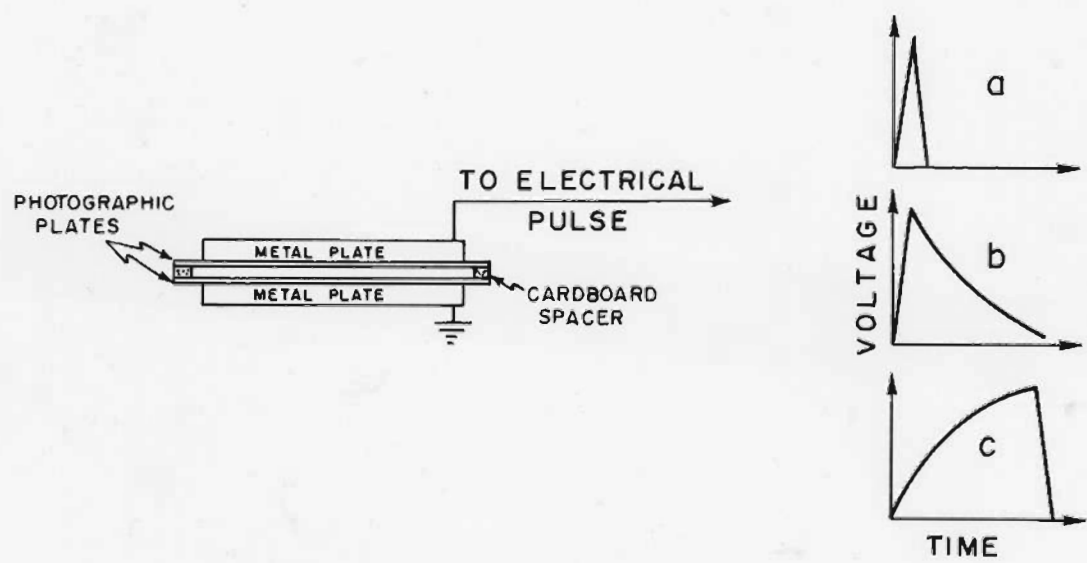
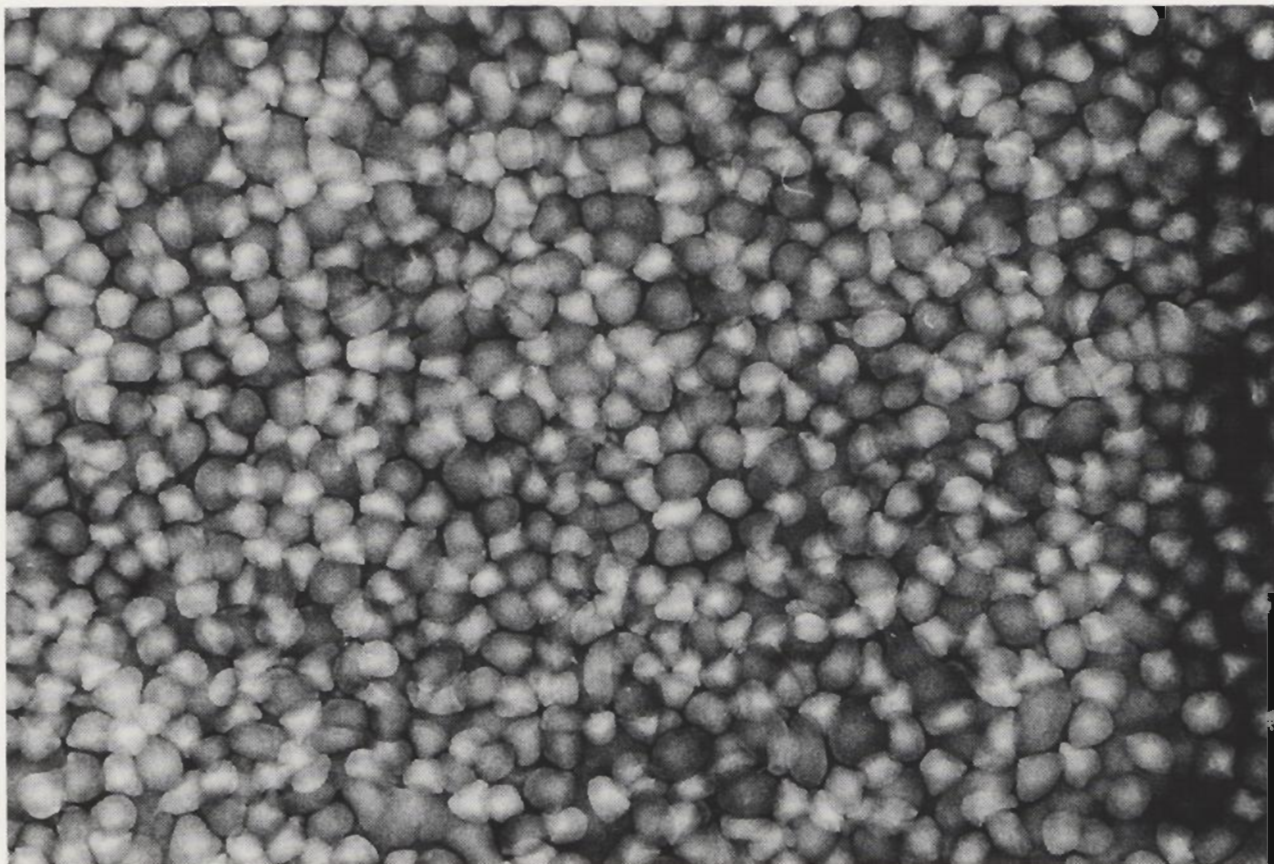


FIGURE 25



a

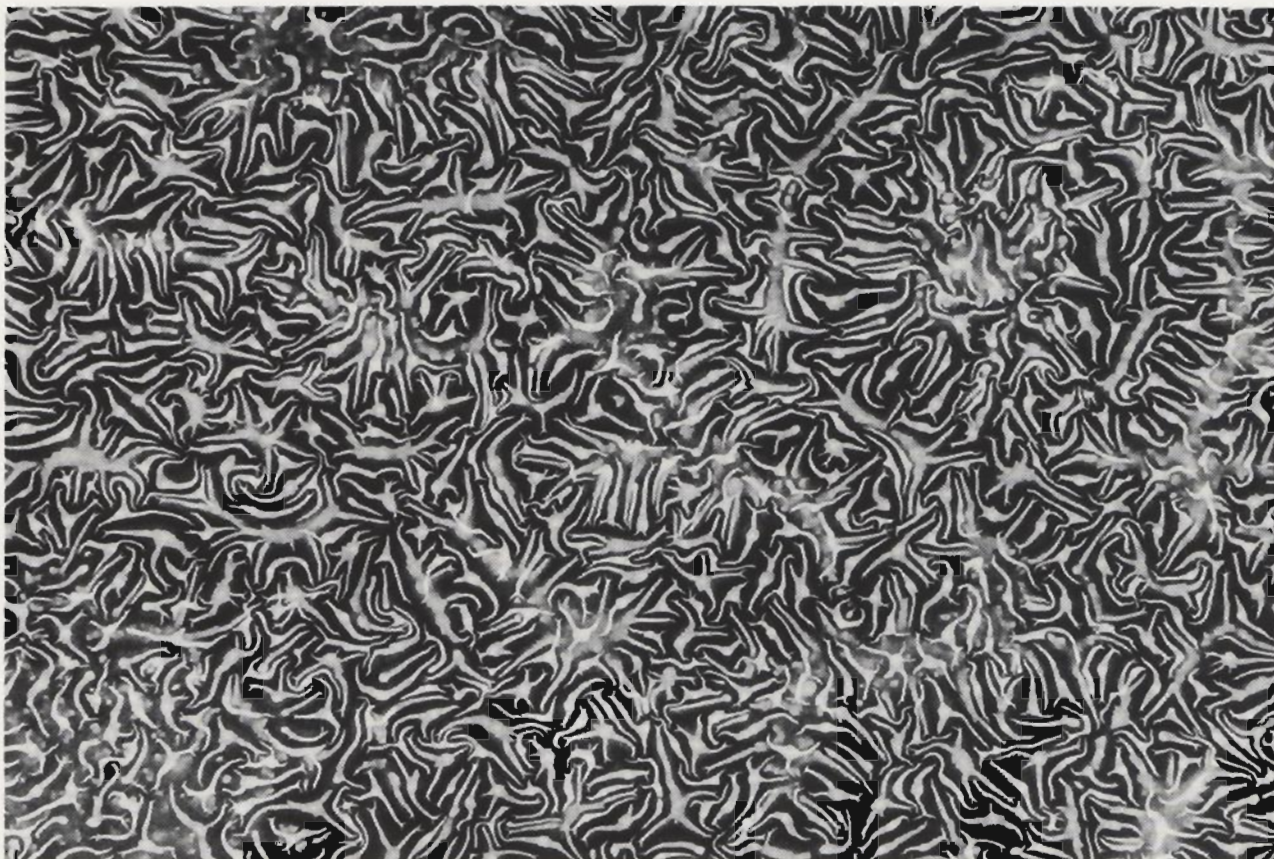


FIGURE 26

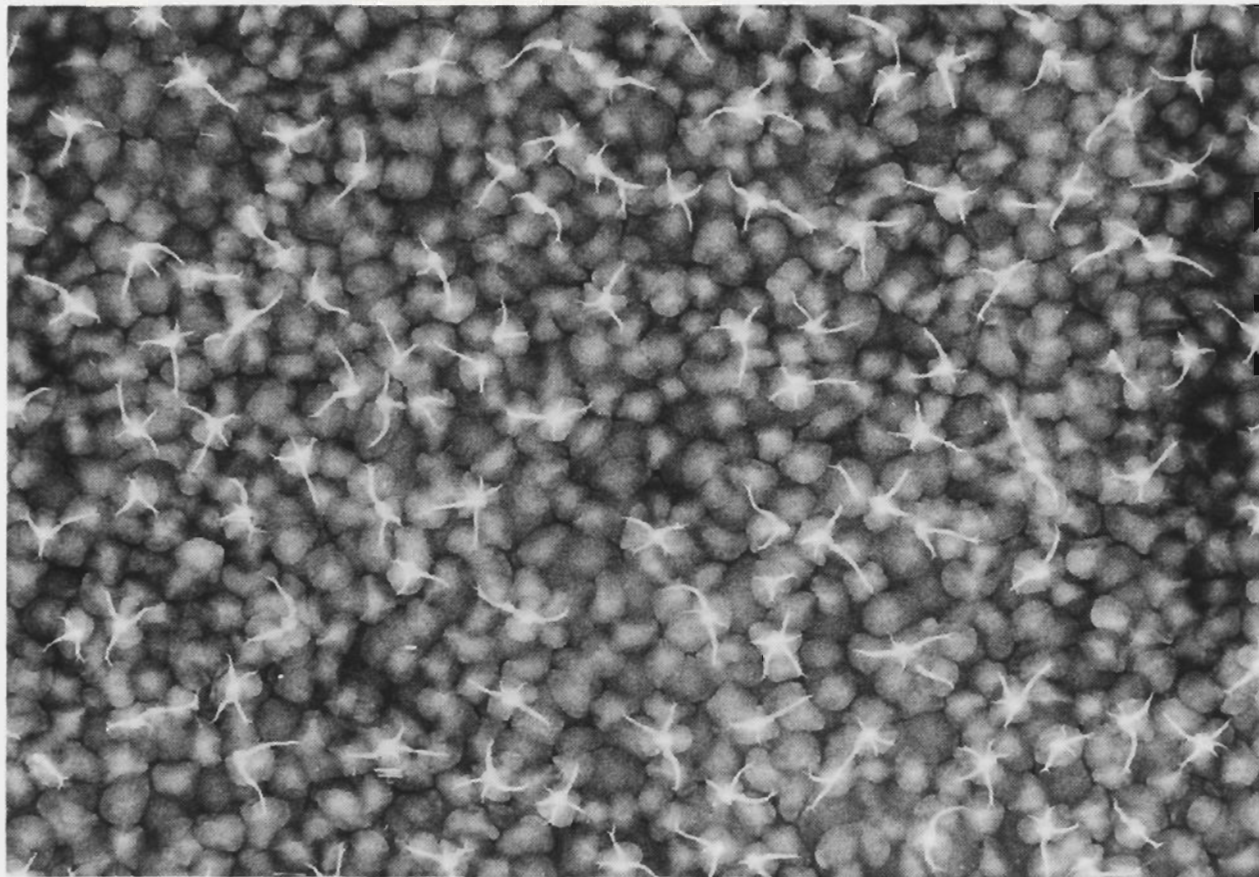


FIGURE 27

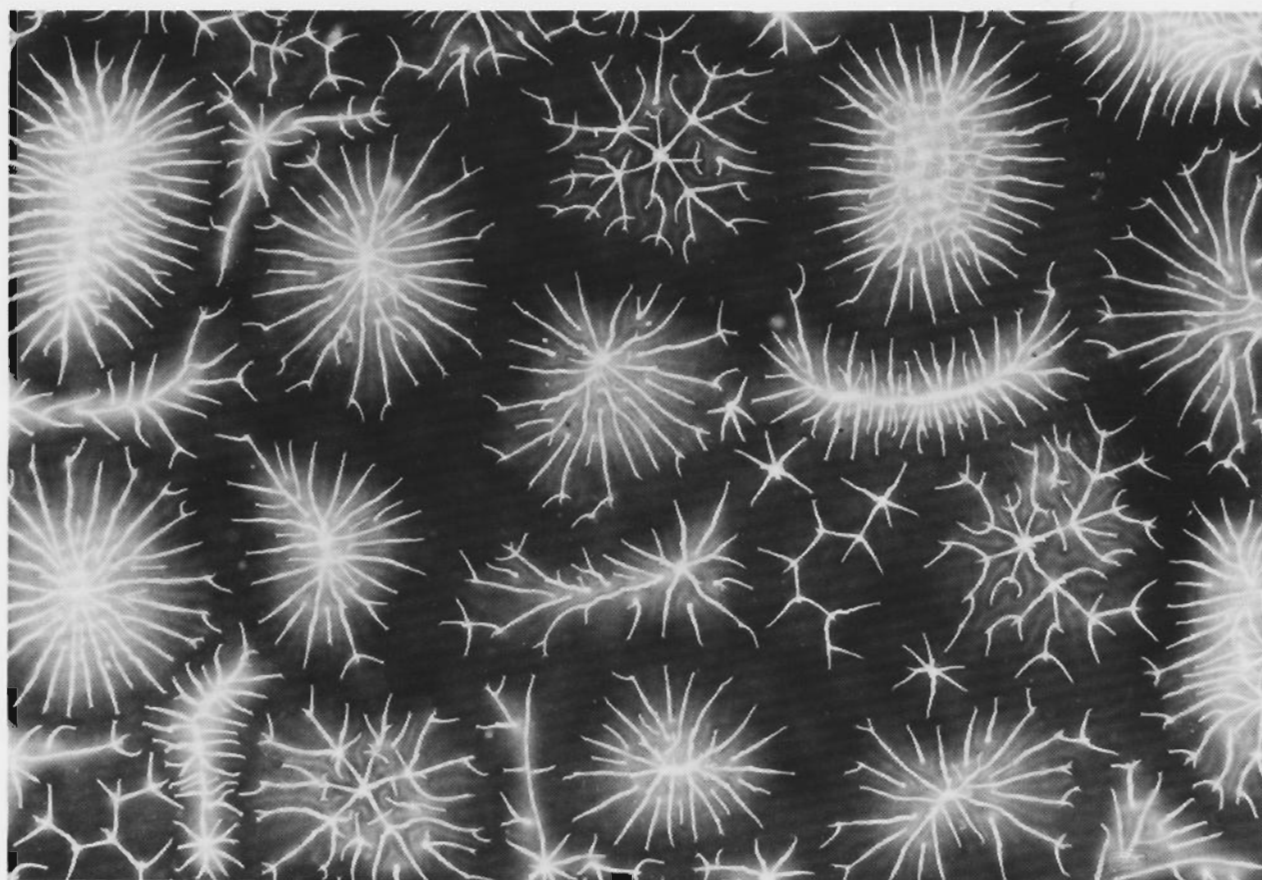


FIGURE 28

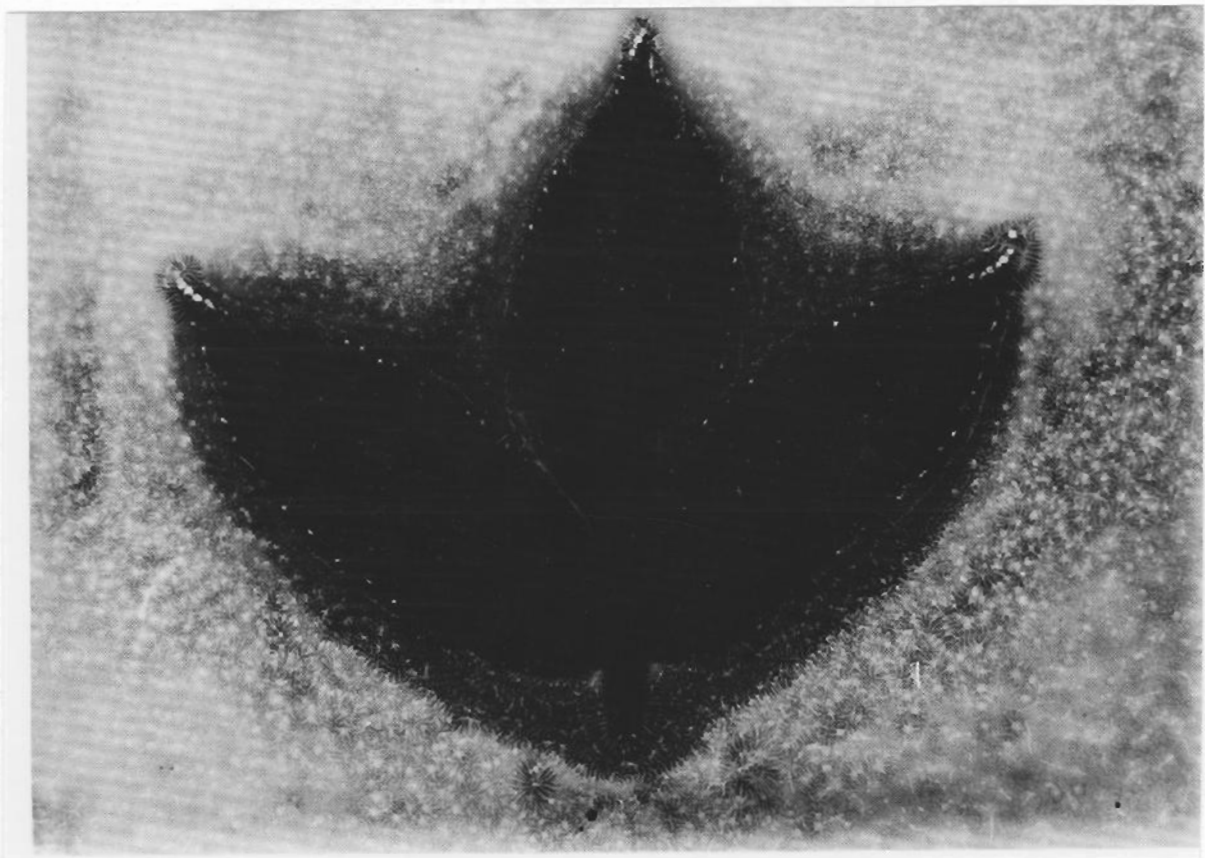


FIGURE 29(a)

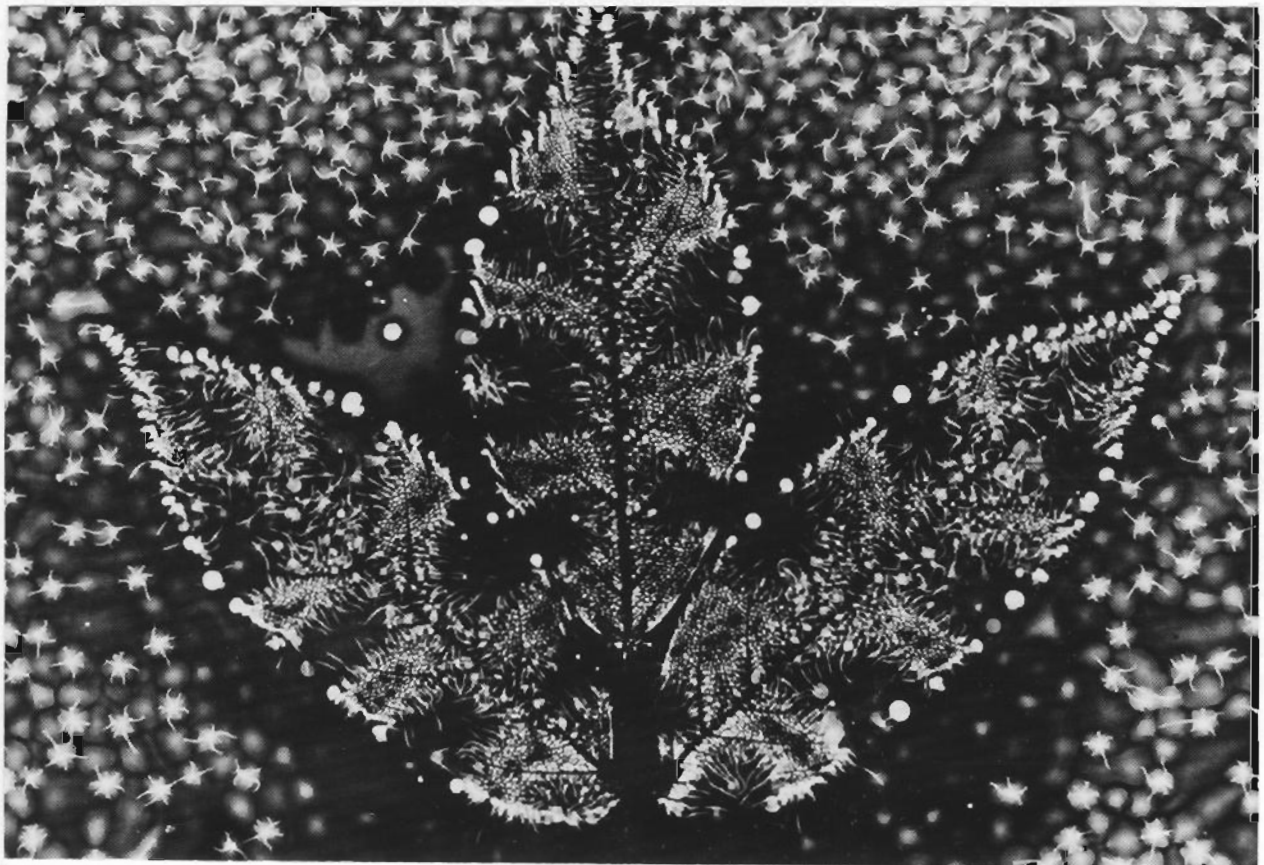


FIGURE 29(b)

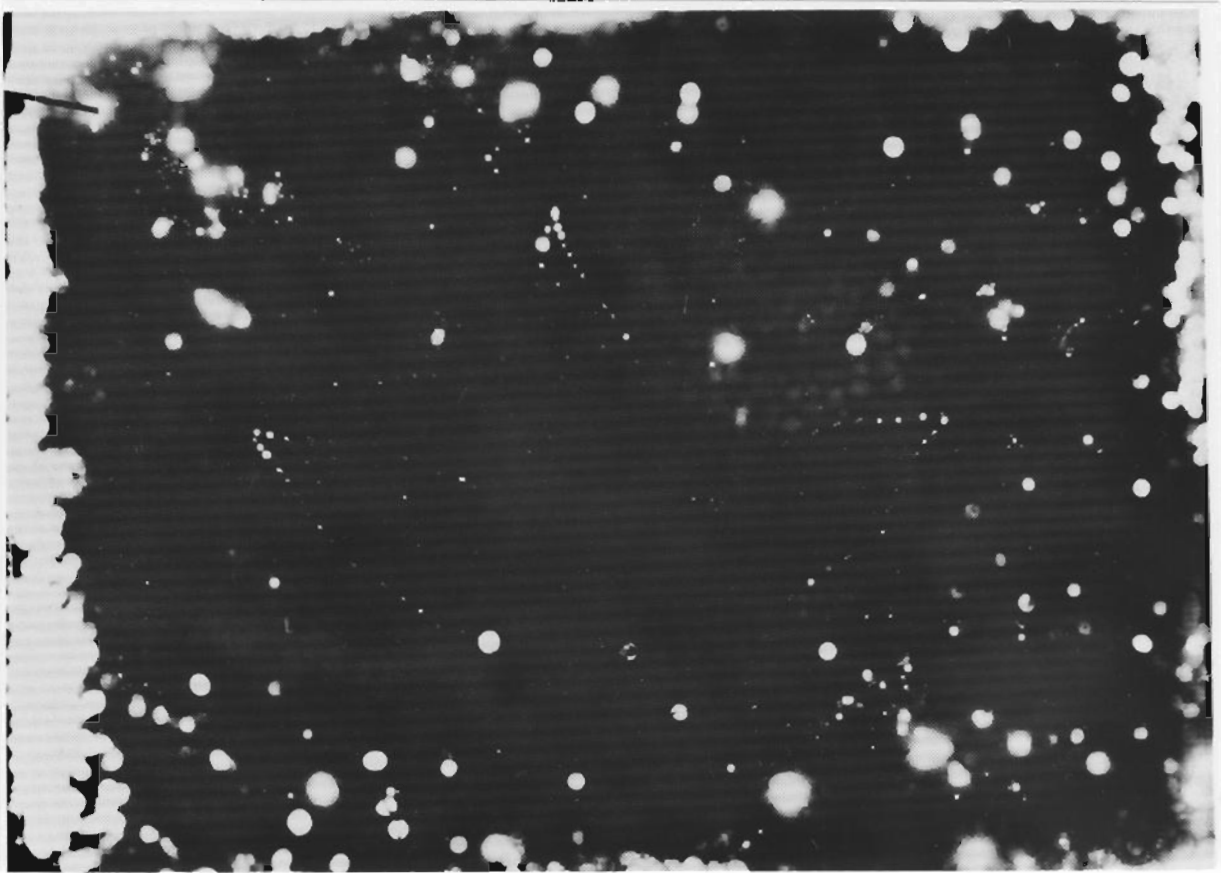


FIGURE 29(c)

more of these bright balls until the flow becomes exhausted and the leaf reverts to its original "dark" state (see Fig. 29c). In Fig. 30, we see an example of an energy transfer interaction between a freshly picked privet leaf (right) and a dying leaf (left) picked 24 hours earlier. [For very rapid pulses, the formative time lag for the initiation of the discharge, $\sim 0.1 - 1.0\mu$ sec, will limit the current flow and thus the light intensity will be very small in the U.V. range.]

To investigate the dependence of the Kirlian results on the presence of life, Van Hasselt et al.⁽¹²⁾ compared the photographs from the fingerpads of living persons with those of cadavers and with those of simulated fingertips made from an impression compound. They used the index finger only and, in order to simulate the impedance and capacitance of the human body, the artificial finger was connected to ground via a 100 pF capacitor. They used 10 living subjects and 3 cadavers (time of death was 30-48 hours before the Kirlian photography). The power supply was 40 kV at 100 KHz and the time of discharge illumination was 400 msec. They found that the corona as it appears on the photographic plate was affected by a large number of variables. Even when the voltage, frequency and illumination time are held constant, it was not possible for them to obtain identical corona photographs of the same fingertip in successive experiments. The principal reason for this is that no subject is able to place his finger on a photographic plate in exactly the same way more than once. They found that the complexity of the corona pattern makes a detailed quantitative evaluation practically impossible. They deduced that the only characteristics of the corona which can be reasonably evaluated are the density of the streamers and the width

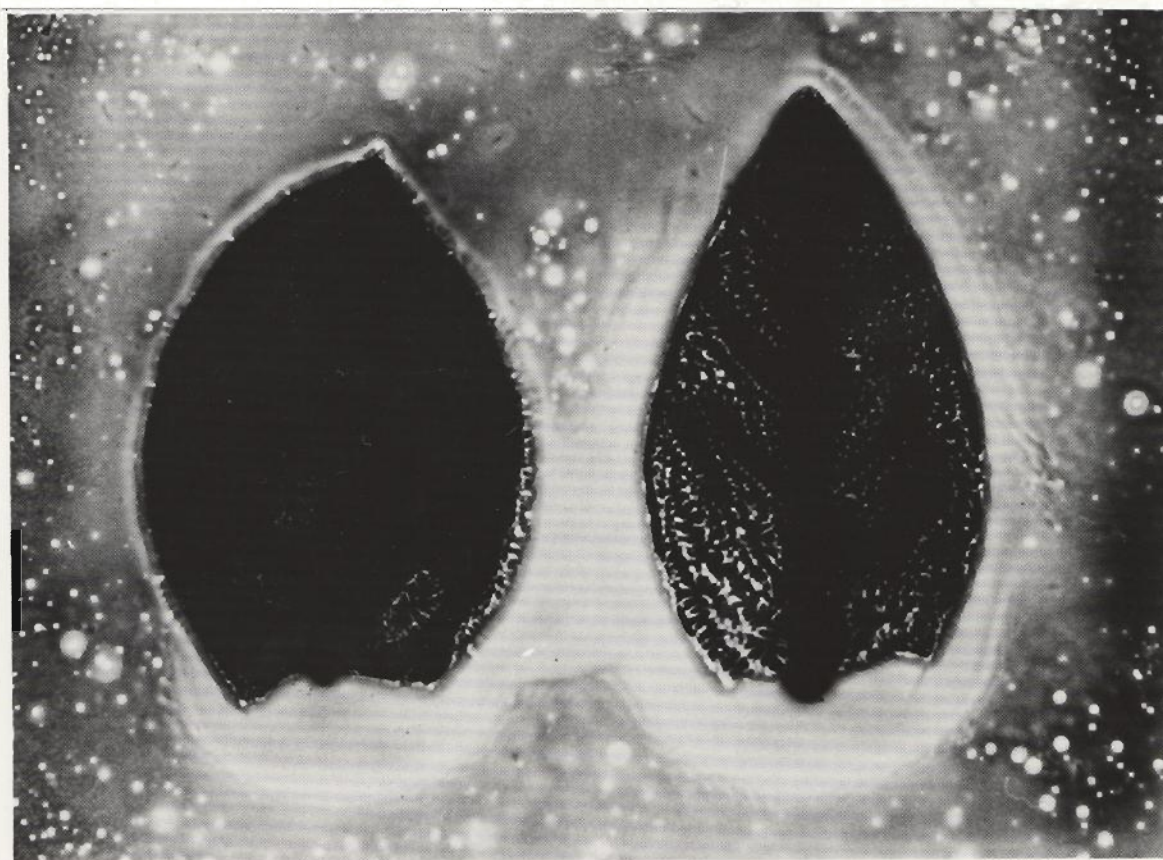
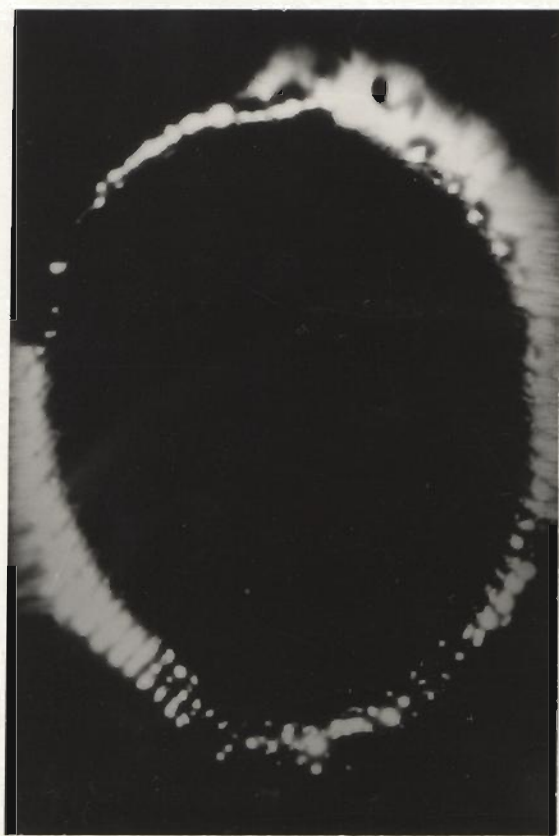
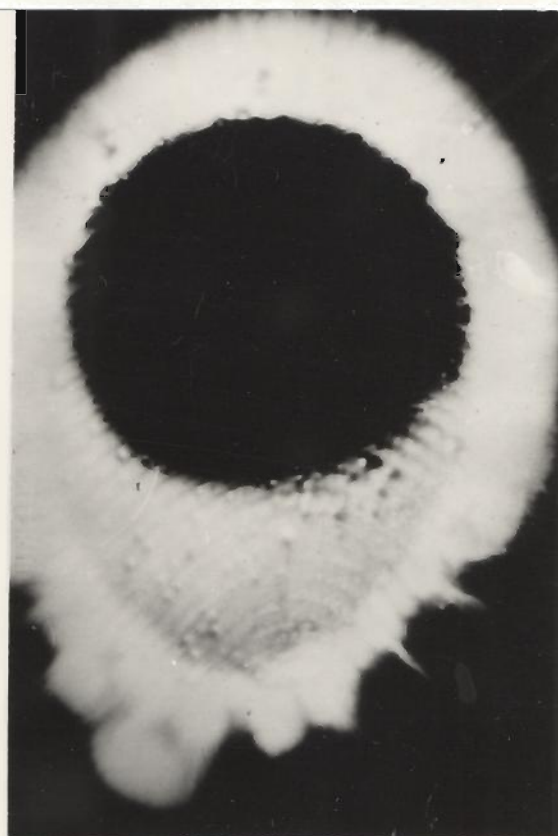


FIGURE 30



(a)



(b)

FIGURE 31

of the corona. Taking those parameters into consideration, they deduced that there is no significant difference between the coronas of index fingers of living subjects, cadavers and imitation index fingers. [A similar result will be given later when we discuss this author's work; however, an explanation is given in a later section showing that 100 KHz is not the proper frequency range for such a study.]

V. SOME AMERICAN WORK

Perhaps the most prolific American Kirlian photographer is Thelma Moss at UCLA^(2,13). She has utilized the simple technique of (1) placing a sheet of film face up on a single large electrode, (2) placing the fingerpad (or leaf) directly in contact with the film, (3) making contact to the body with the second electrode and (4) applying a controlled duration pulse to the electrodes (all in a darkened room). Her basic pulse generator is a low-frequency "ring-down" type of device yielding multiple frequencies in the 1 to 10 KHz range. She has studied the effects of drugs and alcohol on the energy emission from fingerpads (and has shown some remarkable color effects (white, blue, red, orange, yellow-green) and energy intensity effects⁽¹⁴⁾). Some results from these studies are illustrated in Figs. 31^(alcohol study) and 32a,b^(marihuana study).

Another of her investigations concerns the possibility of energy transfer by the laying on of hands⁽¹⁴⁾. In a three-month experiment performed on 12 dialysis patients, a healer placed his hands on their backs in the kidney region for 20 minutes each day. Fingertip photographs taken of the healer showed that a rosy-pink halo, present before the "treatments," was absent afterwards. In contrast, pink was almost nonexistent in the fingertip halos of the patients before therapy but appeared prominently afterwards (see Fig. 32^{c,d}). With one exception, these effects were not obtained when nonhealers performed the laying on of hands. None



(a)



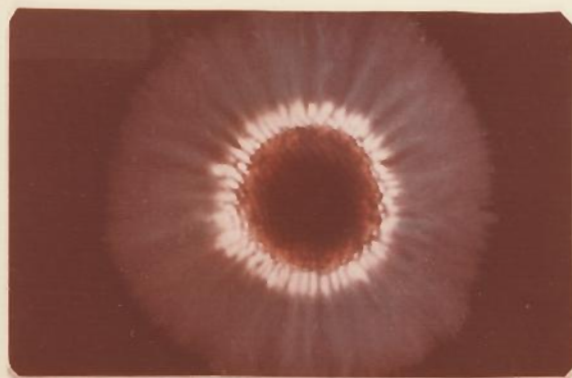
(b)



(c)



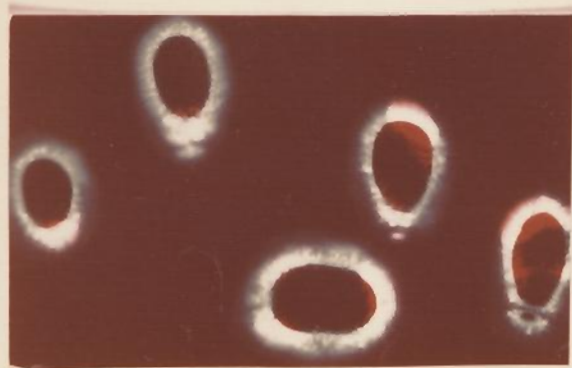
(d)



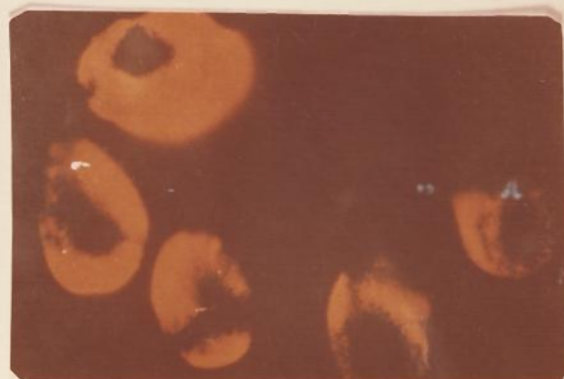
(e)



(f)



(g)



(h)



FIGURE 32

of the patients were cured, although they sometimes showed some symptomatic improvement, often said they felt better and had experienced sensations of intense heat or tingling during the treatments.

Dr. Moss has also extensively studied effects associated with damaging leaves of plants by gashing them with a sharp object. This leaves a dark gap in the inner halo of the leaf. Often, after the "laying on hands" by a healer, the inner halo is largely restored [most people can do this to some degree]. She finds great variability in the fingerpad results from day to day. On certain days, a person will show a wide brilliant blue and white halo with a clearly visible fingerprint. On another day, the same individual will reveal a similar wide and brilliant halo but without the fingerprint. On still other days, the individual will have no halo, only a red blotch or have both the halo and the blotch appearing simultaneously.

Dr. Moss' conclusion, after studying certain individuals for months, is that these dramatic photographic changes are associated with varying physical and mental conditions. Of course, in these experiments, no precautions were taken to clean the patient's fingers in a standard cleaning solution, nor was there any attempt to control the pressure applied by the subject's fingerpad to the film, nor were any of the studies done with photographic plates instead of film [tends to eliminate air gaps between the electrode and the support side of the emulsion which influences discharge formation at the back side of the emulsion--see later].

In Fig. 32, the striking range of before and after effects that have been observed by many investigators using techniques similar to that of Dr. Moss are given. One pair^(Fig. 32e,f) shows a uniform blue halo when a male subject was in good health. On another occasion, when he still felt well, the dramatic configuration of red spires appeared in his halo and six hours later the subject came down with London

flu⁽¹⁴⁾. Joseph and Kientz claimed to have found similar patterns with 6 people who developed influenza but have never seen this pattern in people who did not come down with the illness within 24 hours⁽¹⁴⁾. Another pair^(Fig. 32h,g) shows the five fingerpads of a sitar player before and after giving a concert (left hand)⁽¹⁵⁾. Still another^(Fig. 32i,j) pair shows the halo from a healer's finger while in the resting state and during the healing process⁽²⁾. [Such an array of contrasts seems to defy coincidence and lends hope to the "fact" rather than "artifact" label.]

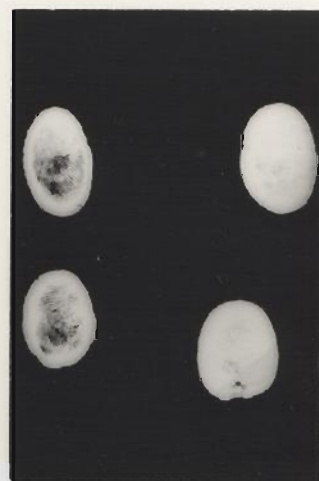
Two psychiatrists, D. Sheinkin and M. Schacter, have been delving into the medical potentials of the Kirlian process. Most of the problems they have studied have been psychiatric in nature, chiefly acute schizophrenic decompensation, alcoholic psychoses and some manic depressives. They observed that, before treatment, most of these patients showed marked spatial fragmentation or annihilation of large portions of the normal emission from the fingerpad as illustrated in Fig. 33⁽¹⁶⁾ (only 1 before and 1 after picture were taken of each subject rather than a large number from which these were selected). In addition, the pattern of emission from the contact portion of the fingerpad appears quite chaotic. As a result of successful treatment, as indicated by conventional psychiatric criteria, one observes (a) the filling in of the emission pattern around the fingerpad, (b) the enhancement of manifested energy intensity and (c) a more orderly and coherent fingerprint pattern on the contact portion of the photographs. They have also noted marked pattern changes associated with respiratory infections as can be seen in Fig. 33g. Finally, the contrast of the discharge halo for a healthy person in a normal state of energy and for a healthy person in a drained state of energy is quite marked (Fig. 33h) when pictures are taken on the same instrument within a few moments of each other. Their apparatus was also of the low frequency type and



(a)



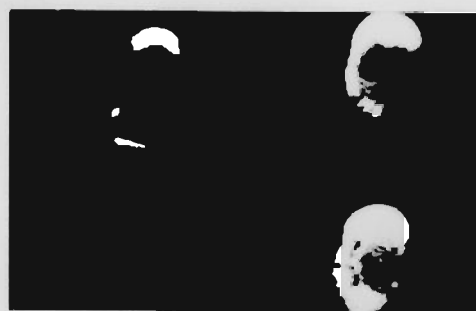
(b)



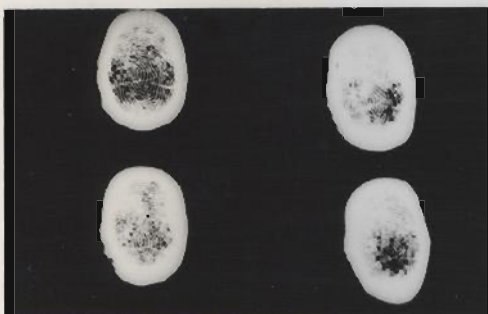
(c)



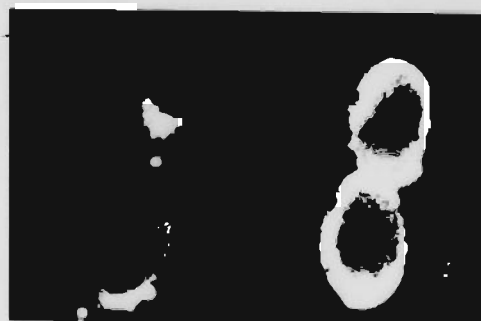
(d)



(e)



(f)



(g)



(h)

FIGURE 33

they used long exposures of 4 to 8 seconds (patients felt a mild tingling-like sensation in their fingers). Once again, no fingerpad cleaning or pressure control procedures were instituted. However, they found, qualitatively, that pressure on the fingerpad had no effect on the results⁽¹⁶⁾.

A recent study by Mazzio and Besch⁽¹⁷⁾, utilizing the arrangement illustrated in Figs. 34 and 35, focused on the photographic side of the process. Their power supply delivered 3 kV to 5 kV as detected by the high voltage probe and delivered it in a range of 0 to 150 KHz with most of the power being in the 9 KHz to 11 KHz range. The currents observed were in the 10 μ amp to 50 μ amp range and they exposed their photographic material for ~ 0.1 to 1.0 seconds. They worked primarily with black and white plates rather than color film because it gave greater resolution, faster speed and no film distortion problems and used mostly spectroscopic plates (Kodak-Type 103A) which are sensitive in the 250 nm to 500 nm range and were especially designed for astronomical investigations. They found that radiation in the 320 nm to 340 nm band dominates the discharge emissions (i.e., short wave U.V.). For such plates, one must consider the absorption of U.V. by the gelatin and the glass [ozone is a strong absorber of U.V. while water transmits, but gelatin is opaque to radiation shorter than 240 nm]. They studied Kodak electron-imaging plates where the emulsion was coated on high strength soda-lime glass (10 KeV - 100 KeV electrons) but didn't find them to be of much use. They also studied projector slide plates which have an antihalation backing and are blue sensitive and found them to be quite useful. Some of their studies were devoted to emissions from minerals, leaves and other objects but most focused on fingerpad emissions. One of their leaf photographs is given in Fig. 36. The fingerpad photograph of

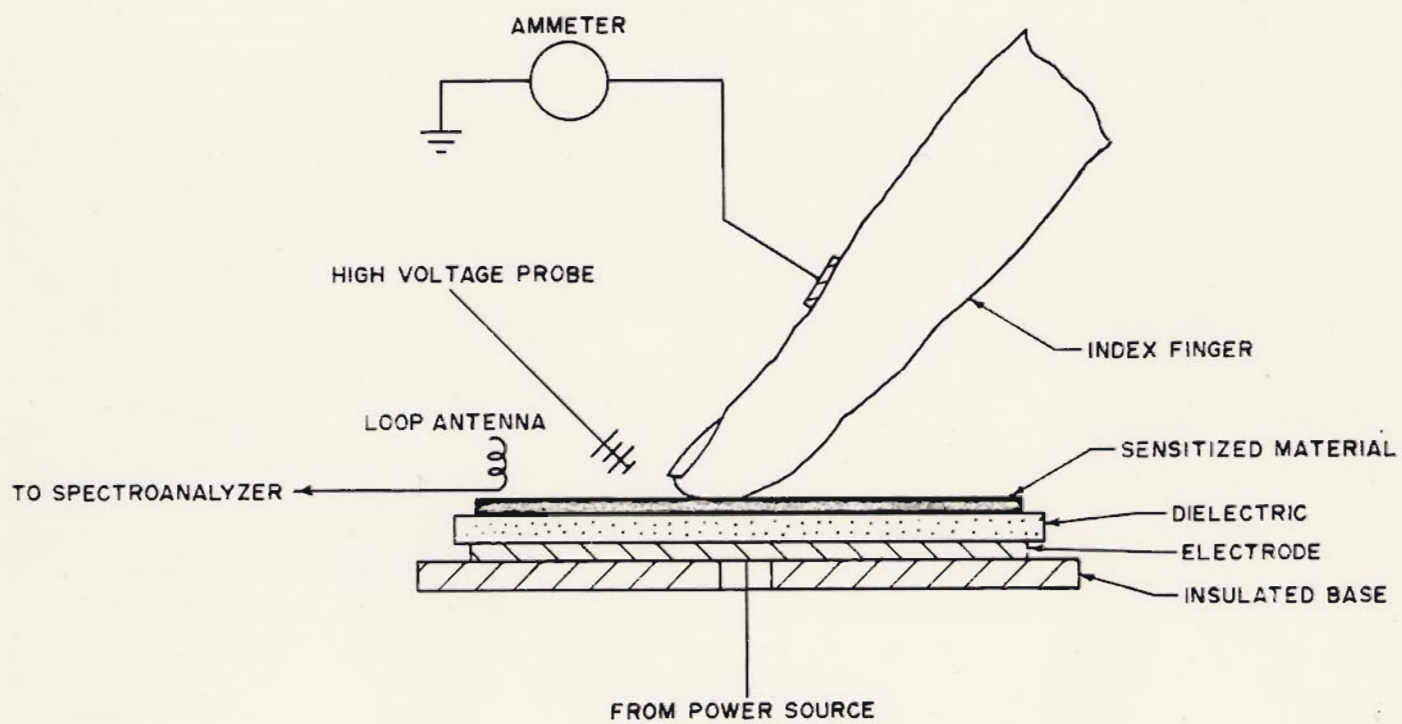


FIGURE 34

FIGURE 35





FIGURE 36

Fig. 37a clearly illustrates the inner intense zone of streamers with tangential bending tendencies like the back figures of Figs. 8 and 9. In addition, the long forked figures look like the classical ^{positive} Lichtenberg figures. We can even see places where one streamer has overlapped another on the plate and produced a greater intensity in the overlap region. This is shown at higher magnification in Fig. 37b [one certainly can imagine flickering flames or solar coronas here]. The depiction of the positive streamers are accentuated in Fig. 38 whereas the streamer extinction zone between two fingerpads is illustrated in Fig. 39. Perhaps one of the most interesting and puzzling effects that they found is that shown in Fig. 40. The inner intense streamer zone has developed an almost complete circumferential ring with some inner partial ring segments. They find that an increased current, voltage and time of exposure tends to produce a masking of the circumferential lines. During the investigation, Besch cracked his big toe on the left foot (see x-ray in Fig. 41) and took a Kirlian photograph shortly after the x-ray was taken (the other toes were held out of the way). The orientation of the two photographs are given in the lower part of Fig. 41 where we can see that long streamers only occurred on the side adjacent the crack. This asymmetric streamer effect was reproduced 5 times to ascertain that it was a real rather than a random effect.

An interesting Kirlian study of interpersonal attraction was made by Murstein. Murstein and Hadjolian⁽¹⁸⁾ on the basis of four hypotheses: (1) When the fingertips of subjects are photographed, larger halos will be produced by an opposite-sex photographer than by a same-sex photographer. (2) Subjects should be more attracted and thereby produce a larger halo ^{an} by inviting somewhat seductive behavior of an opposite-sex photographer of approximately the same age than by the neutral behavior of an opposite-sex photographer. (3) In cases where randomly paired

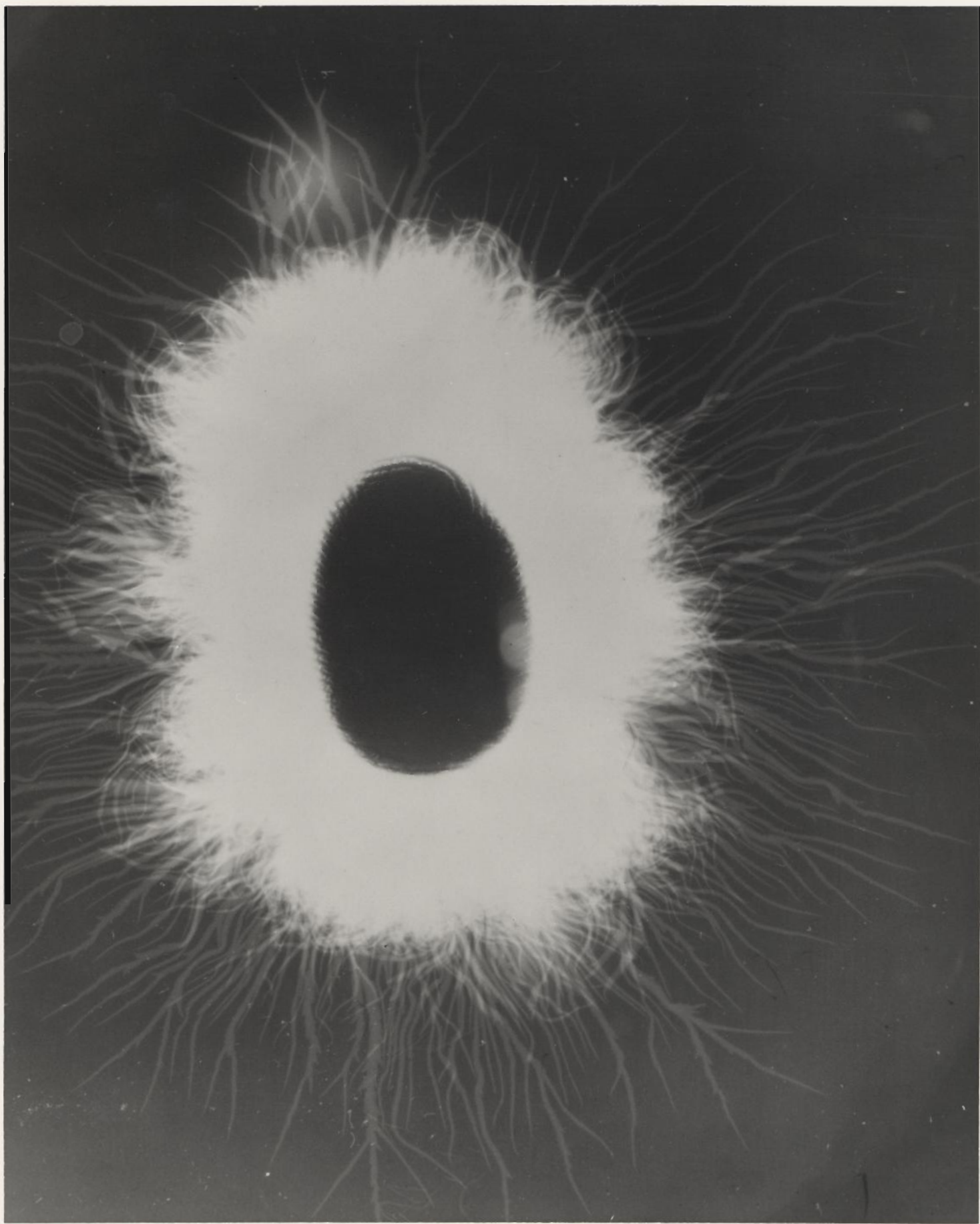


FIGURE 37(a)



FIGURE 37(b)



FIGURE 38

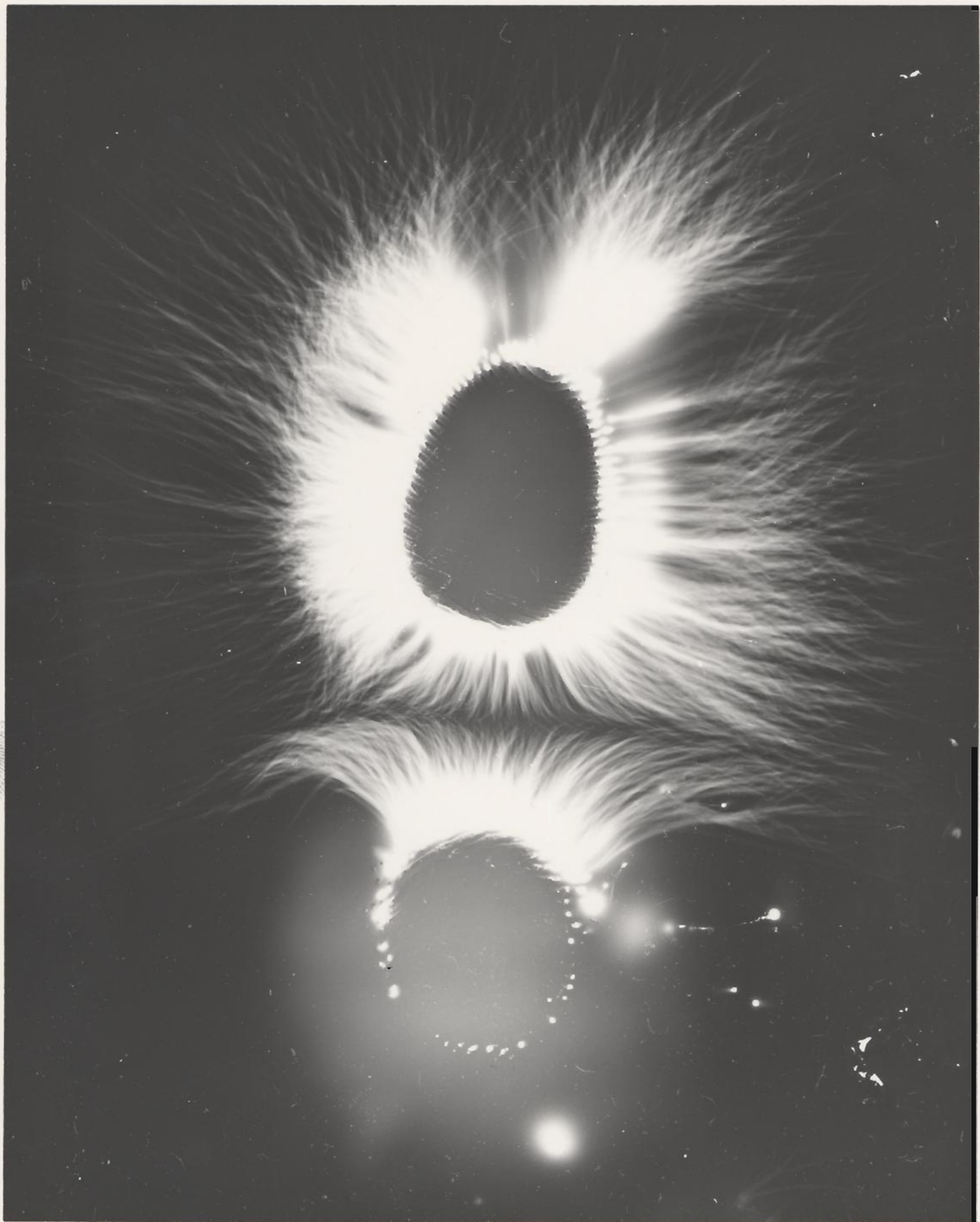


FIGURE 39

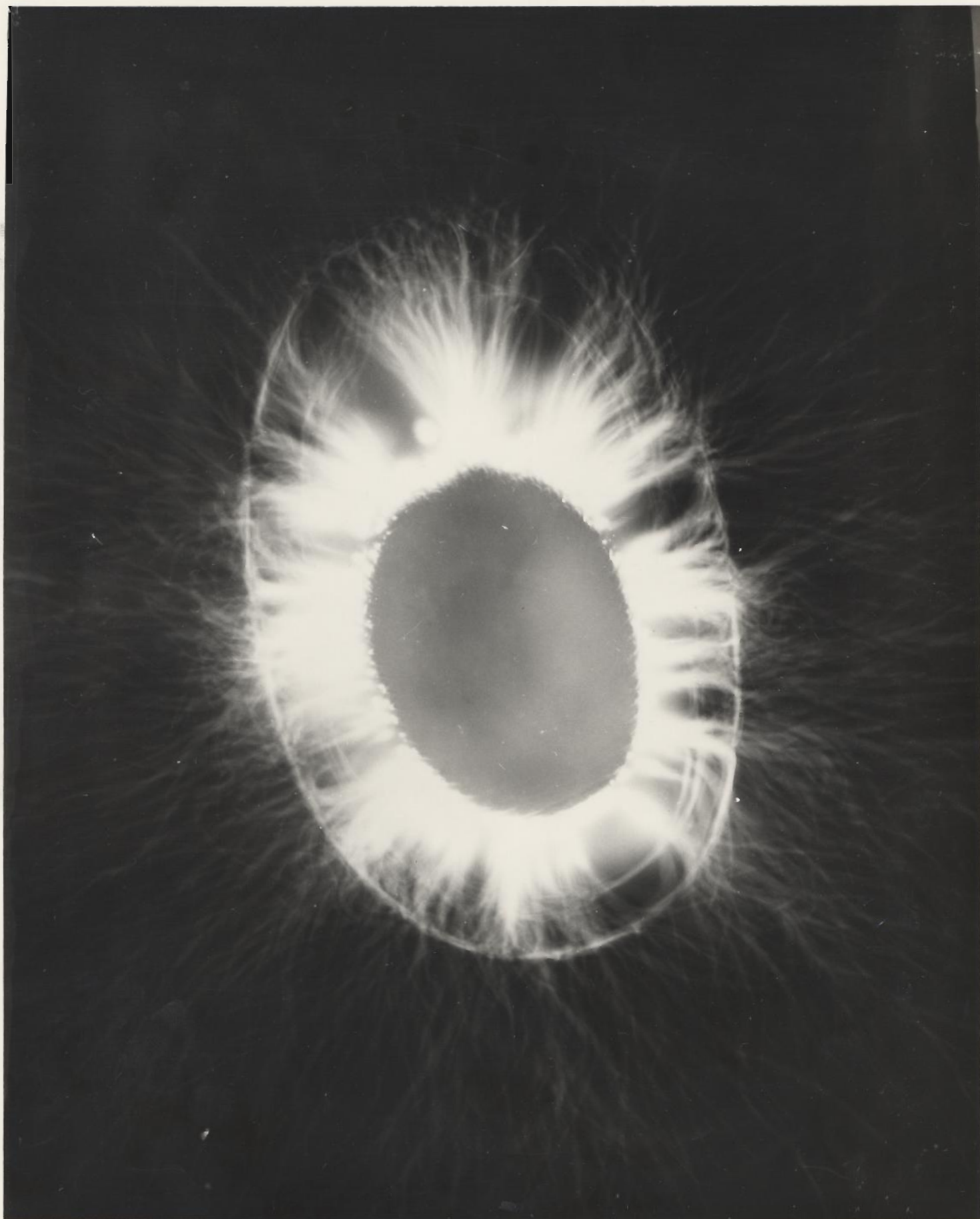


FIGURE 40

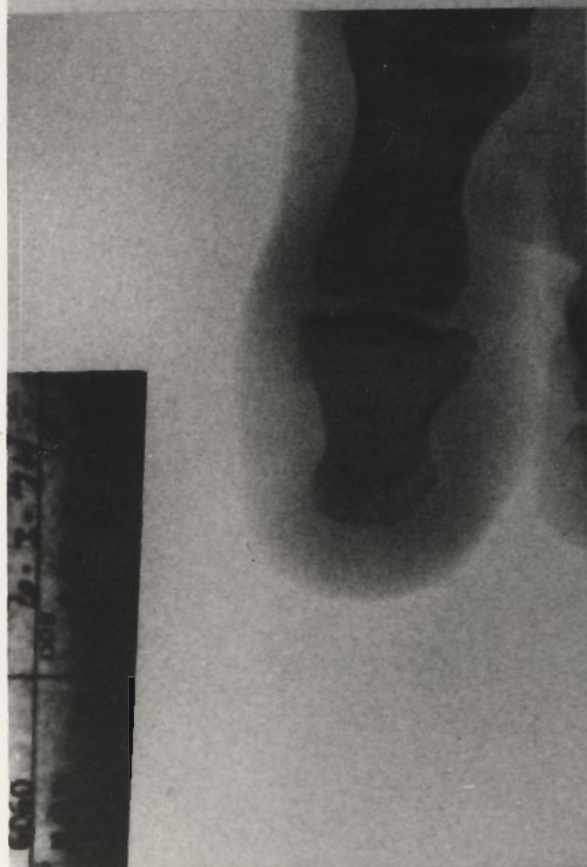


FIGURE 41

members of the opposite sex are photographed with fingertips close together, they will mutually display greater halos than will randomly paired same-sex individuals photographed with fingertips close together. (4) Individuals who mutually like each other will manifest greater halos when their fingertips are photographed close together than will paired subjects who mutually dislike each other.

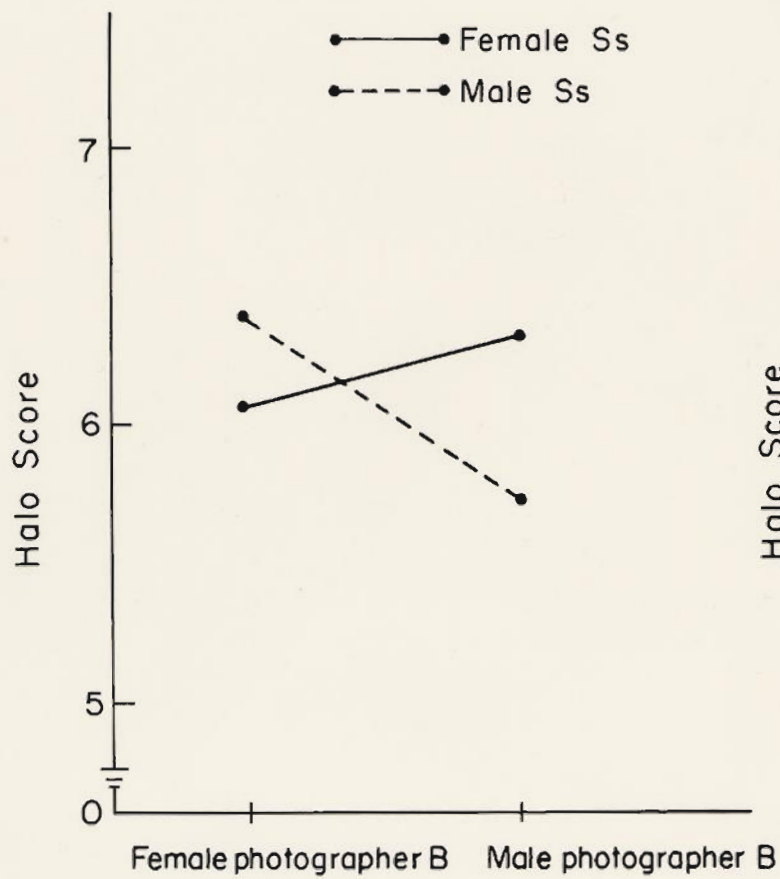
The subjects consisted of white undergraduate student volunteers from two colleges (110 men, 30 women at one and 10 men, 60 women at the other). The apparatus was of the ring down type with voltages peaking in the low frequency range⁽¹⁹⁾ and the exposure time was 1 second. In addition, they had the subjects dip their fingers in talcum powder in order to eliminate sweating that might affect the electrical conduction on the skin. To ensure stability, they took four consecutive photographs of the subject's fingers on slightly different parts of the film in rapid succession. The entire set of photographs was treated as a single score for the subject except for the paired subjects where the combined sets of scores from the pair were treated as a single score.

In order to score the halos, a seven-point scoring system was devised based on intensity, size and "freedom from anxiety." Intense halos were defined by brightness and color. The brighter the halo, the more intense it was. Size was measured to determine the length of the spikes in the halo, but not the diameter of the inner ring which was a function of the subject's finger size. Anxiety was indicated by the presence of fingerprints on the fingerpad⁽²⁰⁾. As an example, a score of 7 was given for those halos that had streamers longer than 1/8 inch and which were predominantly white in color (they were also the brightest or clearest halos); a score of 6 was given for those halos identical in all dimensions with the

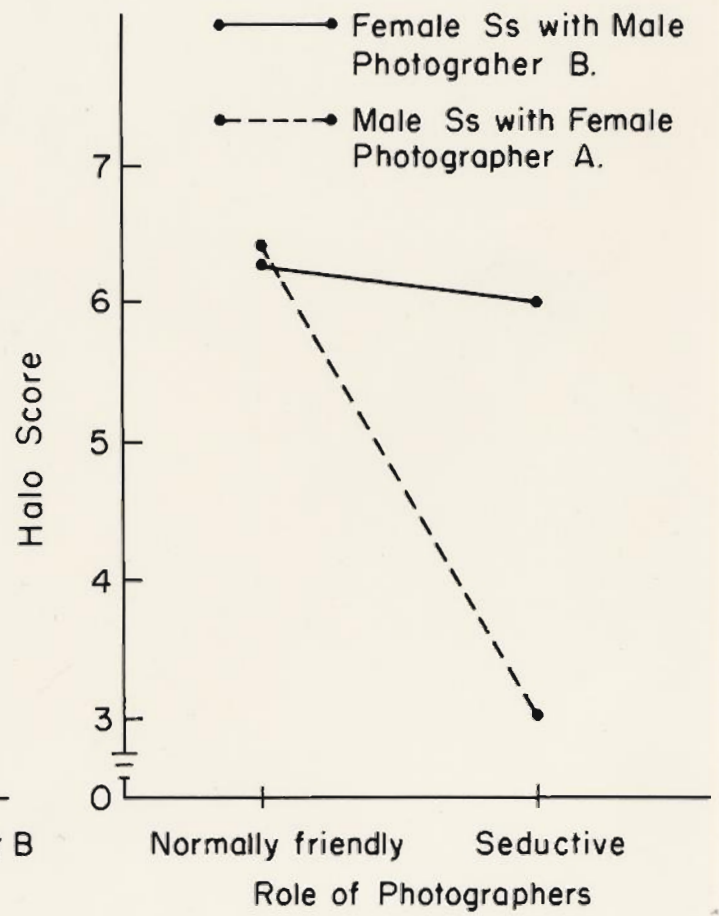
7-halos except that the streamers were less than 1/8" long.

In these experiments, the authors found support for all of their hypotheses except (2) and the subjective evidence was that the seductiveness was too overt and insufficiently subtle. The Kirlian data was significant in a direction contrary to the hypothesis. In Fig. 42, the halo scores for photographer-subject interaction and photographer manner are given. In Table I, the data for subject-pair interactions is given. The results of this study adequately support the notion that Kirlian fingerpad halos are strongly associated with interpersonal attraction. The authors suggest that perhaps men responded more strongly than women to opposite-sex photographers because of sex-role learning. Women are taught to respond much more openly to both men and women and they seem to be much more comfortable in most interpersonal situations as compared to men. It was suggested that men often view other men as potential rivals and competitors but are much more open with women in interpersonal situations. These authors' position is that they have been dealing with a reliable, real phenomenon which appears to be clearly associated with interpersonal attraction though its precise properties and nature await further clarification. In this study, they also checked to see how important were finger pressure effects and found only a negligible change in their data with changes in finger pressure.

Kirlian studies by a Tucson group⁽²¹⁾ have focused primarily on certain conventional biological subjects. In Fig. 43, their study of the influence of the anesthetic procaine on the sciatic nerve of a frog is presented. Immediately after dissection, it was photographed at 8 kV for 7 msec as a control (Fig. 43a). The nerve was then partially dipped in procaine and soaked for 8 minutes. It was then blotted with a piece of tissue paper and another Kirlian

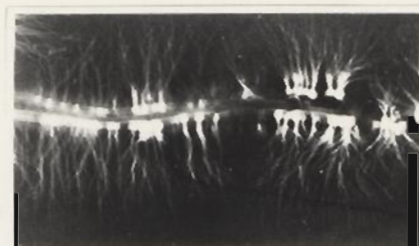


(a)

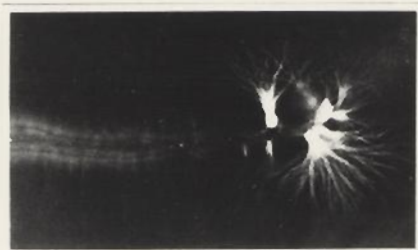


(b)

FIGURE 42



(a)



(b)



(c)



(d)



(e)

FIGURE 43

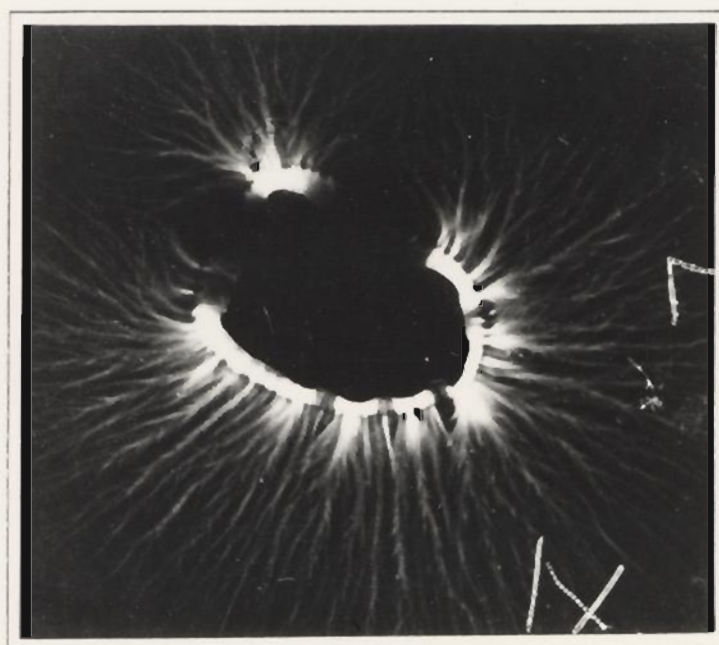
photograph taken under the same conditions (Fig. 43b). The photo shows a pronounced absence of strong flares where the nerve had been soaked. The area where the procaine had not touched the nerve does show flares similar to the control. The nerve was then immersed in a saline solution and photographs made after 22, 37 and 60 minutes (Figs. 43c, d and e). Before each picture, the nerve was blotted on tissue paper to remove as much as possible of the saline solution. We see that, after an hour, the procaine effect has largely worn off and the nerve has returned to approximately the same photographic state as the control.

A frog's liver was dissected and photographed immediately (8 kV, 7 msec). It was then laid aside for 15 minutes in the open air and then a second picture was taken. As shown in Fig. 44b, the second picture shows an incomplete halo. Both pictures show an intense and narrow inner halo plus a much fainter but broad zone of radial streamers [this is very reminiscent of Fig. 37]. These investigators are now initiating a morphine addiction study with rats.

A biofeedback type of Kirlian study has been recently carried out⁽²²⁾ wherein the Kirlian discharge of fingerpads has been monitored through a transparent electrode by a video tape system and immediately displayed on a TV tube facing the subject. The subject is able to observe the emissions from his fingerpad and try to



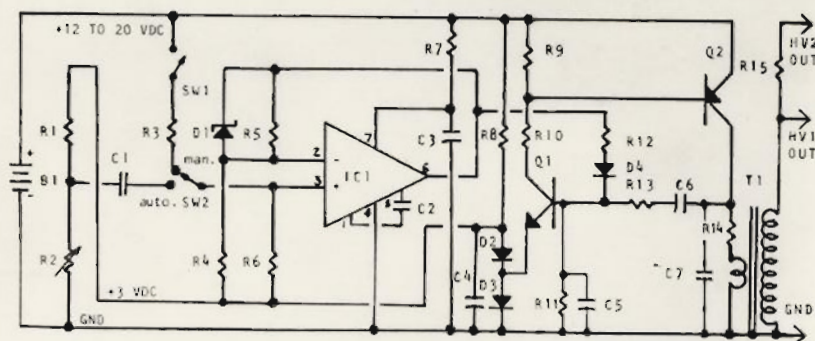
(a)



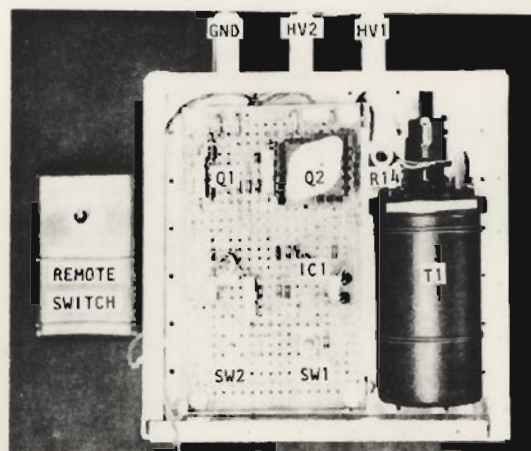
(b)

become mentally interactive with them to a sufficient degree that the emission patterns can be altered. Using both competent psychic subjects and non-psychic subjects, both have been found able to influence their fingerpad emissions without measurably changing the fingerpad-transparent electrode spacing. In these studies, it seems that the control effect on the emissions begins only after about 1 minute of continuous discharge. About a year earlier, Poock and Sparks⁽²³⁾ had utilized the transparent electrode technique coupled with an image intensifier tube to take a movie picture of fingerpad emissions. They found that almost any type of discharge pattern could be produced merely by changing the orientation or the spacing between the fingerpad and the electrode.

Before completing this section, it is important to mention the fine work of H. Dakin⁽²⁴⁾ who has devised many different types of power supplies for Kirlian photography with instructions for assemblage of same by amateurs (Figs. 45 and 46). Some of his more advanced designs are used by a number of Kirlian investigators around the country (including this author). Without such reliable power supplies, little meaningful work could have been done. Many others have generated designs for power supplies of varying degrees of utility^(19,25). These high voltage power supplies are of four basic types (1) iron-core induction coils with electromechanical vibrator current interrupters; (2) iron-core automobile ignition coils, operated by transistors or silicon controlled rectifier circuits; (3) air-core Tesla coils with primary-circuit spark gap and tuned circuits and (4) air-core high voltage transformers in vacuum tube or transistor oscillator circuits. Types (1) and (3) are inherently unstable due to electrode contact impedance variations in normal operation. Types (2) and (4) are inherently stable giving uniform and reproducible



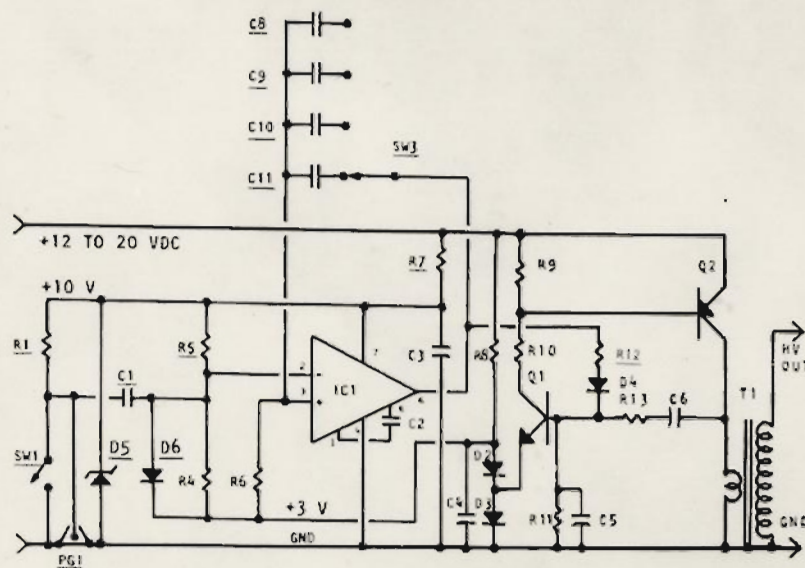
Resistance-Controlled High-Voltage Supply, schematic diagram. Refer to parts list for component identification, and to photographs of completed circuit board for component placement.



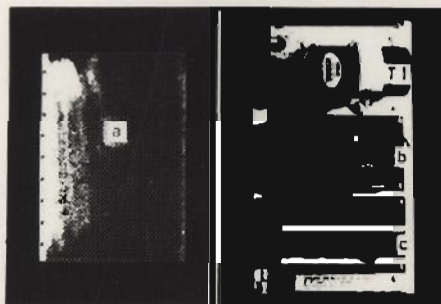
Resistance-Controlled High-Voltage Supply, built by the perforated-board construction method, with circuit board and transformer (T1) mounted on an aluminum chassis, and remote switch plugged into transducer R2 socket.

PARTS LIST FOR RESISTANCE-CONTROLLED POWER SUPPLY

B1	Battery, marine or automobile type, 12 V, 60 ampere-hour, or specially-modified 12-V battery charger (see text)
C1, C5, C6	Capacitor, mylar, 0.1 μ F, 100 to 400 V
C2	Capacitor, ceramic, 100 pF, 50 to 1,000 V
C3, C4	Capacitor, tantalum, 6.8 μ F, 35 V
C7	Capacitor, ceramic, 0.01 μ F, 1,000 V
D1	Diode, zener, 7.5 V, 0.25 W, 1N711
D2, D3	Diode, light-emitting, red, 0.2 W, Sprague type ED123 or Litronix type Red-Lit 2
D4	Diode, rectifier, 600 PRV, 1A, 1N4005
IC1	Integrated circuit, operational amplifier, 8-pin TO-5 case, National Semiconductor type LM308H (for best performance and lowest battery drain) or LM301AH (lowest cost)
Q1	Transistor, silicon NPN, TO-5, 60 V, 0.8 A, 2N2219
Q2	Transistor, silicon PNP, TO-3, 60 V, 5.0 A, 2N4905
R1, R12, R13	Resistor, 100,000 ohms, 1/4 W, 10%
R2	Resistive transducer, 1,000 to 1,000,000 ohms, or switch (see text)
R3, R4, R8	Resistor, 1,000 ohms, 1/2 W, 10%
R5	Resistor, 10,000,000 ohms, 1/4 W, 10%
R6, R11	Resistor, 1,000,000 ohms, 1/4 W, 10%
R7, R9, R10	Resistor, 100 ohms, 1/2 W, 10%
R14	Resistor, 2 ohms, 25 W, 10%
R15	Resistor, 1,000,000 ohms, 1 W, 10%
SW1	Switch, push-button, for 1/4-inch mounting hole, SPST ("HV ON")
SW2	Switch, toggle, for 1/4-inch mounting hole, SPDT or DPDT ("MAN.-AUTO.")
T1	Transformer, automobile ignition coil for 12-V ignition system
--	Transistor sockets, TO-5, for R2 and Q1 (2 required)
--	Transistor socket, TO-3, for Q2
--	Transistor heat sink, TO-3, for Q2
--	Integrated-circuit socket, Nugent 8-pin TO-5, radial leads
--	Wire, tinned copper, solid, uninsulated, No. 26
--	Wire, copper, stranded, insulated, No. 22
--	Wire, copper, insulated, high-voltage ignition cable
--	Circuit board, pre-cut perforated, 3-1/2 x 6 inches, with matching aluminum panel (Radio Shack 270-097)
--	Miscellaneous mounting hardware



Timer-Controlled High-Voltage Supply, schematic diagram. Refer to Parts List for Resistance-Controlled High-Voltage Supply, and to Supplementary Parts List for this circuit.



Complete High-Voltage Photographic Apparatus, showing (a) electrode-insulator assembly, (T1) ignition coil transformer, (b) Circuit board for Timer-Controlled High-Voltage Supply, (c) control panel.

SUPPLEMENTARY PARTS LIST FOR TIMER-CONTROLLED HIGH-VOLTAGE SUPPLY

<u>C1</u> , <u>C11</u>	Capacitor, mylar, 0.1 uF, 200 to 400 V
<u>C8</u>	Capacitor, mylar, 100 pF, "
<u>C9</u>	Capacitor, mylar, 0.001 uF, "
<u>C10</u>	Capacitor, mylar, 0.01 uF, "
<u>D5</u>	Diode, zener, 10 V, .25 W, 1N714
<u>D6</u>	Diode, rectifier, 600 PRV, 1A, 1N4005
<u>PG1</u>	Phone jack, standard 1/4 in. i. d. (for external switch connection)
<u>R1</u>	Resistor, 10,000 ohm, 1/4 W
<u>R5</u>	Resistor, 100,000 ohm, 1/4 W
<u>R7</u>	Resistor, 1,000 ohm, 1/2 W
<u>R12</u>	Resistor, 51,000 or 100,000 ohm, 1/4 W (try both)
<u>SW1</u>	Switch, push-button, spst, normally open
<u>SW2</u>	Switch, rotary, 4 position, non shorting

NOTES

- (1) For parts not shown above, refer to Parts List for Resistance-Controlled High-Voltage Supply.
- (2) Underlining of part numbers indicates new parts or changes in value, placement, or function of old parts in the original Resistance-Controlled High-Voltage Supply circuit.
- (3) Parts removed for this modification are C7, D1, R2, R3, R14, SW2. C7 and R14 were found unnecessary for normal operation, but should be added as a protective measure when testing effects of changes in R12, R13, and C6.

high voltage pulses when controlled by suitable timing circuits.

VI. THE STANFORD STUDIES

A. Metallic Electrodes

We shall deal here with a discussion of the Stanford work^(2,26-29). We conducted a number of experiments using a similar electrode configuration to Fig. 18 and a high frequency power supply operating at 1 MHz. A block diagram of the initial equipment set up is given in Fig. 47. Initially, single pulse discharges from both biological and metallic electrodes were found to occur from a network of points on the electrode surface (see Fig. 48). Multiple pulses were found to produce a superposition effect such that a more uniform halo exposure appeared on the film around the object. During the fingertip studies, it was found that the photographs depended significantly on the electrode-film combination and considerable variance occurred in these results as a consequence of the inability to repeatedly establish a well-defined and controlled discharge spacing and finger orientation. Thus, we decided to restrict our initial studies to those where reliable information could be gained and started by studying discharges between flat, polished metal electrodes. All the photographs were found to reveal the same characteristic dot discharge pattern, like that given in Fig. 49, with relatively uniform dot spacing even though brass, steel and silicon electrodes were used. Even when the electrode work function changed by more than 1 eV, the dot pattern was unaltered. In a number of photographs, large clear patches containing no dots were found; these patches disappeared when photographic plates rather than film were used. This suggested that air gaps could sometimes form behind the film and alter the discharge operation.

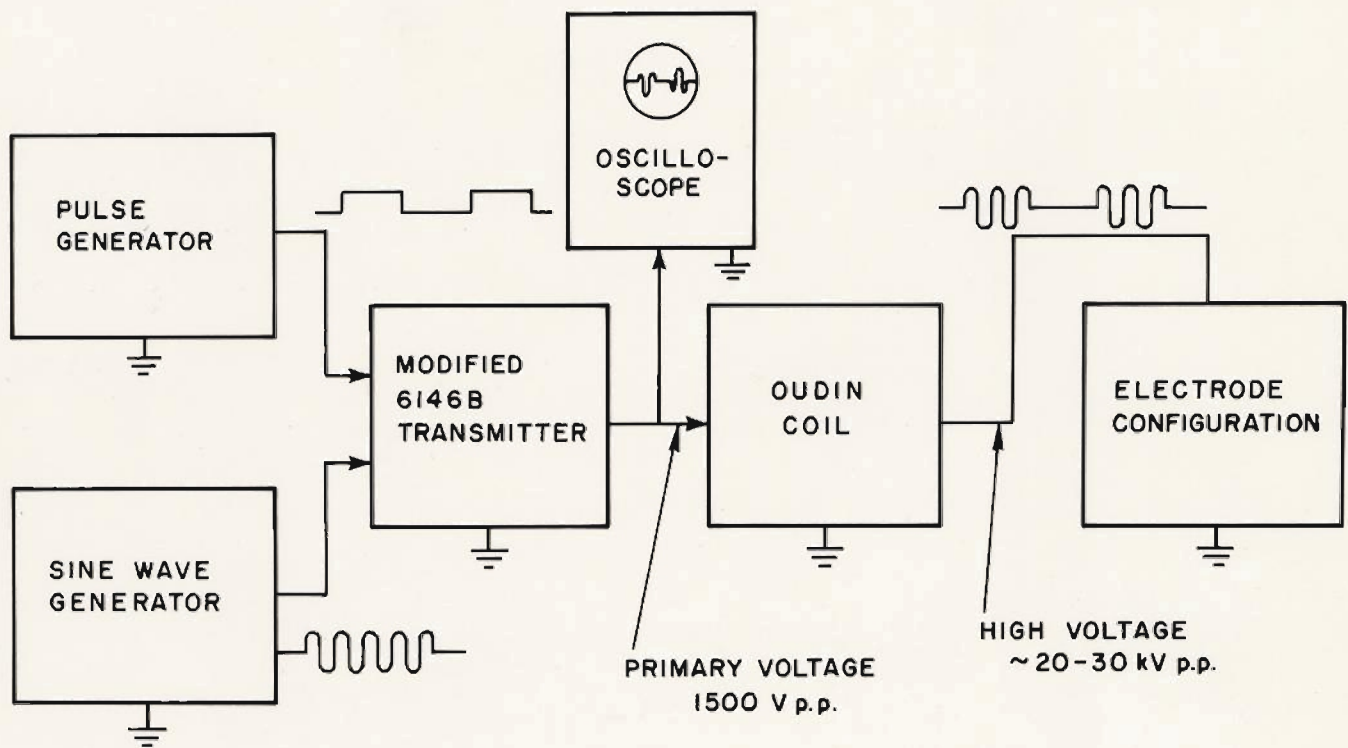
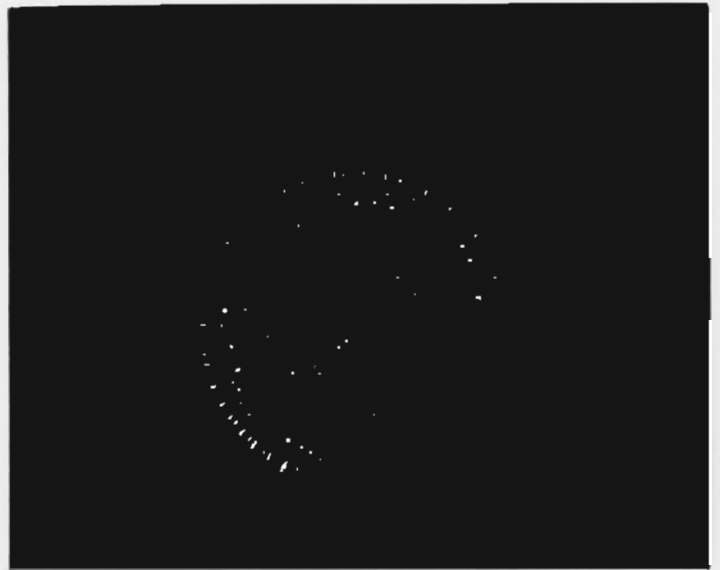


FIGURE 47



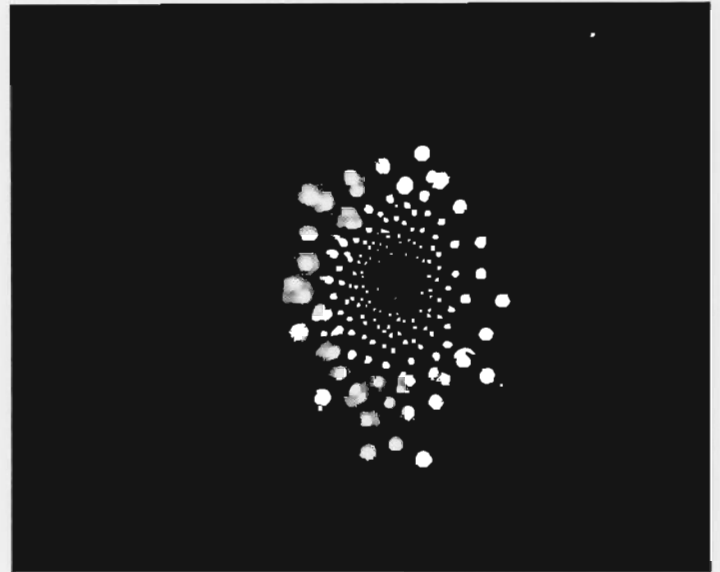
(a)



(b)



(c)



(d)

FIGURE 48

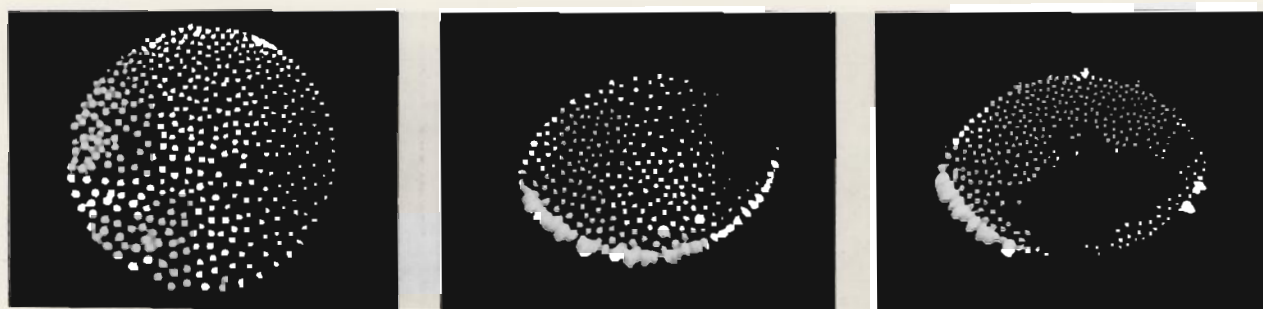
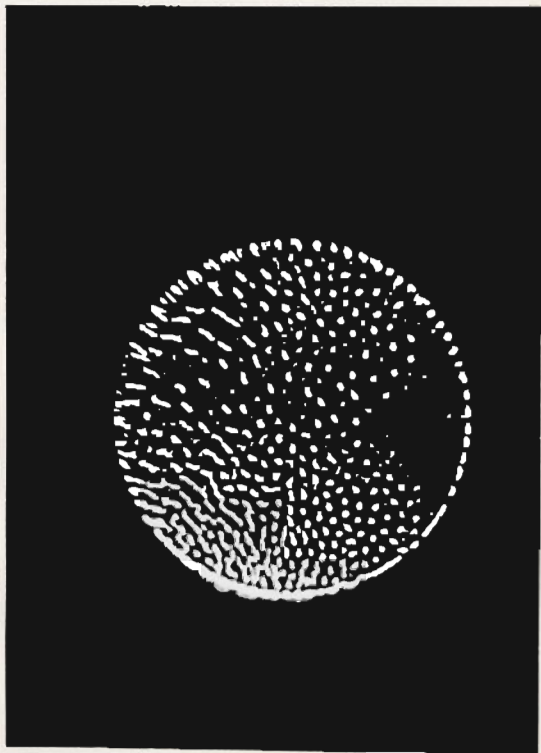


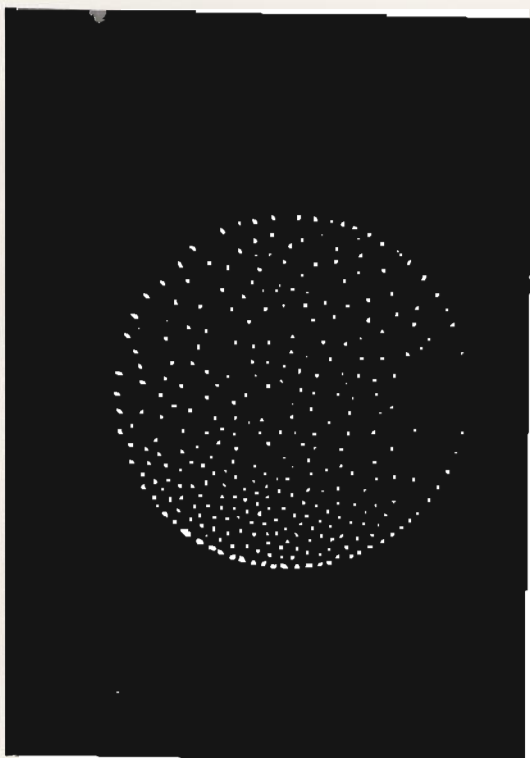
FIGURE 49

To study the effect of discharge spacing, the metal electrode (polished to about 6μ smoothness) on a ball and socket joint was attached to a microscope frame and a transparent electrode (thin transparent conductive coating on a glass substrate) was attached to a modified stage table of the microscope. In this way, the metal electrode could be aligned parallel to the transparent electrode (by using a laser technique) or tilted and adjusted to any desired spacing to within $\pm 2\mu$. Using an angled mirror below the transparent electrode, one could directly observe the discharge with the unaided eye or could photograph it at will. The electrode system was set at the desired spacing by first adjusting it to zero spacing and then backing off the fine adjustment a specified number of turns. The R.F. frequency was ~ 1 MHz and a pulse width, typically ~ 1 -8 milliseconds, was used at a 1 Hz repetition rate. To obtain a dynamic visual display of the discharge, a pulse repetition rate of ~ 20 Hz was used.

The changes in the discharge pattern due to changes in the electrode gap size, d , and R.F. pulse duration, τ , are presented largely in Figs. 50 and 51. At a spacing of 200μ , the discharge structure for $\tau = 2, 4$ and 8 msec are very similar and essentially identical with Fig. 50b. From Figs. 50a and b, we note that an increase in τ by a factor of 4 at $d = 400\mu$ leads to noticeable elongation of the discharge spots. At $d = 600\mu$, we notice a marked decrease in density of the discharge spots and the appearance of elongated discharge traces, hot spots that appear to be due to discharge points of intense exposure and the development of both diffuse exposure zones and trace substructure (Fig. 50c). At 800μ , the trace density decreases further and, at large τ , the substructure in the discharge traces has a greatly accentuated halation surrounding it (Fig. 50d). The process continues as



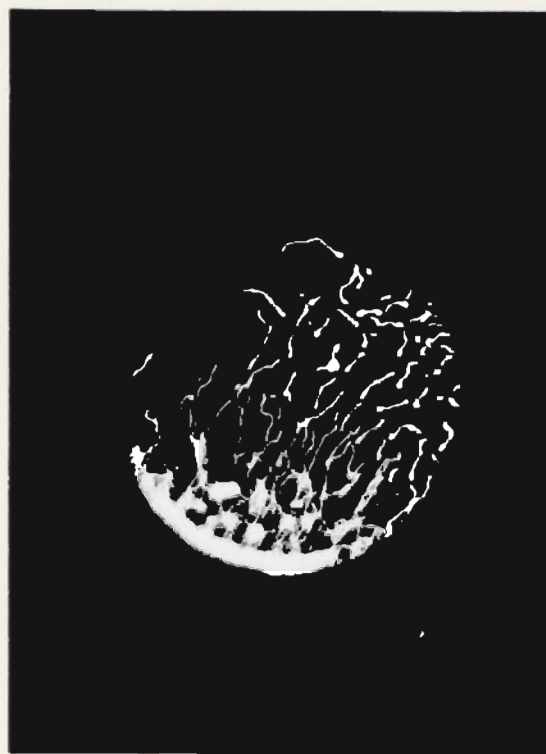
(a)



(b)



(c)



(d)

we reach $d = 1000\mu$ but saturates at this level showing no further characteristic changes (for the voltage we used). One noticeable feature at large d and large τ is the appearance of strongly curved and even spiral type discharge traces.

As one would expect, producing an electrode tilt led to elongated discharge traces and the effect of multiple pulses is to multiply the number of discharge traces. When thin microscope coverglasses are used adjacent to each electrode, the exotic halation and "birdsnest" type structures begin to appear only when d is about a factor of 2 larger than in the case where only the transparent electrode contains a coverglass. When the second coverglass was removed from in front of the polished metal electrode and placed in intimate contact with the first coverglass, the discharge structure was analogous to that without the second coverglass but at a reduced d spacing (because of the thicker glass).

From the observations with the transparent electrode, it was apparent that the only colors observed were blue and white (very high intensity points). It was also noticed that when the discharge streamers impacted the coverglass adjacent to the transparent electrode, a zone of blue halation appeared on the coverglass surrounding the impact points. In addition, at the small d , the use of multiple pulses at high repetition rates made the individual discharge spots move about quickly like bees in a hive. At larger d , the elongated traces snaked and coiled their way along the surface. At values of $d \gtrsim 1,200\mu$, the discharge was difficult to initiate and generally had to be started at a smaller d and then d increased slowly to maintain the discharge.

From these studies, it was very apparent that in Kirlian photography we were dealing with the streamer formation process of corona discharge as discussed in the second section of this article. From the theory of streamer formation, the single

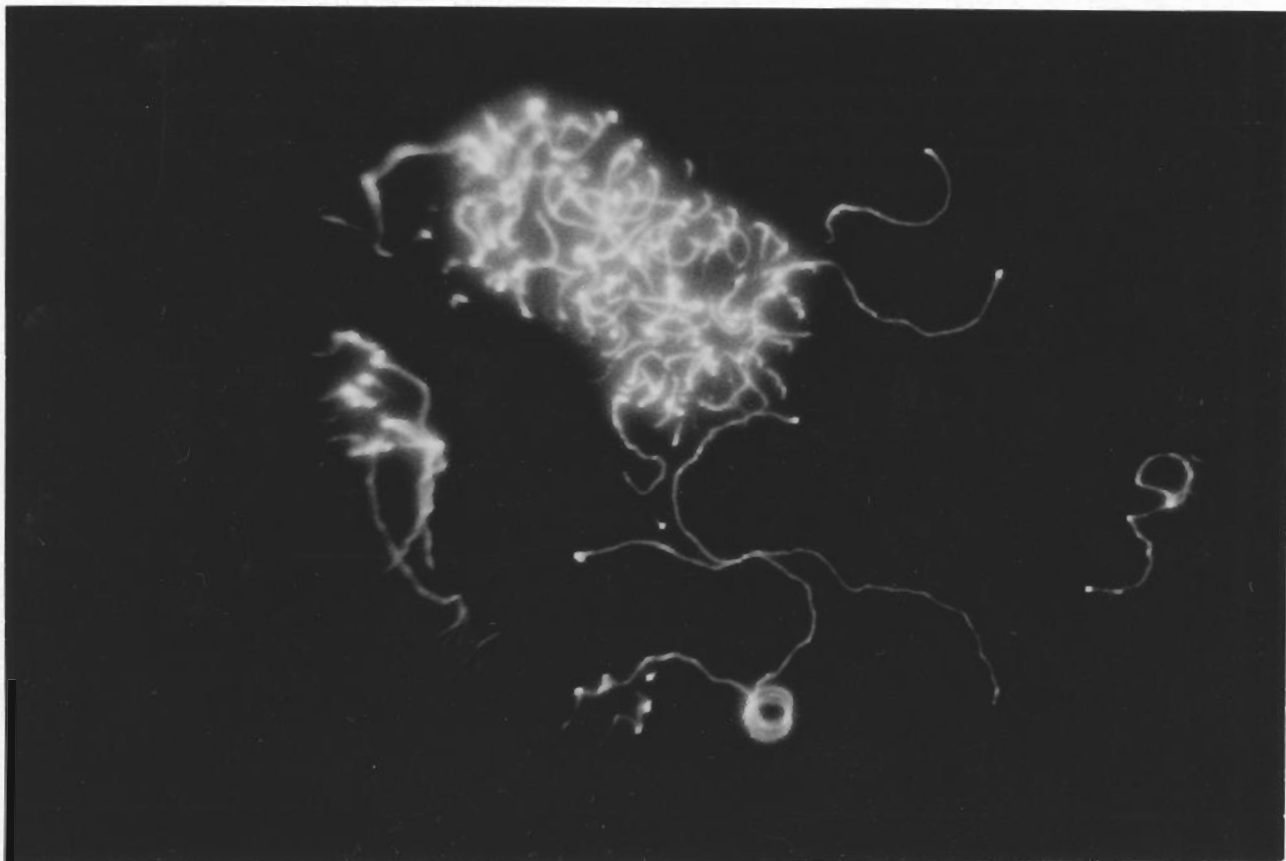


FIGURE 51

most important factor in the process is the collective ionization coefficient from both primary and secondary mechanisms leading to avalanche formation and abundant light generation. In terms of the device parameters d and τ , for fixed electrode difference, we expect the following: (a) increasing d decreases the electrostatic field E leading to a decreased density of discharge traces and an increase in the current density of each trace up to some limit, (b) increasing τ increases the ambient temperature via sustained ion impact and thus the ambient ion content of the gas increases producing a larger effective ionization coefficient for the system. As d and τ increase, the circular discharge spot elongates, presumably due to the main discharge front bouncing back and forth between the electrodes and traveling laterally along the electrodes in a straight line track. Any tilt in the electrode spacing produces a macroscopic lateral electric field which tends to produce a drift of a particular discharge tip in this lateral field direction. As the spacing increases, the change in the individual discharge channel current is such as to allow more ready lateral movement of the discharge, still largely in a straight line.

The next dramatic step in the pattern development occurs when the ambient ion current increases sufficiently that hot spots begin to develop. The enhanced secondary electron, thermionic and photoemission from the region gives a local increase in the avalanche coefficient so that many short streamers develop and move laterally to the main streamer probably joining it at the electrode surface or very close to it. Since the movement of a streamer creates a perturbing field that is comparable to the macroscopic driving field at the large spacings, as noted by Winn and Dawson⁽⁶⁾, the system eventually reaches the stage where a growing hot spot produces a "birds-nest" of clustered and intertwined discharge traces. The single main thread of the

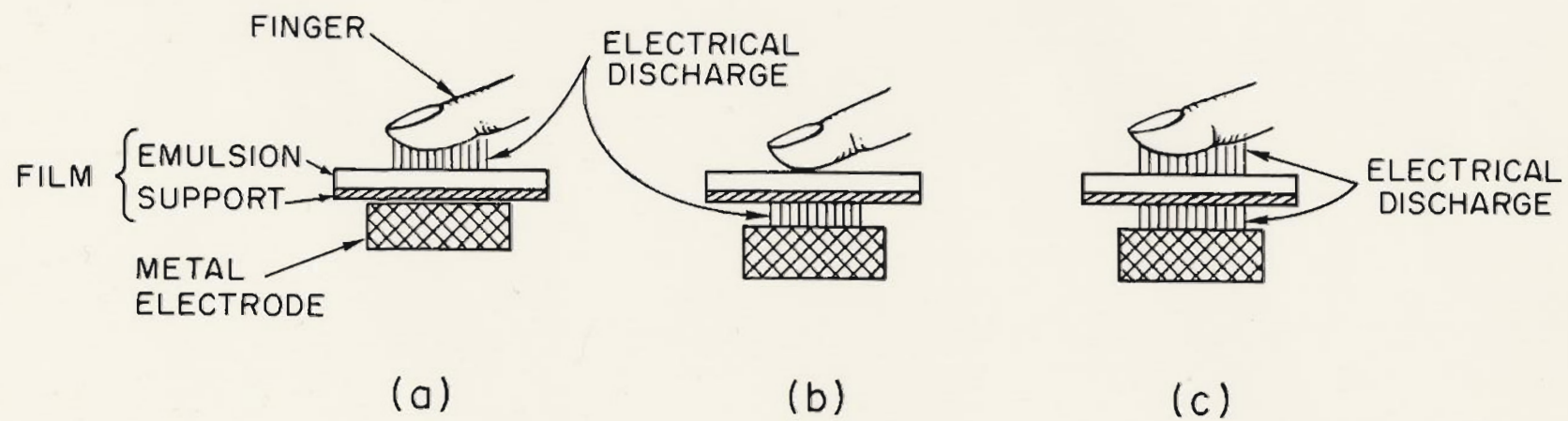
earlier stage has disappeared. At this stage, one sees very mobile lateral motion of the discharge tip and a great tendency for circular, spiral and snakelike motion. This may be due merely to random walk type of events but is very likely influenced by the local magnetic field⁽⁸⁾ due to the discharge current and by the evaporation pressure of the electrode surface atoms along this discharge track.

The effect of the coverglass seems to be twofold, (a) it increases the resistance of the interelectrode gap at breakdown and thus the discharge current and (b) it greatly alters the avalanche coefficient, γ , due to the emission of secondary electrons from the electrodes by ion impact in the discharge and by photoemission. Since the discharge cannot impact the metal electrode, secondary emission is greatly reduced. In addition, any electrons released by photoemission will be trapped between the electrode and the glass and thus will not contribute to the avalanche process. Of course, secondary emission does occur from the glass and this coefficient can change by a factor of 10 between different materials. This is likely to be an important consideration for biological electrodes.

B. Fingerpads and Color

In one of our earlier articles, D. Boyers and the author⁽²⁶⁾ postulated (1) that the generation of light in the Kirlian process was associated with electrical streamers developed between the metallic electrode and the biological electrode, (2) when color film is placed in the air gap between the fingerpad and the metallic electrode, the electrical discharge may form between the fingerpad and the front side (emulsion) of the film or between the metal electrode and the back side of the film or on both sides of the film, as illustrated in Figs. 52a, b and c respectively, and (3) it is the ultraviolet light produced by the electrical discharge that exposes the color film and provides the entire range of colors one observes in Kirlian photography. [Of course, if one replaced the air with helium or a hydrocarbon gas, one would observe green and red light respectively in the discharge.]

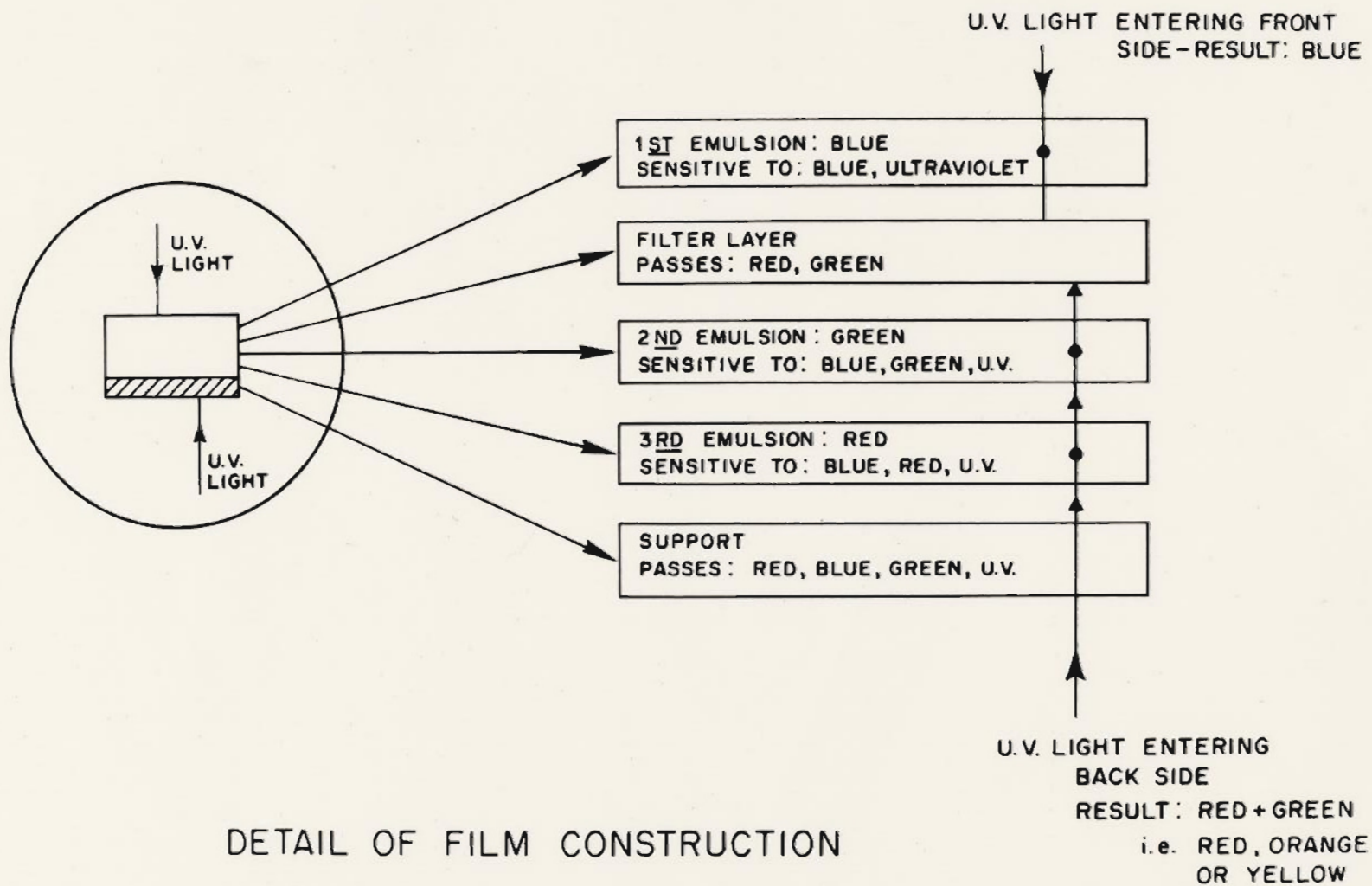
FIGURE 52



When a discharge forms between the fingerpad and the front side of the film, as illustrated in Fig. 52a, U.V. light exposes the film from the front side producing a blue or white color (white is just a bleaching effect due to high light intensity). This can be understood by considering the multilayer construction of a color film depicted in Fig. 53. The typical film is composed of three light-sensitive layers or emulsions, a filter layer between the blue and green layers and a support or backing. Exposure of the first layer produces a blue color upon development. Exposure of the second and third layers produces green and red colors, respectively, upon development. Thus, blue, green or red light entering the emulsion side of the film will expose the blue, green or red layer, respectively. Although the first, second and third layers can be exposed by blue, green and red light, respectively, all layers can also be exposed just by blue or ultraviolet light. To prohibit this from happening, a yellow filter layer is placed between the first and second emulsion to block the blue and ultraviolet light entering the film from the front side from passing through to expose the second and third emulsions. Thus, as illustrated in Fig. 53, ultraviolet light entering the film from the front side will produce a blue color in much the same way as would blue light.

But the marvelous reds, oranges, and yellows and magentas seen in the results of other investigators, when color film was located in the gap between the finger and metal electrode, must have some explanation--where do they come from? In our earlier paper⁽²⁶⁾, we explained the presence of these colors by differentiating the direction from which the light enters the film. These other colors are due to the ultraviolet light produced by a discharge between the back of the film and

FIGURE 53



a metal electrode exposing the color film from the back side (see Fig. 52b) or from both front and back side (see Fig. 52c). When the film is placed between the finger and a metal electrode, one normally imagines the electrical discharge to occur between the finger and the front surface of the film with the ultraviolet light produced exposing the film from the front side to produce a blue color. However, it is equally possible for a discharge to develop in a small air gap appearing between the metal electrode and the back side of the film with the ultraviolet light produced exposing the film from the back side. This air gap can be quite small, less than the thickness of a sheet of paper (2 to 5 thousandths of an inch), and still be sufficient to allow discharge formation. Generally, the larger the air gap, the brighter the discharge.

When U.V. light enters the film from the back side, it passes through the transparent film backing and exposes both the third and second emulsions producing red and green, respectively (see Fig. 53). For low intensity exposure, the third layer is exposed strongly and the second layer is weakly exposed producing an almost pure red color. The lack of exposure of the green emulsion for low light intensities is due to the strong attenuation of the U.V. light upon passing through the red layer. For more intense exposures, the second emulsion is exposed more and more leading first to an orange and then to a yellow color. Thus, the origin of the red, orange and yellow colors is due to ultraviolet light entering the back side of the film. It should also be noted that areas exposed from both the front and the back side of the film, as illustrated in Fig. 52c, will develop to a magenta (mixture of blue and red) or a white (mixture of blue and yellow).

Surprisingly, the majority of Kirlian investigators did not like this theory and so two further experiments were performed⁽³⁾ to completely validate it; the

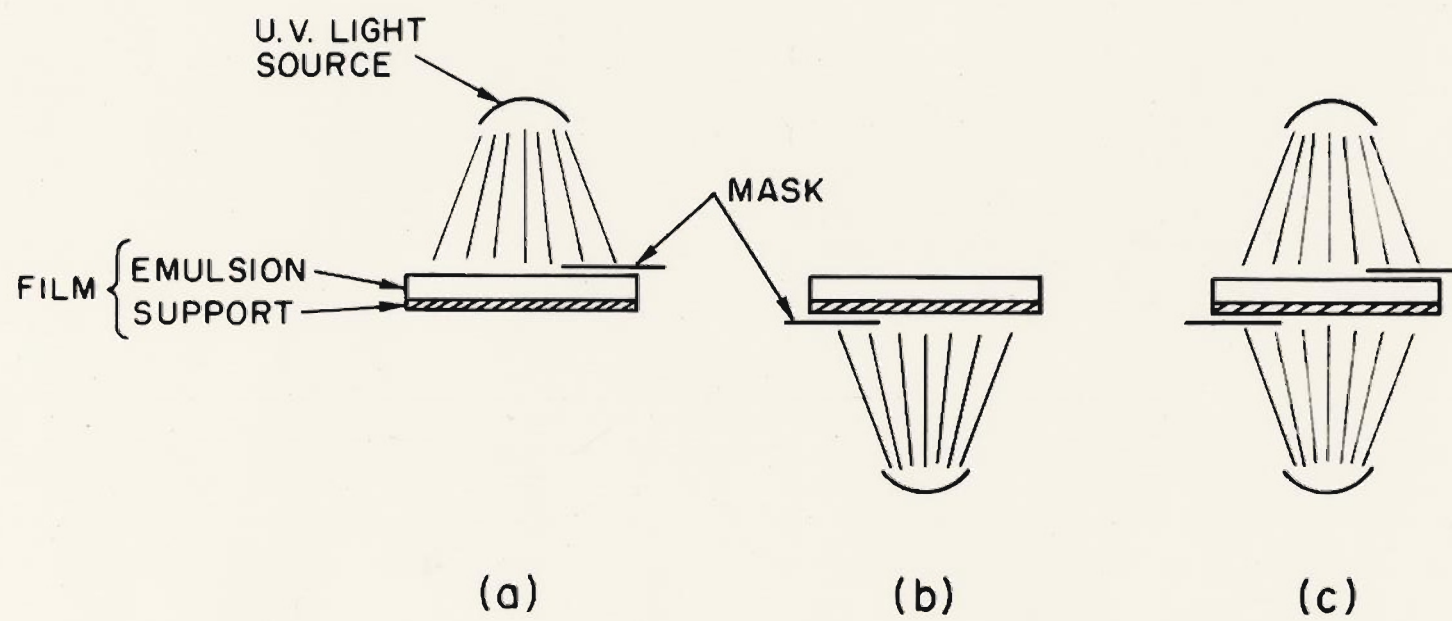
first showing that we could produce, at will, any color in the Kirlian spectrum by following the teachings of the theory and, second, we could produce any type of fingerprint pattern and color just by altering the electrode-film spacings.

The purpose of the first experiment was to verify the film construction model shown in Fig. 53 which predicts the result of exposing the film with U.V. light. For each frame of a strip of Kodak high speed Ektachrome film, one-third of the film was exposed from the front side, one-third was exposed from the back side and one-third was exposed from both sides, as illustrated in Figs. 54a, b and c, respectively. This was achieved by the use of a set of suitable opaque masks on the front and back sides of the film. In order to show the shift of colors from red to orange to yellow predicted by our model, several frames were taken at different exposure levels yielding the results shown in the top four photographs of the left column in Fig. 55. We note that the left one-third is exposed only from the front side producing blue, the middle one-third is exposed from both front and back yielding magenta, and the right one-third is exposed only from the back yielding red, orange, or yellow. The exposure times from top to bottom were, respectively, 1/200 sec, 1/100 sec, 1/25 sec, and 1/2 sec.

All of these results are in accord with theory; i.e., that the red changes to orange and then to yellow plus the magenta changes to pink and then towards white as the exposure time increases and, finally, that all the colors tend to bleach out as the exposure time increases greatly. The color contrast is even more striking on the original color transparencies since the normal printing process tends to smooth out tonal differences on the prints.

The purpose of the second experiment was to show that, by varying the finger-film-electrode spacing as depicted in Fig. 52, the resulting colors are consistent

FIGURE 54



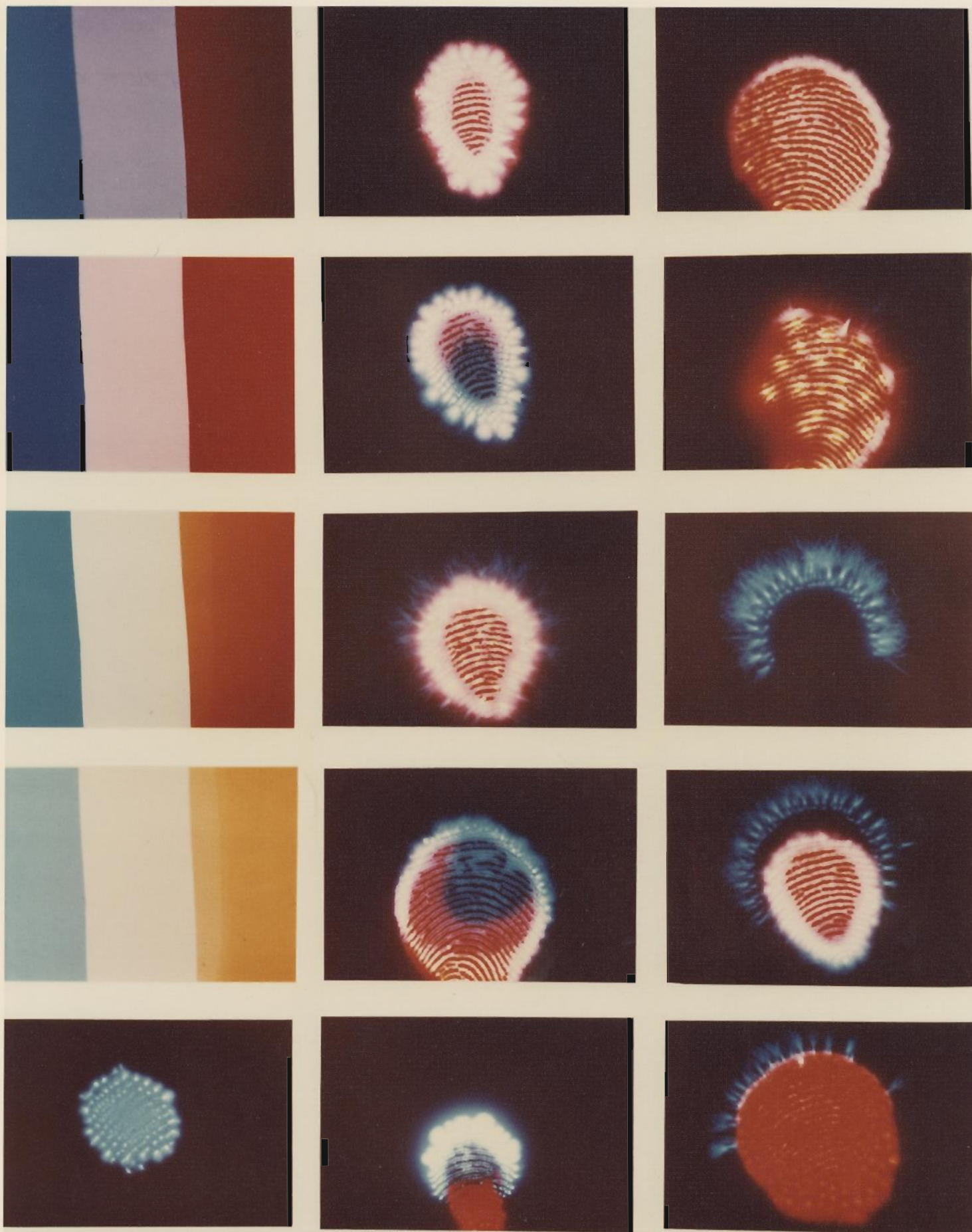


FIGURE 55

with the above model. A strip of Kodak high-speed Ektachrome film (ASA 160), identical to the type used in Experiment #1, was placed in the air gap between the fingerpad and the metal electrode. The metal electrode was connected to a 100 KHz high-voltage, low-current power supply of the type illustrated in Fig. 47. A suitable insulated film stage and movable metal electrode enabled one to change the distance between the back side of the film and the metal electrode. The distance between the finger and the front side of the film was controlled only by moving the finger toward, or away from, the film surface. The final criterion for determining where the discharges occurred was to observe the discharge as it occurred in a darkened room.

We took a number of exposures, with D.G.B. as subject, while attempting to explore a representative sample of finger-electrode-film spacing combinations. Some of these results are shown in the central and right-hand columns of Fig. 55. In the central column, from top to bottom, the following can be noted: (1) the red center indicates predominantly back side exposure, peripheral regions magenta indicating both back side and front side exposure; (2) the red top region indicates predominantly back side exposure and the blue bottom region indicates predominantly front side exposure; (3) a similar situation to (1) but the filamentary blue outermost periphery indicates a front side exposure in that region; (4) the top blue region indicates a predominantly front side exposure whereas the bottom red region indicates predominantly back side exposure; (5) the top blue region shows exposure only from the front side whereas the bottom red region shows exposure only from the back side. It is interesting to note the color of the fingerprint serrations in the upper blue portion of this picture. They are blue-white separated by black strips. The black strips correspond to intimate contact with the film and no

discharge, whereas the blue-white strips correspond to the grooves providing small air spaces wherein discharge can take place. In the right-hand column, from top to bottom, we have the following: (1) the large center region shows predominantly back side exposure, the narrow peripheral region shows both back side and front side exposure, the grooves in the fingerprint show both front side and back side exposure (in contrast to the above); (2) this is the same as (1) except that a larger spacing between film backing and the metal electrode produces a number of strong localized streamers yielding intense localized exposure from the back side (yellow spots); (3) the fingerpad was pressed tightly against the film eliminating any back side air gaps or fingerprint groove gaps so that only peripheral region exposure occurred from the front side; (4) the fingerpad was not pressed tightly against the film so that both front side and back side exposure occurred, the outer peripheral region shows front side exposure, the inner peripheral region shows both back side and front side exposure, the central region shows back side exposure and the magenta fingerprint grooves show both back side and front side exposure; (5) the metal electrode was backed off to increase the gap size at the back side of the film, some outer peripheral front side exposure, main central region shows only back side exposure.

From the above commentary, we see that these results are fully consistent with the proposed model. The model may be further checked by noting that it predicts that one should never see a green color alone (with this type of film)--a result that is observed. Additional confirmation is that the fingerprint grooves produce blue color from purely front side exposure and shift red to magenta when coupled with back side exposure. This is caused by the grooves allowing a small air gap to form at the front side.

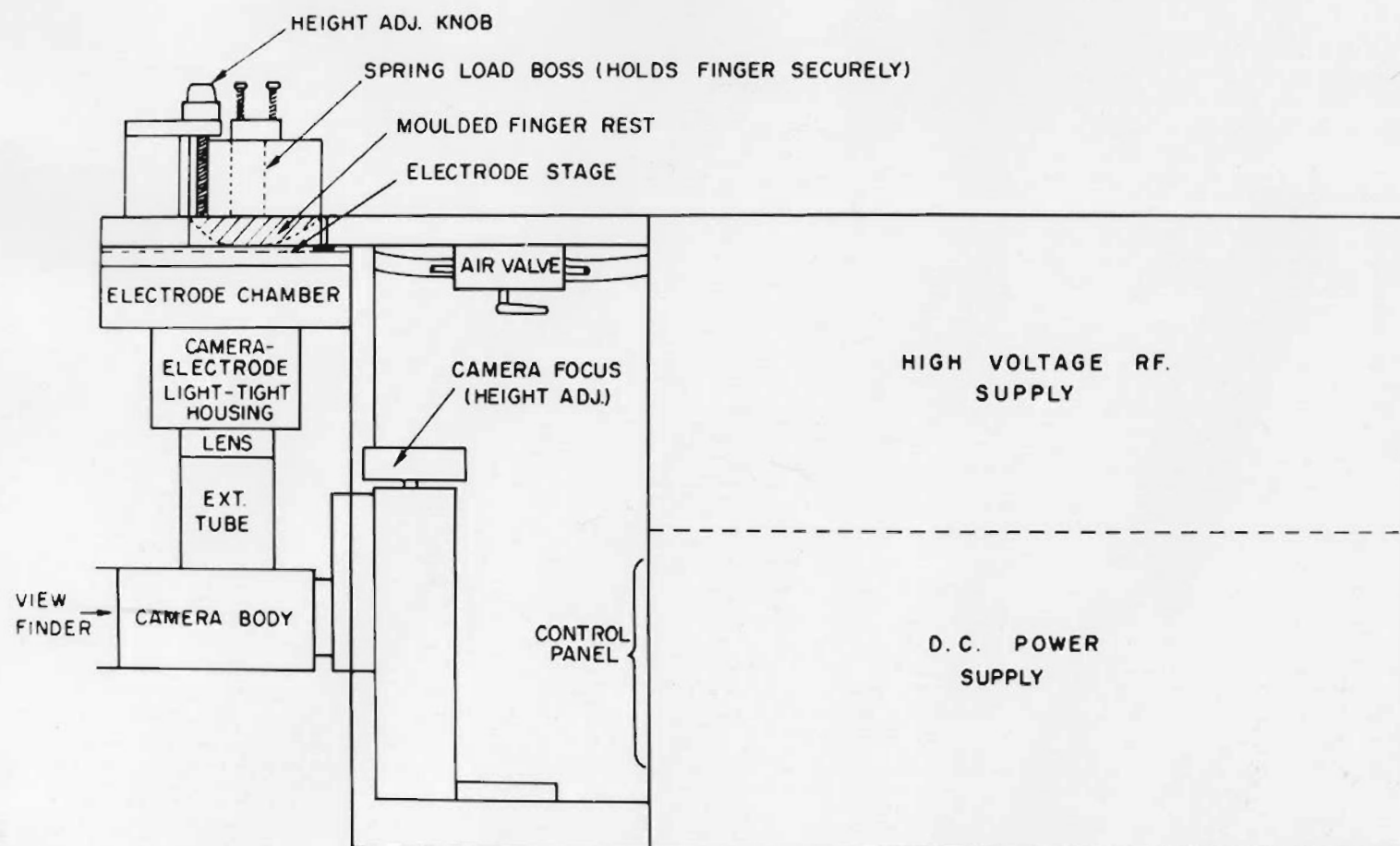
Additional support for this overall explanation of the source of color came when we used the transparent electrode and externally photographed the light coming through the electrode. Provided the electrode was kept clean of organic deposits, we observed only blue (and white) color patterns. This is shown in Fig. 55 (left-hand column, bottom picture) where the discharge from a subject's finger has been photographed using the superposition of five 100 microsecond pulses (note that the discharge is from a network of points rather than uniformly from the whole electrode).

These two experiments show that it is possible to reproduce the interesting Kirlian color effects, heretofore attributed to altered energy states of the living system, by simple changes in the electrode-film configuration. Further, they have shown that these color effects can indeed be produced by ultraviolet light in the manner proposed earlier⁽²⁶⁾. They support the postulate that the mechanism of light generation in Kirlian photography is a purely physical one associated with the electrical discharge. Thus, Kirlian photography does not directly reveal the aura that clairvoyants see. Finally, these experiments show that most work done to date on Kirlian photography has not been done carefully enough to stand as incontrovertible proof of energy changes in living systems associated with healers, changes of mental states or emotional states, etc.

C. Towards a Physiological State Monitoring Device

From the Soviet claims and from much of the American work described earlier, it appeared that the Kirlian technique could be utilized to reveal objective information about the living system if the work was done carefully enough. We⁽³¹⁾ thus embarked upon a program to build an effective, reliable and easy to use instrument which could be utilized to determine the nature of the relationship between a

FIGURE 56



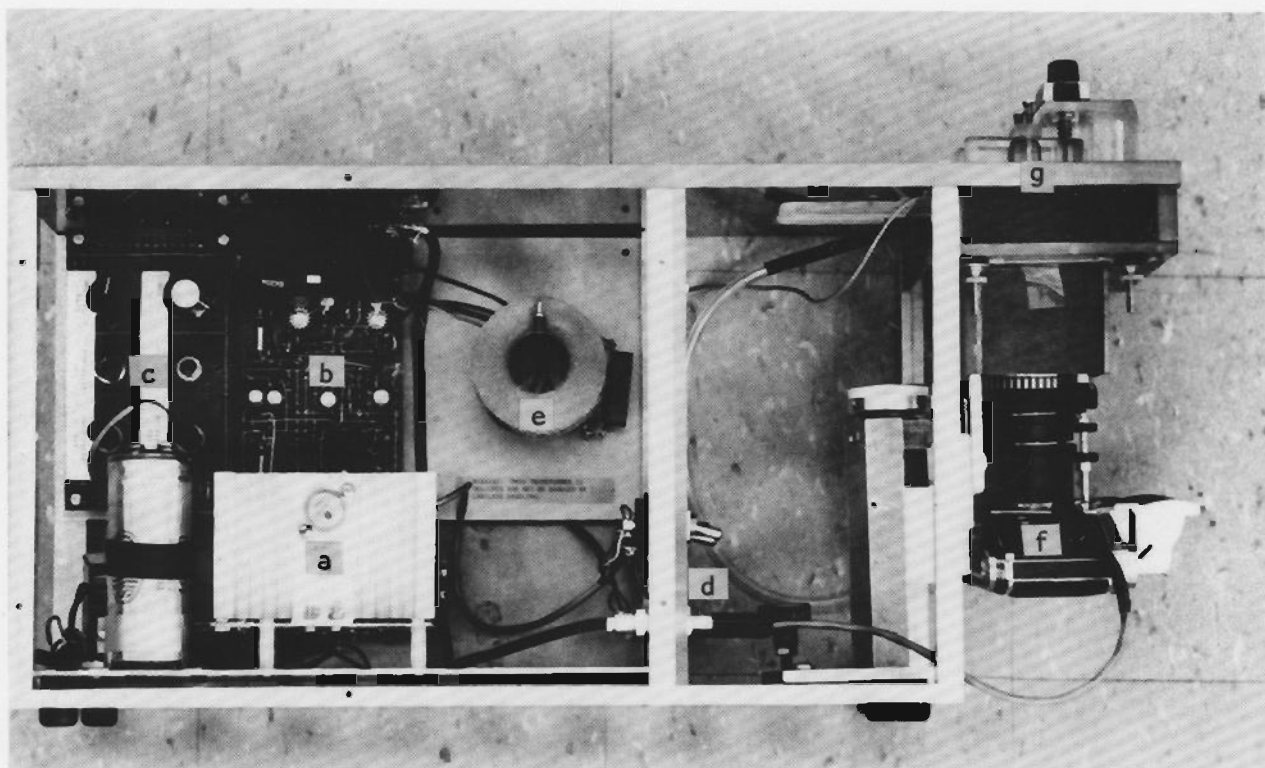


FIGURE 57

subject's physiological state and Kirlian photographs of his or her fingertips. We decided to use the transparent electrode technique since the contact photography technique suffers from the possibility of artifacts being generated by physical contact between the film emulsion and the chemicals of the skin and also by the possibility of discharges occurring at the back side as well as at the emulsion side of the film. However, two weaknesses that were present with both techniques were (a) the lack of control of finger orientation and of finger to electrode spacing and (b) the buildup of moisture during extended tests.

The design goals for the new apparatus were as follows: (1) to provide accurate control over finger orientation and finger to electrode spacing for a single finger; (2) to provide a means of preventing moisture buildup on either the transparent electrode or the finger during extended tests; (3) to provide the capability for taking pictures under normal room illumination; (4) to provide a simple control capability for taking the photographs; (5) to provide a capability for taking both single and multiple pulse exposures; (6) to provide a rugged and reliable device that is fully consistent in its operation so that meaningful comparisons could be made between different data; (7) to provide a finger holder and armrest so that the subject would be comfortable during the tests and, finally, (8) to provide such a simple operation that unskilled operators could readily learn to use the equipment. The power supply for our initial device was the 100 KHz unit used in our color studies. Since this was in the range that the Soviets indicated was best for such studies, we saw no reason to doubt its choice.

A schematic drawing of the device, showing the location of the main components, is presented in Fig. 56. A photograph of the actual device is given in Fig. 57.

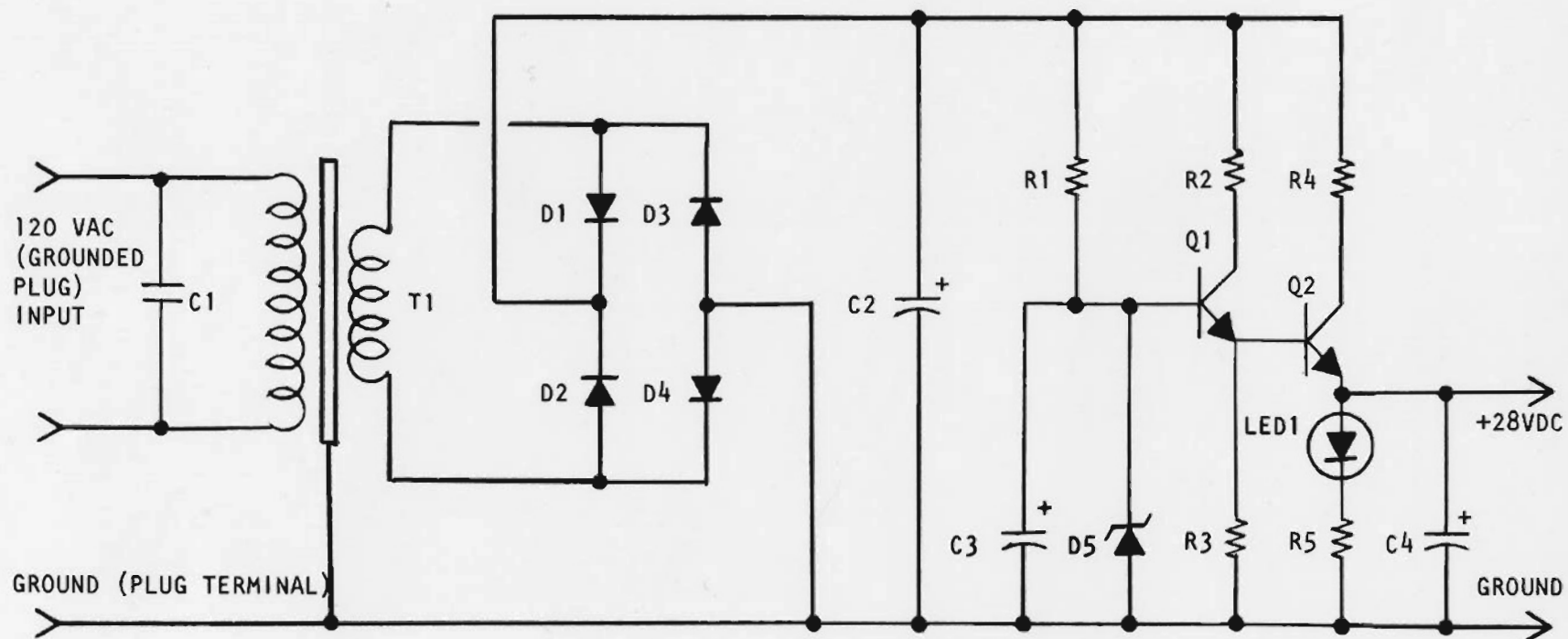
The power supply was a pulsed R.F. source producing high voltage (20 KV) pulses at 100 KHz R.F., with the capability of varying both the pulse width and the pulse repetition rate. A schematic diagram of the especially designed circuit is given in Fig. 58a with that for the input D.C. supply given in Fig. 58b.

To test the performance and the usefulness of the device, a number of experiments were conducted. It was found that (1) the effect of changing the pulse width and number of pulses on the appearance of the photographic pattern was as expected; i.e., an increase of these factors merely enhanced the brightness of the pattern on the film; (2) the discharge pattern was highly repeatable with all parameters held constant from one exposure at a particular spacing to the next; (3) it was possible to reproduce the same finger spacing and thus the same photographic condition after removing the finger from the finger holder and a few minutes later placing it back in the finger holder (see Fig. 59); (4) the fingerpad to electrode spacing was decreased in steps of 125μ leading to the results of Fig. 60 (we can see that, as the spacing is reduced, the pattern becomes larger in diameter due to the finger flattening on the electrode) and (5) it was not possible to detect any significant changes in physiological state of a subject in various states of meditation or of a psychic subject in different internal states or between a psychotic and a healthy patient.

The results described above were certainly a shock. The device performed beautifully in every engineering way except it yielded negative results concerning the utility of Kirlian photography as a useful physiological state monitoring device. This was at marked variance with so many of the studies by other investigators⁽¹³⁻¹⁶⁾. Were their results just due to poor controls or had we been missing something essential in our considerations of this subject? Although the former is partially true, we shall see in the next section that the latter is also. We shall see that the



FIGURE 58(b)



b

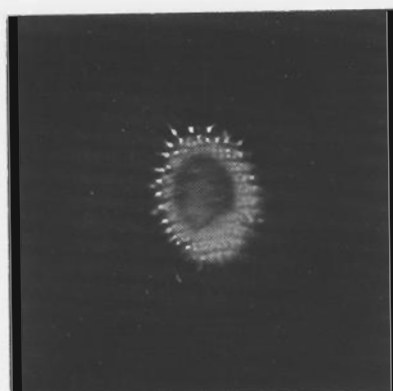
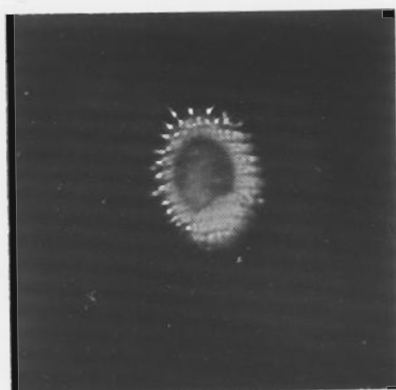
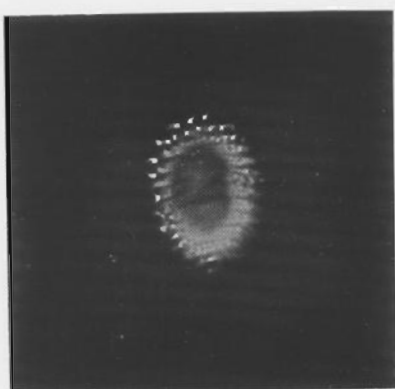
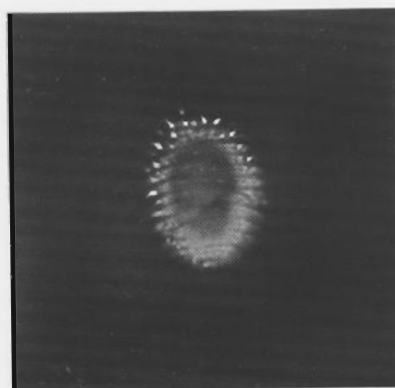
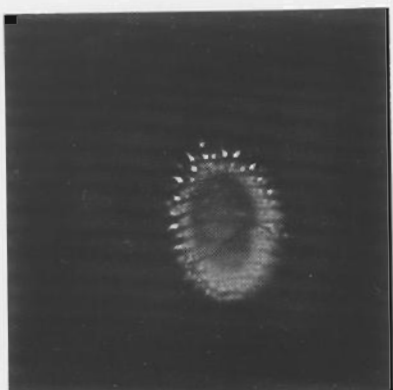


FIGURE 59

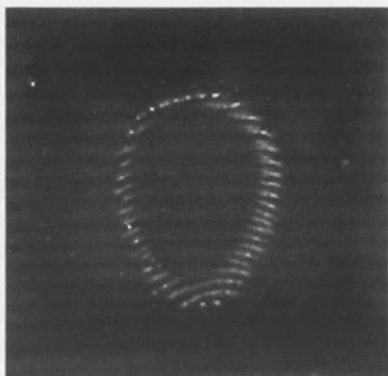
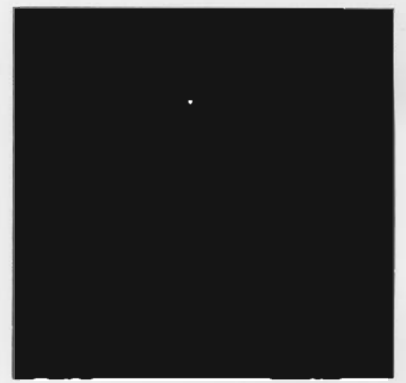
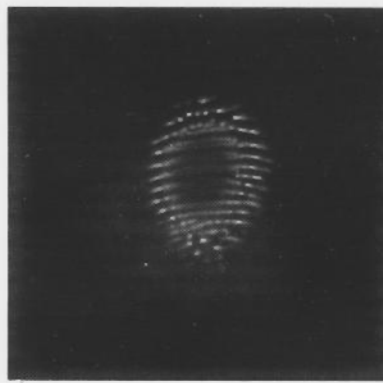
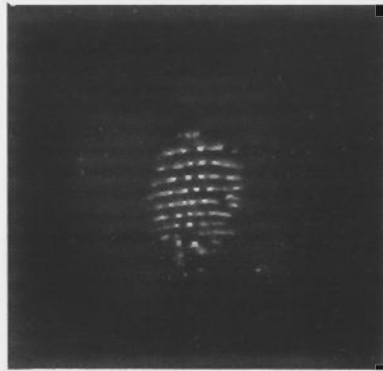
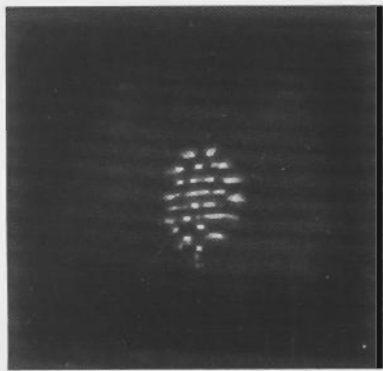


FIGURE 60

physiological state of humans cannot be monitored using a 100 KHz power supply as had been stated by the Soviets.

VII. ANALYSIS OF KEY CIRCUIT CHARACTERISTICS

Our electrical system consists essentially of the components depicted in Fig. 61; i.e., a power source V with an internal impedance Z_0 (strongly inductive), a subject impedance Z_s , ^{a film impedance Z_f} and a discharge gap impedance Z_G . Depending upon the degree of coupling between the primary and secondary transformer coils, the Q of the coupled circuits and the frequency dependence of Z_0 may change appreciably. This is illustrated in Fig. 62. Here, as the coupling between L_1 and L_2 increases by bringing the coils closer together, the reflected resistance, R , increases and the resonance of the tuned circuit decreases; i.e., $Q = 2\pi fL/R$ decreases.

For a ^{spark} discharge to occur across the gap, the gap voltage V_G must be equal to or greater than the sparking voltage given by Paschen's law. According to Paschen's law, the sparking potential V_G^* of a gas between parallel plates at a short separation distance is a function of pd (gas pressure at 0°C in mm Hg $\times$ interelectrode distance in cm). The general shape of the curves $V_G^* = f(pd)$ is shown in Fig. 63; at high pressure the sparking potential is high because the electrons lose much energy before they reach their ionizing velocity, at low pressures the sparking potential is high because there are few ionizing collisions and at an intermediate value of pd , V_G^* has a minimum value. Penning⁽³²⁾ has found deviations from this type of curve in certain mixtures. For example, in mixtures of neon with a small amount of argon, he found two minima instead of a single one. Figure 64 shows the results of two series of measurements, one for Ne and one for Ne + 0.0018%A. The curve for Ne has the normal shape; however, the other has two minima which can be

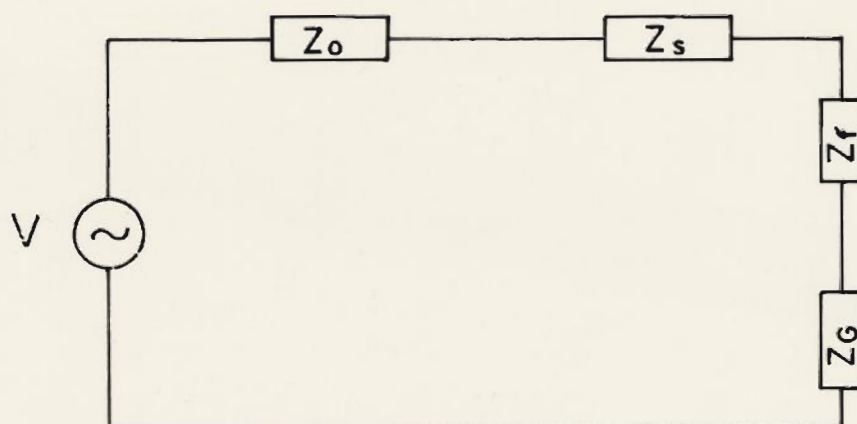


FIGURE 61

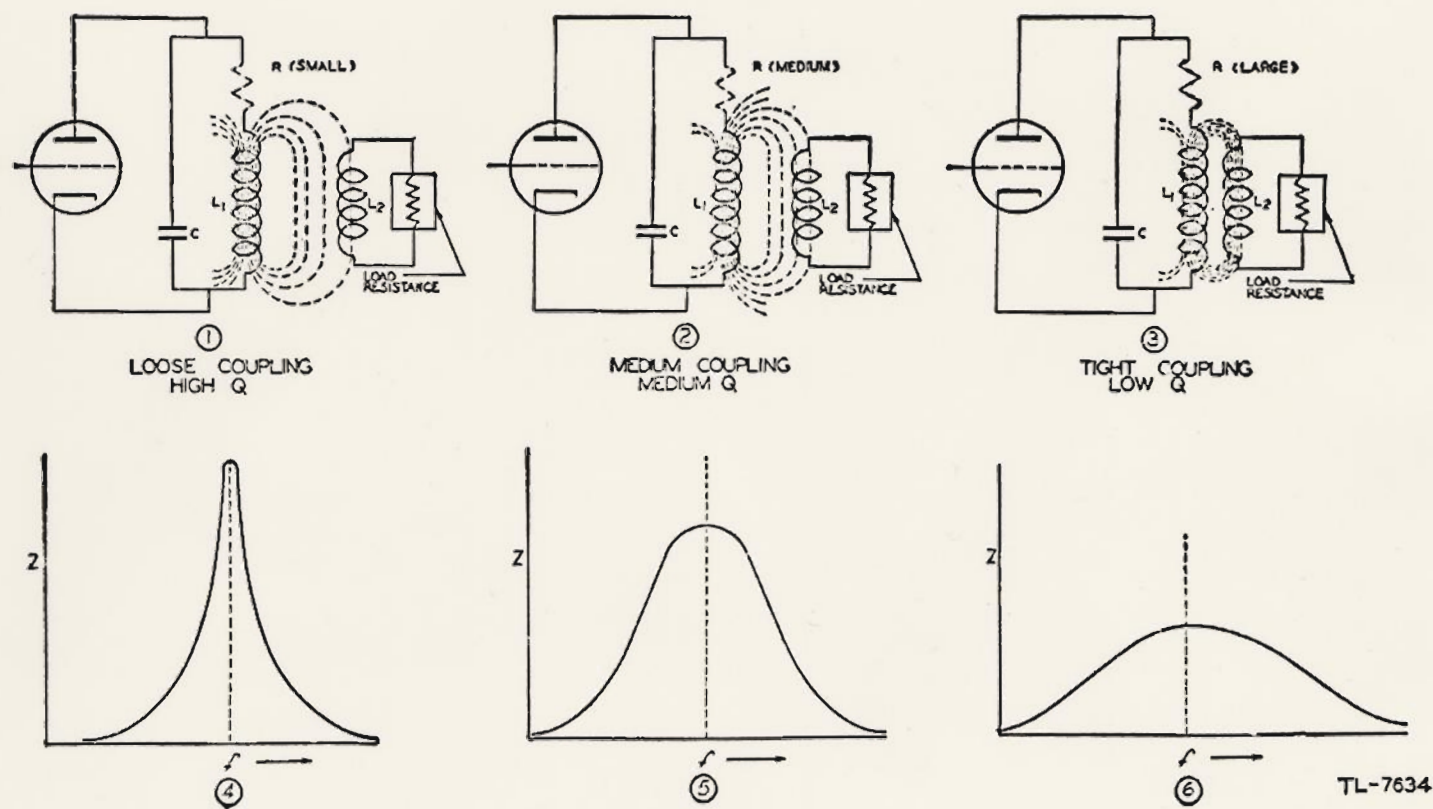


FIGURE 62

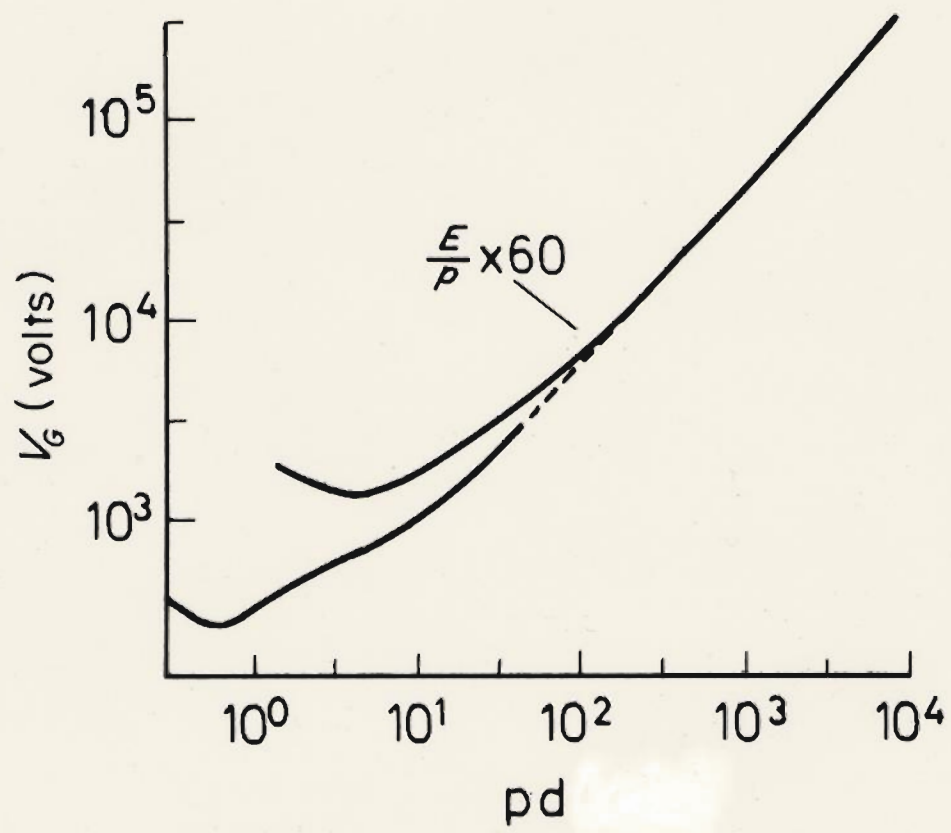


FIGURE 63

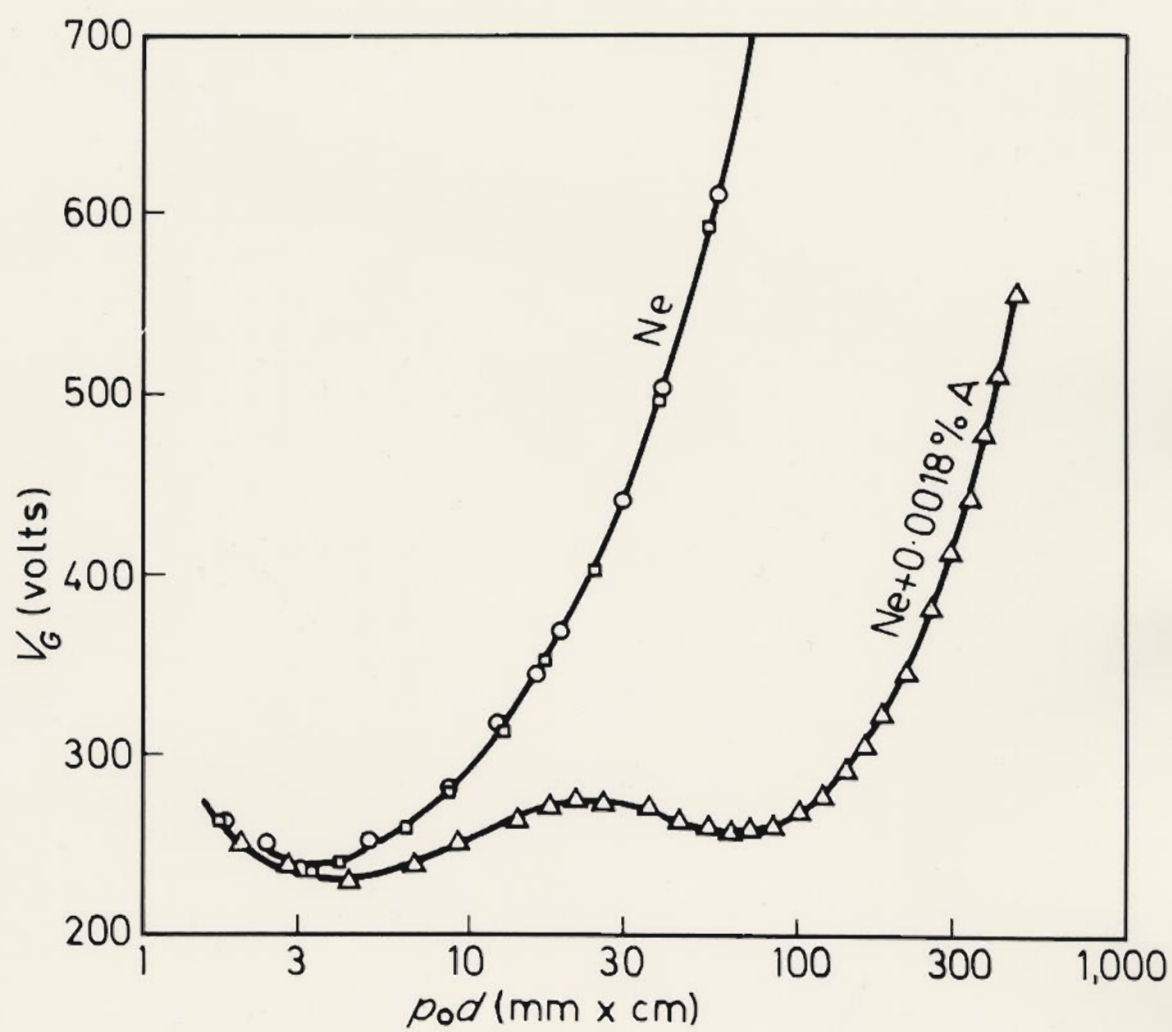


FIGURE 64

explained in the following way.

At large values of pd , the sparking potential of neon is decreased very much by a small admixture of argon because the metastable neon atoms are able to ionize the argon atoms. At low values of pd , this effect will only have a small influence; the probability for the formation of metastable atoms is not large and those that are found have a short lifetime because they return to the normal state at the electrodes. Therefore, in this region of pd , the value of V_G^* for Ne + 0.0018%A is about the same as that for Ne. At still larger values of pd , the effect of the metastable atoms becomes appreciable and V_G^* decreases until a second minimum is reached. This effect would occur, of course, only for admixtures of certain kinds of atoms.

From the foregoing, we see that discharges will occur across an air gap for applied D.C. potentials in the range $10^2 - 10^3$ volts with the optimum discharge spacing depending upon the gas pressure and, to some degree, on the chemical admixtures to the air. The minimum is about 200 volts at $pd \approx 0.6$. However, at $pd = 10$ and 10^2 , $V_G^* \approx 1500$ V and 9000 V respectively ($d \approx 130\mu$ and 1.3 mm respectively). We must also anticipate a shift of V_G^* with frequency. Meek and Craggs⁽³³⁾ report that for point-plane electrodes, the breakdown voltage decreases by 50% as the frequency of the field increases from 50 Hz to 10^6 Hz. In addition, V_G^* will depend upon the shape of the electrodes. If we consider the point-plane configuration, the local electric field at the point will increase as the radius of curvature of the point decreases and the critical electron avalanche can be more easily obtained so that V_G^* will decrease for sharply pointed electrodes.

The sequence of events involved in the development of spark channels depends

very greatly on the percent overvoltage applied to the gap. Marked visual differences exist between the various phases of development in the low ($\approx 1\%$) and highly ($\sim 15\text{--}50\%$) overvolted gaps. These differences stem from the fact that, at low percent^{over-}voltage, both primary and secondary electron avalanches contribute to the growth of current whereas, at high overvoltages, high amplifications can be produced in a single avalanche which then change the luminous appearance of the spark channel as it develops⁽³⁴⁾. We are primarily interested in the "streamer" domain which occurs at low overvoltages. Here, the early stages of current growth between plane parallel electrodes may be understood in terms of the superposition of succeeding generations of avalanches. At voltages fractionally below that required to produce a spark, a diffuse visible glow has been observed at more or less stable currents of about $1\mu\text{A}$. Even with moderate overvoltages, dynamic studies have shown that the current may remain diffuse to quite high current levels ($\sim 100\text{A}$ in N_2) before a filamentary spark channel is formed. Figure 65 shows a comparison between the current growth in air at atmospheric pressure measured by Bandel⁽³⁵⁾ and the theoretical curves computed by Ward⁽³⁶⁾. The very prominent influence of overvoltage on the discharge current at fixed time is clearly seen. For the Kirlian application, higher discharge current translates into higher light production and thus more intense exposure of the film. Thus, for the same maximum applied overvoltage, the lower the frequency used, the greater is the time available for current growth and thus the greater is the film exposure in a single cycle.

If we look at the time dependence of the applied voltage V and the discharge current I , then if we have only 0.5% overvoltage at V_{max} , the discharge current is flowing for only about 1% of the cycle period and thus, during the time $t_1\text{--}t_2$, the

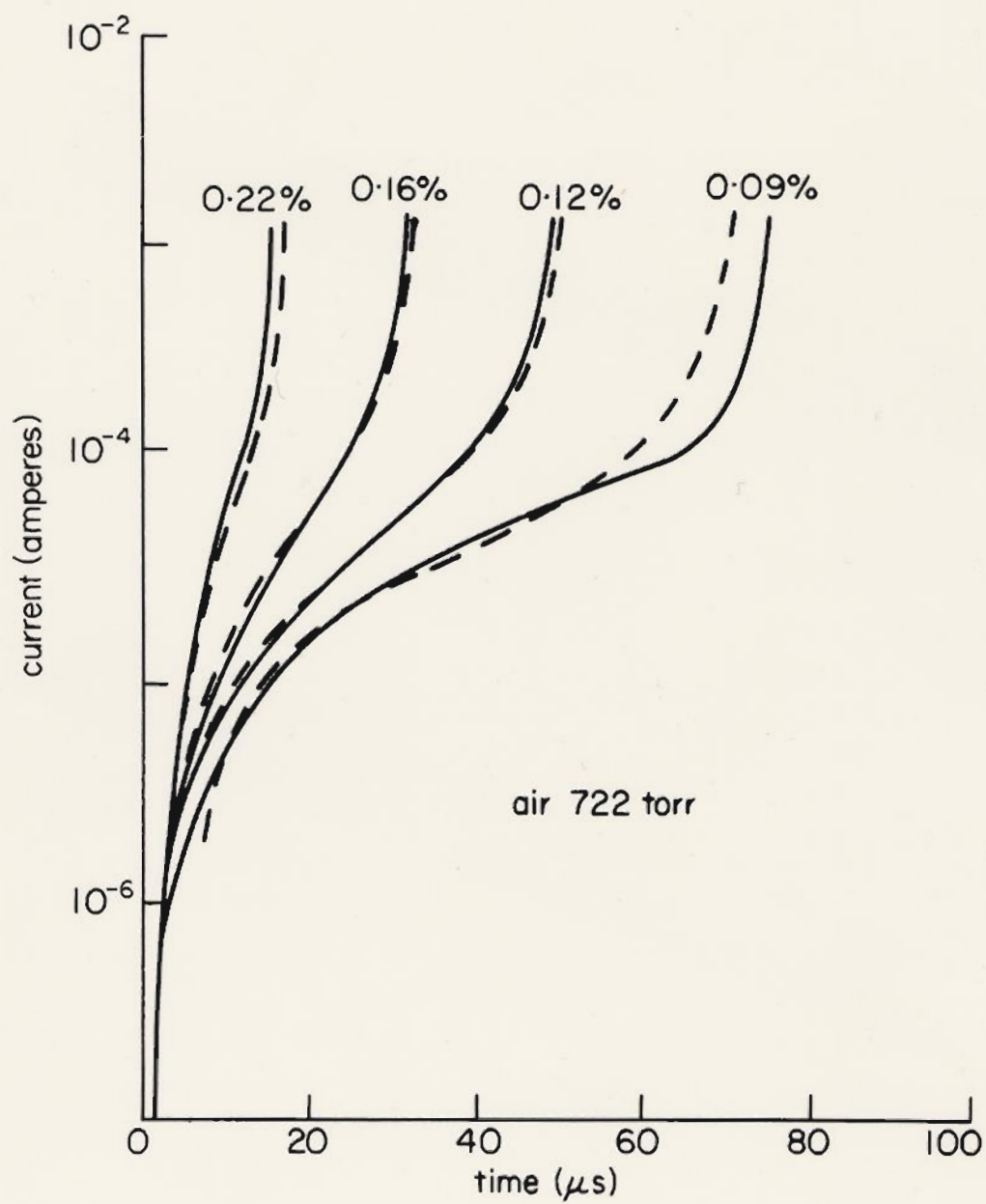


FIGURE 65

average current flow will be about 10^2 times that read on an ^{averaging} ammeter in the circuit. One can readily observe this fractional discharge sequence with oscilloscope techniques. Finally, from Figs. 65 and 66, we should anticipate that, during the discharge phase, the average current flow in air at 1 atmosphere will probably be in the range 10^{-4} to 10^{-2} amperes.

Finally, we are ready to ask the questions (1) is it possible for the physiological state of the subject to meaningfully influence the discharge process, (2) if so, how can one maximize this influence in terms of power source characteristics and (3) how can one minimize this influence?

Obviously, from Fig. 61, the physiological state of the subject can meaningfully influence the discharge process only when the voltage developed across the subject can significantly affect the overvoltage on the gap; i.e., when $I Z_S / V_G^* \lesssim 10^{-2}$. We know V_G^* and I to some degree, let us now evaluate Z_S . As shown by a number of investigators, biological tissues may be represented electrically by an equivalent network which is shown in its simplest form in Fig. 67. The leaky condenser, which is symbolized by C and R_2 , is a function of the polarizability of the living tissues due to the properties of the cell membrane. R_1 , the internal resistance of the organism, may be measured with a high frequency alternating current where it is found to be small relative to the effective resistance at low frequencies. A simple procedure is the transient current measurement method ^{described by Tregear⁽³⁷⁾ and Motoyama⁽³⁸⁾} wherein a 3 volt battery is imposed across the tissue and the current monitored to yield the type of result given in Fig. 68. Analysis yields

$$i_0 = V/R_1 \quad ; \quad i_\infty = V/(R_1 + R_2) \quad ; \quad \tau = R_1 R_2 C / (R_1 + R_2) \quad (1)$$

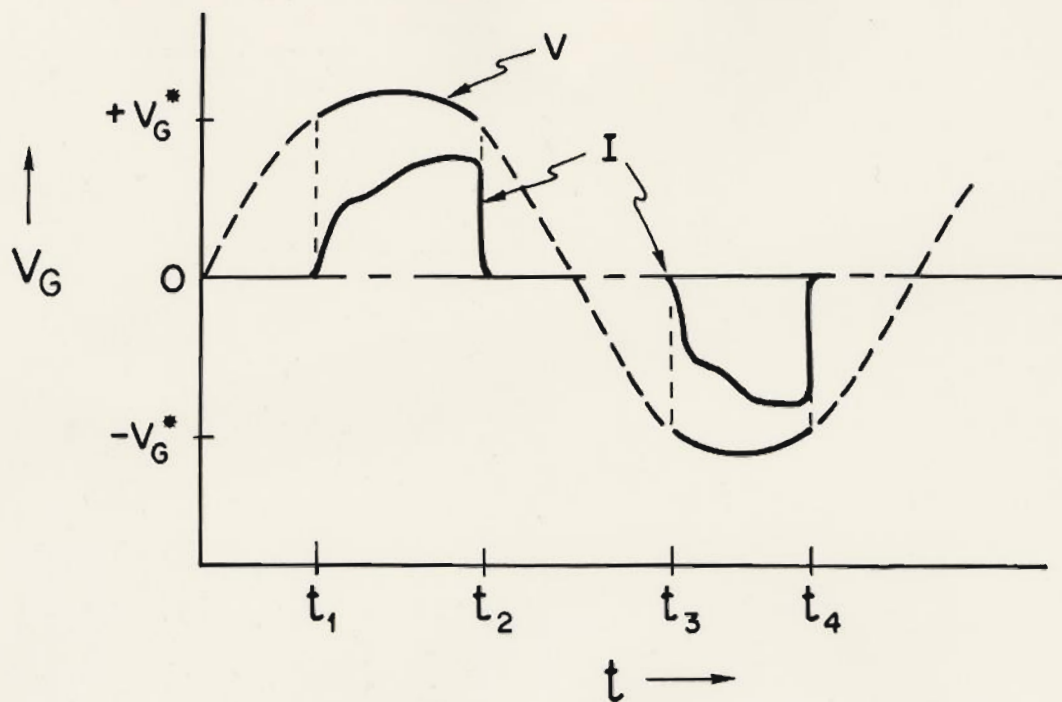


FIGURE 66

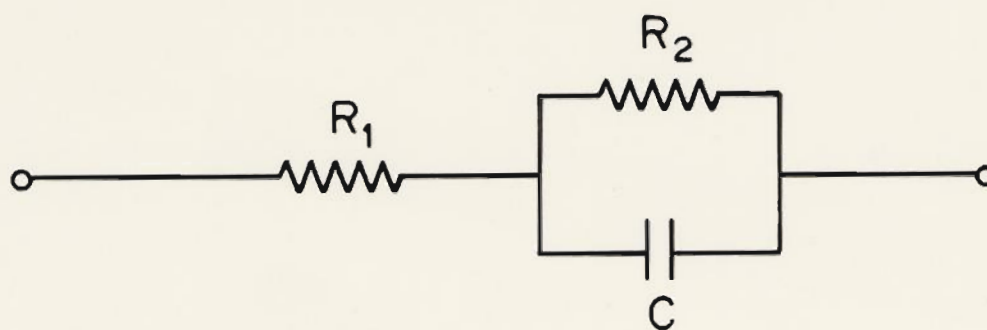


FIGURE 67

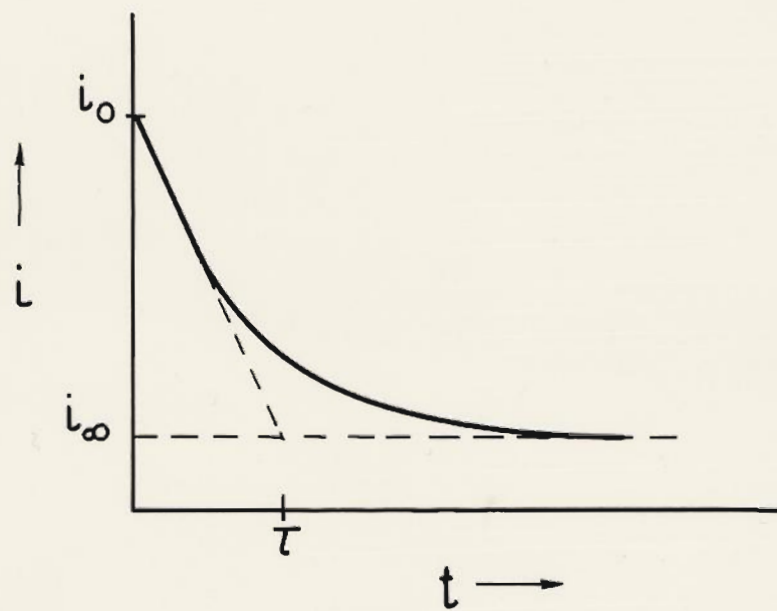


FIGURE 68

Motoyama⁽³⁸⁾ found these values of R_1 , R_2 and C to vary with the age of people and with seasonal conditions (children have a greater value of C and a smaller value of R_1 such that $\tau_{\text{children}}/\tau_{\text{adults}} \sim 50$. Measuring from the ends of the acupuncture meridians on the fingers and toes to a common large electrode on the wrist, he found $R_1 \approx 2K\Omega$, $R_2 = 45K\Omega$, $C = 4 \times 10^3 - 6 \times 10^3$ pF.

For practical purposes, therefore, living tissues behave at low frequencies like a condenser and resistance in parallel. During the psychogalvanic reflex, the resistance of the skin drops and this change can be readily measured with a direct current. The associated change in impedance depends also upon the behavior of the condenser which is still a subject of dispute. Various estimates of the skin capacitance put it in the region, $C \approx 0.005 - 0.03 \mu\text{F}/\text{cm}^2$ for the skin of the forearm and hand and values of R_2 range between 25×10^3 and 10^6 ohms. In one study⁽³⁹⁾, the impedance of the human skin was found to decrease from approximately $130 \times 10^3 \Omega$ to $30 \times 10^3 \Omega$ as the frequency of the input was increased from 1 to 10^3 Hz. Over the same range of frequencies, the phase angle, δ , changed from -2 to -58 degrees. In addition, changing the peak to peak current through the subject from 14 to 62 μamps had no effect on either the impedance of the skin or the phase angle. This range of values of R_2 and C lead to resonant frequencies in the range 1 KHz - 50 KHz ($\omega = 1/R_2C$). Thus, as pointed out by Schwartz⁽⁴⁰⁾, the skin will act as a simple RC filter. Frequencies higher than the cutoff frequency will appear as voltage drops across the resistive element R_1 of the circuit and frequencies lower than this will also appear as voltage drops across the capacitive elements. Any variation, therefore, in either the value of the skin resistance or in the body capacitance will change the impedance Z_s and may influence the Kirlian discharge if the effect is large

enough.

The skin impedance is given by

$$Z_S = R_1 + \frac{R_2}{1 + (\omega CR_2)^2} + j \frac{\omega CR_2^2}{1 + (\omega CR_2)^2} \quad (2)$$

which goes to $R_1 + R_2$ as $\omega \rightarrow 0$ ($\sim 30\text{K}\Omega$ to $10^3\text{K}\Omega$) and goes to R_1 as $\omega \rightarrow \infty$ ($\sim 2\text{K}\Omega$). In the intermediate range, $(\omega CR_2)^2$ may be smaller or comparable to unity only at $\omega \lesssim 10$ KHz and more fully in the region of 1 KHz. We may also note that, at $\omega \gtrsim 100$ KHz, $Z_S \lesssim 5 - 10 \text{ K}\Omega$ which would lead to a developed voltage of less than 10 V to 50 V for $I = 1 \text{ ma}$ during the time of current flow. Therefore, since $V_S \ll V_G^*$ during the discharge, we cannot expect changes in the physiological state of the subject to significantly influence the overvoltage of the discharge and thus be revealed by Kirlian photography. Conversely, in the frequency range 1 KHz to 10 KHz, $Z_S \sim R_1 + R_2$ so that $V_S \sim 0.1 \text{ KV}$ to 1 KV for $I = 1 \text{ ma}$ during the time of current flow and we can expect physiological state changes of the subject to significantly influence Kirlian photographs.

In addition to the foregoing, it should be noted that Z_0 is largely an inductive impedance so that Z_0 will increase as ω increases. Thus, to provide sufficient excess power for discharge in the gap, the source voltage, V , will need to increase as ω increases. This means that, the lower the driving frequency of the system, the lower the required source voltage for gap discharge and the easier is it for the subject to influence the gap discharge by changes in physiological state. However, in order to significantly alter the Kirlian photograph, there must be an appreciable change in R_2 and C ($\sim 10\% - 20\%$ change should be adequate).

VIII. TIDYING UP THE PICTURE

A. Rational Experimental Expectations Re Nonphysical Energies

By nonphysical energies, the author means (a) energies of a nonelectromagnetic, nonsonic and nongravitational variety as we know them, (b) energies that do not directly stimulate our five physical senses as we know them and (c) energies that do not propagate in the 4-dimensional space-time continuum as we know it. By this definition, the radiation pattern seen around objects and living organisms by clairvoyants and called the aura is a nonphysical energy. Likewise, that which the Soviets intend via the name bioplasma is reference to a nonphysical energy. Such radiation patterns directly stimulate a different sensory information processing system which is probably latent in all humans but reliably developed in only a small fraction of humanity at present⁽⁴¹⁾.

There are three categories of devices one may use for monitoring nonphysical energies: (a) a human being who has already developed other sensory systems makes observations with them and provides a verbal readout, (2) a living system (animal, plant or human) plus an attached electromagnetic or mechanical device such that the living system unconsciously or consciously transduces the nonphysical energies into physical correlates that input to a readout device via a purely physical path (e.g., Kirlian devices), and (3) a totally inanimate device based upon a different logic system than that which we call the physical, which acts as a transducer and a readout mechanism (nothing available in this category at present).

As the Kirlian device falls in the middle category, we should not be at all surprised (or dismayed) to find a perfectly reasonable explanation for the generation of light and for the color observations. The important and difficult step is to

prove that such observations are indeed directly correlated with energy changes in the living system rather than just random fluctuations associated with inadequate experimental technique. In the previous section, we discussed the requirements for revealing a physiological change via Kirlian but careful experiments have yet to be carried out in order to prove the point. However, since we know that the Galvanic Skin Response (GSR) is related to some similar physiological changes of the skin and is the basis for polygraph investigations, we might anticipate a successful outcome of such carefully conducted Kirlian experiments.

B. Some Living Organism Modulation Mechanisms of the Streamer Process

To move forward and reliably identify psychoenergetic effects via high-voltage photography, we must monitor those parameters of the system that can directly influence the "streamer" process. These appear to be at least five-fold:

(1) A change in the electrical impedance of the skin or the surface membrane of a plant, as discussed in the previous section, may appreciably alter the amount of current flowing during the discharge so that the generated light intensity would also be altered and the Kirlian photograph noticeably changed. It is well known that these impedance factors vary appreciably with changes in emotional and mental states. This is perhaps the main factor influencing the discharge process.

(2) A change in the electrostatic potential, ϕ , of the skin will lead to a change in the half-cycle voltage difference between the skin and the driving electrode. Thus, if the fingerpad has a positive surface potential of 500 volts and the amplitude of the driving voltage is 1000 V, the voltage difference will swing from -1500 V to +500 V. Streamers will very likely be generated only on the negative

half-cycle yielding the Lichtenberg figures (Fig. 4, left) characteristic of the +ve point and -ve plane configuration. If discharge also occurs on the positive half-cycle, then the negative discharge figures (Fig. 4, right) will also form in the domain close to the fingerpad (see Fig. 44). Such changes in the positive and negative voltage swings affects the maximum possible light-emitting streamer length (increases linearly with ΔV) which determines the width of the corona around a fingerpad, for example. Since we know that emotional changes in the human organism can increase the skin potential by up to 500 percent, this effect should be noticed in the relative widths of negative and positive halos and in the brightness of those halos provided that the skin potential change is sufficiently large. As a type of supportive information for this kind of effect, we know that electrostatic potentials of about 5,000 to 10,000 volts may be discharged on metallic objects, like doorknobs, after one has walked on certain carpets when special atmospheric conditions prevail. We must also be cognizant of the fact that the flow of discharge current through the skin may alter the prevailing value of ϕ via the trapping of carriers in different energy states within the skin material.

(3) As a result of mental or emotional state changes in the organism, one may expect to find a change in the surface chemistry of the skin or surface membrane. This effect may give rise to electronegative ion type effects which would alter the morphological character of the discharge (see Figs. 12-14). It should be noted that small electrical arcs can create hot spots on a metal electrode as much as 2000°C higher than the ambient temperature; thus, we should not be too surprised if the corona discharge produces a sufficient hot spot to evaporate and ionize organic molecules from biological specimens. We might expect to find weak color

radiation arising from the excitation of these molecules; however, these colors are unlikely to be seen distinct from the background of intense streamer color unless there is a confined space and the baked-off hydrocarbon concentration is large. If the Soviets carried out their experiments in the $\omega > 75$ kHz range, perhaps their data was largely due to this effect. In fact, they probably work in this region so as to avoid any artifacts associated with the skin impedance channel in the ~ 10 kHz range.

(4) There will be a geometrical induced-field effect due both to the shape and to the polarization of the skin or membrane surface which may lead to certain types of diffraction effects resulting from the spatial and temporal variation of the dielectric properties of the skin. Thus, a perturbation of the local ΔV in the gap should occur as a result of their dielectrically generated phase-angle effects. Changes in average dielectric properties of the skin, via changes in water content, for example, will have the same effect as a shift in the spacing between the electrodes. As the average skin dielectric constant increases, the ratio of the voltage developed across the gap to that developed across the skin must increase ($\epsilon_S E_S = \epsilon_G E_G$). Since skin is strongly piezoelectric, an electrical stimulus in the proper frequency range will generate a mechanical stimulus and vice versa. Certainly, mechanical noise in the high audio range is heard during the discharge. The coupled cellular resonance (mechanical) is probably in the low kHz range so this is probably another justification for driving the electrical system in the 1-10 kHz range.

(5) As discussed in the early portion of this article, conventional secondary emission events due to impacting photons, ions and electrons will lead to photoelectron and secondary electron emission which greatly influence the overall avalanche process and thus the degree of streamer light emission. Changes in mental or emotional states should change the electron density of states, $N(E)$, in the finger and thus should reveal itself via an alteration in the electrode injection rate of electrons.

As an example, one should be able to get some idea of this density of states curve by operating the transparent electrode system such that $V_G \approx V_G^*$ by a small amount. By shining ultraviolet light through the electrode and into the fingerpad, photoelectron emission may be sufficiently stimulated to trigger streamer formation. This photoelectron yield will tell us about the $N(E)$ curve. Of course, we may find this technique to be just as or more effective at much lower voltage where streamers will not be generated by monitoring the change in discharge current with a meter as both the frequency and the intensity of the U.V. light are changed.

C. Is Discharge Formation Behind the Film a Random Event?

Many investigators have placed unique importance on the presence of red blotches or other non-blue colors in their Kirlian photographs (see Fig. 32). The author and his coworker, D. Boyers, have shown that such colors arise primarily as a result of the electrical discharge occurring between the driving electrode and the back side of the film. The important question to be answered here is thus, "Are such discharges purely random events due to the presence of small air gaps between the electrode and film; are they due to involuntary pressure changes on the fingerpad or are they perhaps associated with a real physiological change in the subject?". It is clearly possible that some of these events could be associated with random chance and inadequate finger control; however, the remarkable coincidence of some of these events suggests that this explanation is insufficient and that we should look further.

From the study of "Sentics" by Clynes⁽⁴²⁾, a quantitative correlate of emotional expression has been monitored through normalized expressive touch using a specially designed touch transducer system. For the measurement of essentic form, two strain gauge pressure transducers were mounted at right angles to one another. The

transducers were mounted through an independent suspension design, so as to have no cross interference, and movement of the transducers was less than 0.001 inches. The pressure transducers were coupled into an FET high impedance input stage providing a frequency response essentially D.C. to 50 Hz. A special plastic touch surface which is "grey" to the touch was provided; i.e., it did not cause either tactile pleasure or irritability. In Fig. 69, essentic forms are present for several emotions (the upper trace for each emotion is the vertical component of transient pressure whereas the lower trace is the horizontal component at twice the scale). Clynes⁽⁴²⁾ states that in each case, the brain algorithm programs of emotion states are highly precise, as are the natural communication of these expressive forms in real time. However, the ensuing physiologic responses may vary according to how much and what type of autonomic body functions are permitted to be included in the mode of experience concerned.

From the foregoing, it seems quite likely that subtle changes of finger pressure will be associated with altered states of consciousness of a Kirlian subject, but is the effect large enough to account for the effects observed? Only further research can tell whether effective load changes of ~ 200 gm (see Fig. 69) on the fingerpad in either the vertical or horizontal directions could produce a sufficient gap behind the film for initiation of a discharge at that location rather than at the emulsion side of the film. From the impedance change of the system with finger pressure data of Dakin⁽²⁴⁾, taken at 10 KHz, we note that a relatively steep and a relatively flat portion exists in the curve (see Fig. 70). Thus a region of insensitivity and sensitivity is expected to exist.

To see how the physiological state of the subject might influence the back side discharge, we must consider the governing constraints involved. These appear to be threefold and arise from (i) Paschen's law, (ii) Kirchhoff's voltage law and (iii) conservation of electric flux, respectively; i.e.,

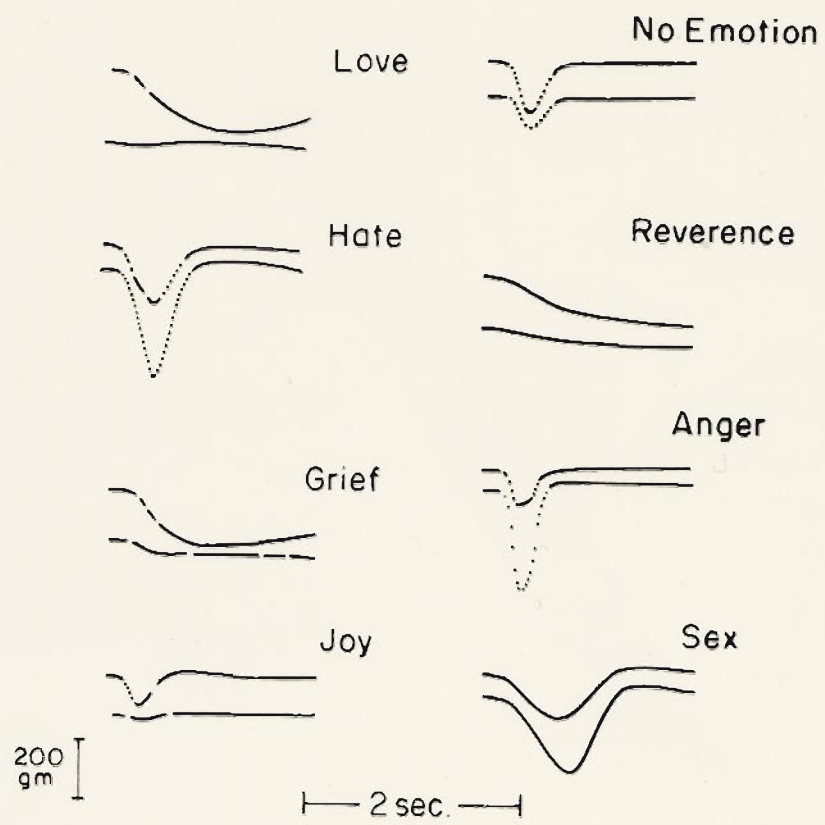


FIGURE 69

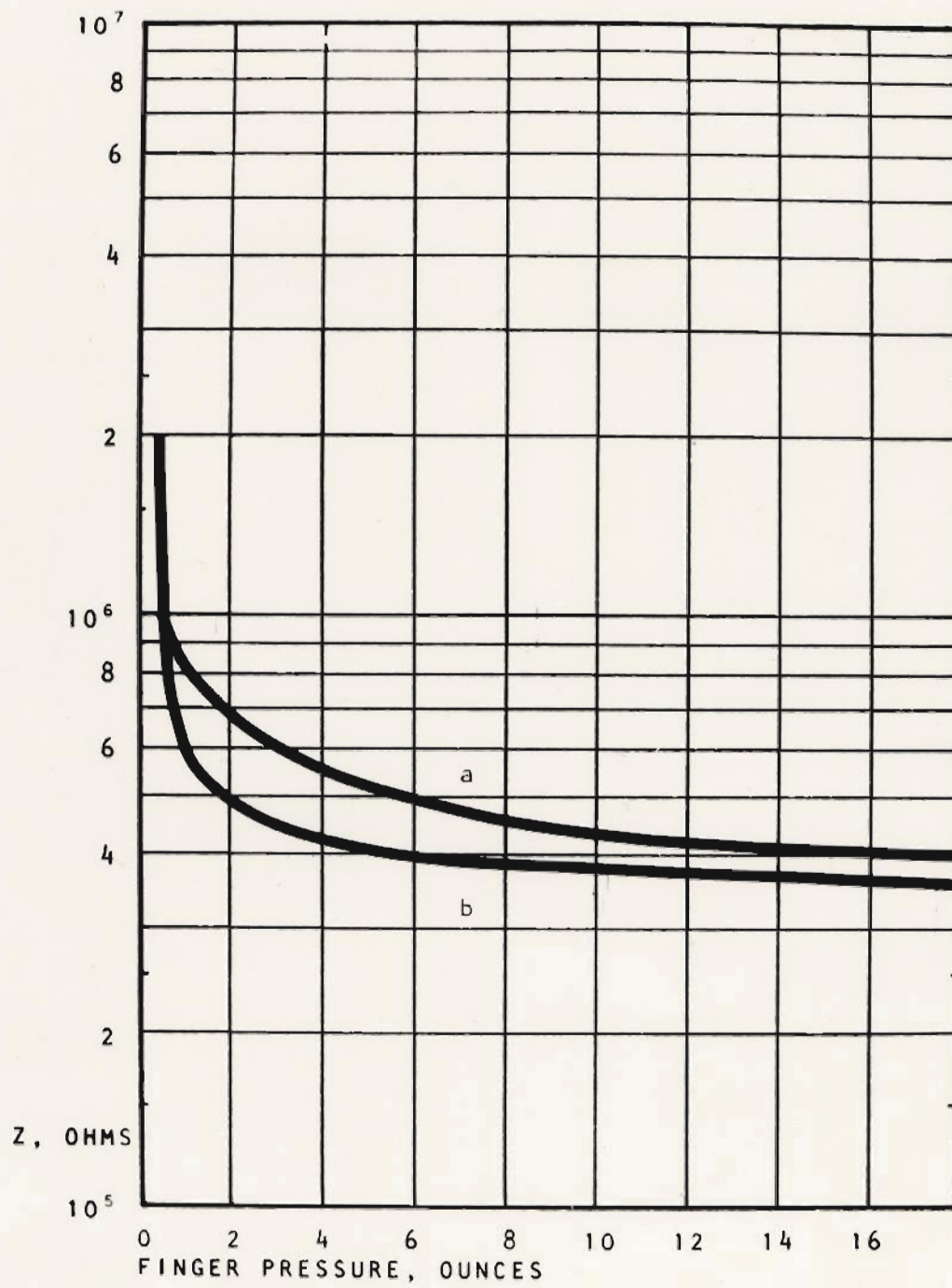


FIGURE 70

$$V_G^* = f(pd) \quad (3)$$

$$V = IZ_o + IZ_f + IZ_S + V_G \quad (4)$$

and

$$\epsilon_S E_S - \epsilon_G E_G = \rho_S \text{ or } \epsilon_f E_f - \epsilon_G E_G = \rho_f \quad (5)$$

p is the gas pressure,
Here, d is the gap spacing over which the discharge occurs, ϵ is the dielectric constant, ρ is the surface charge density and subscripts S, G and f refer to skin, gap and film, respectively. The last equation expresses that the normal component of the flux density changes at a charged boundary between the two dielectrics by an amount equal to the surface charge density. We can utilize the approximate relationships

$$E_S \approx \frac{V_S}{\ell} = \frac{IZ_S}{\ell} \quad \text{and} \quad E_G \approx \frac{V_G}{d} \quad (6)$$

where ℓ is the thickness of the skin. Thus, for fixed V , ω and ρ_S or ρ_f , I is fixed for a given V_G . For this same V_G , d is fixed via eq. 3 and, from eqs. 5 & 6, the choice of V_G is given for a particular value of ϵ_S . In a particular case, the discharge initiates with $V_G = V_G^* + \Delta V$ and I grows according to Fig. 65 until V_S becomes comparable to ΔV and I levels off at some optimum value that allows the discharge to be maintained. We can expect that the human condition is manifested via a particular value of ϵ_S and ρ_S (or ρ_f via charge transfer) so we have three equations to solve for the three unknowns d , V_G and I . Because a band of driving frequencies, $\Delta\omega$, usually exists, a range of gap widths, Δd , are selected for the discharge domain. If ρ_f is large and negative then, from eqs. 5 and 6, E_G is large and d must be very small

for the discharge which can thus^{only} occur behind the film in a small gap which may exist there. At the emulsion side of the film, if ϵ_S increases (e.g., higher water content) and ρ_S decreases, the d must likewise be very small and must occur under the fingerpad portion which contacts the film or in close proximity to this juncture. For the reverse situation, the discharge must occur at large values of d . At this juncture, it at least looks possible that these non-blue color effects have a precise physiological correlate. Such a correlation may prove to be of considerable future value if this possibility can be experimentally validated.

Before leaving this subsection, it is useful to comment on those few observations wherein no discharge pattern is seen on the film for a particular subject (see Fig. 33h). This must be a case where conditions obtain to yield $V_G < V_G^*$ so that the Paschen's equation is not satisfied for the range of d available and the onset condition for streamer formation is not attained. Several possibilities or combinations thereof exist for rationalizing such behavior, (a) ϕ decreases so that $V_G + \phi < V_G^*$ for both half cycles implying that large ϕ is the normal case and discharge usually occurs only on one half cycle rather than on both, (b) the skin impedance Z_S increases greatly (perhaps due to loss of skin moisture) so that V_S increases greatly even for I less than the streamer onset and V_G never reaches V_G^* , (c) the skin exudes a chemical leading to many electronegative ions which scavenge electrons so that the avalanche is never able to reach the level where streamers form; i.e., V_G^* increases, (d) ϵ_S decreases and/or ρ_S increases so that V_G decreases to values less than V_G^* for all suitable values of d and no light generation occurs, or (e) if the basic power supply has a small V and a small Z_0 , then changes in Z_S might cause important changes in ω such that V_G is reduced to a value less than

V_G^* ; i.e., if ω increased sufficiently, Z_0 would increase and V_G must decrease.

To account for Fig. 28 and its mirror image having morphological forms like those of Fig. 26a, we must recall the streamer mechanism. Here, we shall think of the streamer as a light-emitting plasma channel which is growing towards both plane electrodes but with the streamer tip being highly electron-rich at the anode end and highly positive ion-rich at the cathode end. Thus, at the one end we have a positive point-negative plane potential condition which leads to the characteristic Lichtenberg figures of Fig. 4a and Fig. 28. At the other end, we have the negative point-positive plane potential condition leading to the soft discharge figures of spherical form shown in Fig. 4b and Fig. 26a. These microforms are localized on the main structural points of the streamer cluster so that a true mirror image occurs on a macroscale level with positive and negative discharge points occurring on a microscale level.

D. The Phantom-Leaf Effect

Although a number of investigators in several countries have reproduced the phantom-leaf effect, this author has only recently seen a respectable picture of the phantom leaf that cannot be attributed to artifact associated with inappropriate experimental protocol. In the past, no one took a fresh leaf, cut a portion away and then carefully placed it in the device for photographing--and ultimately obtained a clear leaf-like pattern on the film in the region of the cut segment. The general procedure was to either (a) place the whole leaf on the film and cover it with a glass plate to weigh it down for ~ 1 to 30 minutes, then carefully remove the glass plate without disturbing the leaf and then carefully cut away a portion of the leaf without moving the rest of it on the film. The upper glass plate may then be replaced and a Kirlian photograph taken. Often

the phantom leaf appears but this can be readily attributed to either chemical sensitization or electrostatic sensitization of the film; (b) a glass plate is first placed on the film and then the whole leaf is placed on the glass plate and covered by a second glass plate for ~ 1 to 30 minutes. Then the procedure followed is the same as in (a). In this case, the Kirlian photography may also show the phantom effect but again this must be considered as artifact because we now have an electrostatic and chemical imprinting of the electrostatic charge pattern from the leaf onto the glass plates. This electrostatic charge pattern strongly influences the location of the electrical discharge channels when voltage is applied to the system (just as in the xerography process as suggested by Miller⁽⁴³⁾); (c) in different variants of these two techniques, a very short discharge is applied to the system (below photographic exposure threshold) which sensitizes the film with a leaf-like charge pattern. Once again we have the xerography type process in operation.

As a teaching example, we might consider the configuration given in Fig. 71 to illustrate the type of phenomenon that may arise during the discharge process. We will assume that a fresh leaf with all its surface chemicals and charge pattern intact was first placed between the two thin glass plates before cutting a segment of the leaf away. Continuous application of voltage pulses will first lead to a discharge over both the intact leaf and the absent portion if V is sufficiently large. In the absent portion, the discharge will occur from the preferential pattern of transferred chemistry and charge. With the passage of time, the charge buildup on the different glass plates will cause V_G to decrease below V_G^* on the cut-away portion and the discharge will cease in that region. If we wait long enough, this impeding charge buildup will leak away and V_G in that region will again increase above V_G^* so that discharge can again occur and

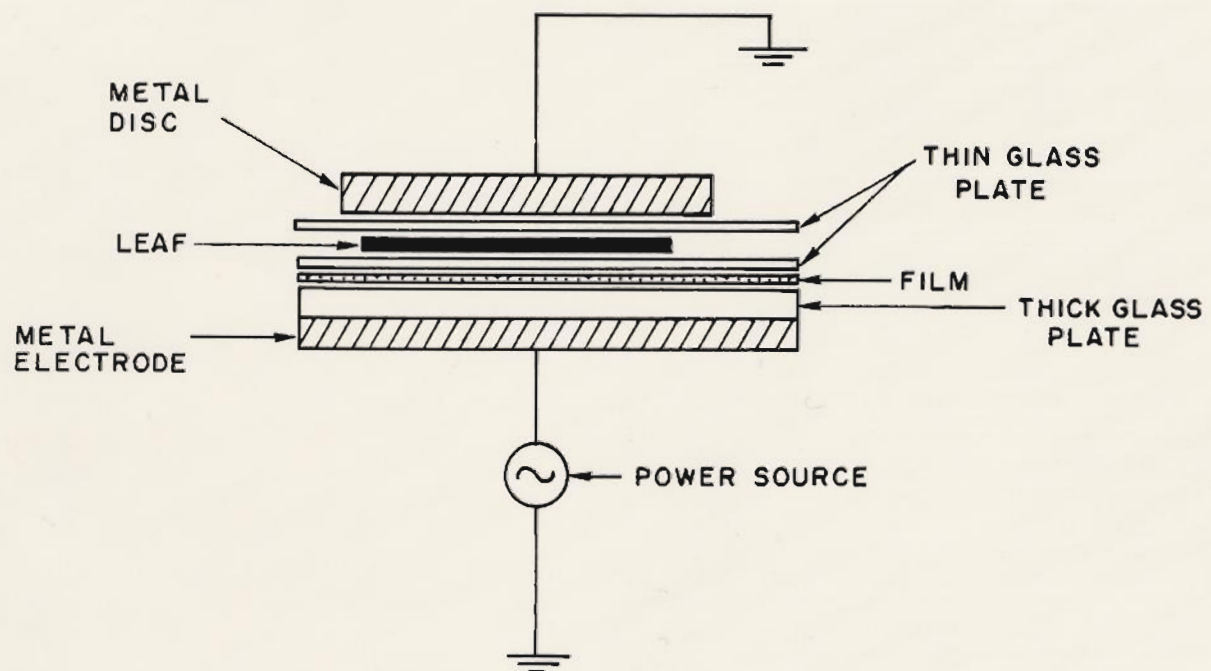


FIGURE 71



FIGURE 72

outline the absent portion of the leaf until sufficient charge buildup occurs to again extinguish the discharge in this region. Thus, a cyclic reappearance and disappearance of the phantom leaf effect is expected. For a humid and somewhat ionized atmosphere, the charge leakage rate should increase and the time between pattern disappearance and reappearance should decrease. Of course, the chemical template of leaf remains intact on the glass surface. This charge buildup process has considerable implications for the problems discussed in the previous subsections!

Recently, this author has seen some videotape results by Dr. Moss and her coworkers and also a sheet film result by Mr. R. Wagner⁽⁴⁴⁾ which, as stated, utilized acceptable protocol. In both cases, the phantom leaf could be seen (see Fig. 72). Light patterns were seen to occur in the cutaway portion but they were of distinctly different quality than those in the remaining leaf region. The videotape results strongly suggested ionized gas emission from the solid leaf (probably due to vaporization by the arc channels) into the adjacent space which then allowed some streamer discharges to occur there. Curiously, these discharges stayed reasonably well confined by the outer envelope of the original whole leaf in both the videotape results and in Fig. 72. Perhaps a type of mechanical resonance develops in the remaining leaf setting up constraining waves in the adjacent air to confine the vapor emissions largely within the original leaf envelope.

This phenomenon is likely to be most prevalent with young leaves in spring-time because that is when they have a high ion and fluid content (and perhaps also special chemicals that support this type of process).

IX. FUTURE POTENTIAL

It is interesting that the inexpensive Kirlian devices that are so popular

in this country operate in the appropriate frequency range for revealing a physiological correlate of the living system. It is unfortunate that the power source is sufficiently erratic that the output voltage spectrum fluctuates sufficiently in both amplitude and frequency that they are inherently unreliable for serious research studies. However, we now seem to know enough about the overall process to design reliable power supplies with the optimum characteristics for obtaining useful physiological information about living systems. Although much of the real information displayed in the Kirlian photographs can be obtained using alternative techniques, it is quite likely that the pattern information can be uniquely useful once we have gathered more well-controlled study data. This author is now optimistic about the future usefulness of Kirlian photography.

This high-voltage photography technique utilizes a very complex process that will be its strength when used by knowing hands and its weakness when the opposite condition prevails. It will require very sophisticated instrumentation for its control and for its effective utilization as a life-energy monitoring system. Once sufficient background work has been carried out, it should be possible to (a) develop an early warning system of growing pathology in living systems, (b) develop a reliable monitoring system for revealing the physical, emotional and mental tone of human beings, (c) develop systems for determining the peak conditions of participants in critical team activities, (d) develop a fatigue device useful for industrial operations, (e) develop what could be called a "thermometer" for psychiatrists who are sorely in need of an objective standard and (f) develop monitoring devices that reliably register cause-effect relationships associated with nonphysical energies, etc. Similar types of information can be gained by

monitoring animal, plant and other living systems.

We must eventually develop high-voltage photography devices that control and vary the applied voltage, pulse duration, pulse repetition rate, R.F. under the pulse, electrode spacing, gas chemistry, etc. In addition, we will need to independently monitor the discharge current, dielectric properties, plus skin chemistry and capillary blood flow, if possible. In this way, we should be able to eventually develop a reliable and useful life-energy monitoring device that will be of great utility to the life sciences.

At the moment, Kirlian photography does not constitute a diagnostic instrument of living system pathology and perhaps it never will. However, it promises to be very useful as a physiological state monitor and is of sufficient complexity that a variety of unanticipated benefits may be forthcoming.

Acknowledgements

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Table 1

Means, Standard Deviations, and t Value Comparisons of
Mutually Liking and Mutually Disliking Couples

<u>Description of Conditions</u>					
Number of Pairs	Sex of Pairs	Types of Pairs	Mean	S.D.	$\frac{t}{\text{Ratio}}$
10	Males	Most liked each other	6.08	.62	11.22***
10	Males	Least liked each other	3.01	.60	
10	Females	Most liked each other	6.30	.50	12.62***
10	Females	Least liked each other	2.37	.84	

<u>Comparison of Halo Scores of All-Female, All-Male, and Heterosexual Groups</u>					
N (in pairs)	Type of Group	Mean	S.D.	$\frac{t}{\text{Ratio}}$	
10	Heterosexual	5.51	.58	2.37*	$\frac{t}{\text{Ratio}} = 6.44***$
10	All Males	4.80	.74	4.65**	
10	All Females	2.57	1.32		

* $p < .05$

** $p < .01$

*** $p < .001$

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Figure Captions

1. Schematic illustration of electron avalanche process.
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33. Before--left; After--right

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(Courtesy of D. Sheinkin and M. Schacter)

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(c) Photograph of fingertip; multiple pulses, pulse width = 100μ sec, rep. rate = 20 Hz, duration $\sim$ 2 sec. (4 x mag)
(d) Photograph of fingertip; single pulse, pulse width = 100μ sec, rep. rate = 1 Hz. (3 x mag)
49. Photographs of a single 500 microsec discharge between flat polished brass electrodes. Left: concentric electrodes. Center: non-concentric electrodes. Right: non-concentric electrodes with local film buckling.
50. Changes in discharge pattern from metallic electrode due to d and τ variation: (a) $d = 400\mu$, $\tau = 2$ msec; (b) $d = 400\mu$, $\tau = 8$ msec; (c) $d = 600\mu$, $\tau = 4$ msec; (d) $d = 800\mu$, $\tau = 4$ msec. (1 x mag)
51. High-voltage discharge traces showing marked curvature at a gap spacing of 1.0 mm (metal electrode, 4 msec, 3 x mag).
52. Exposure of film via light produced by the electrical discharge in air gaps between both film and finger and film and metal electrode.
(a) Only film-finger air gap discharge--produces ultraviolet light exposing film from front side leading to blue color.
(b) Only film-metal electrode gap discharge--produces ultraviolet light exposing film from back side leading to red, orange and yellow colors.
(c) Discharge through both gaps--produces uv light exposure of both sides of film leading to magenta, pink or white colors.
53. Simple model of color film construction illustrating the effects of uv

53. (cont'd.)

light entering either the front or the back side of the film. Dot (·) indicates emulsion is exposed by the radiation.

54. Exposure of film from front and/or back side with an uv light source. Analogous to Fig. 52.

(a) Exposure of film from front side leading to blue color.

(b) Exposure of film from back side leading to red, orange, or yellow colors.

(c) Exposure of film from both front and back side leading to magenta, pink, or white color.

55. Composite color print.

56. Functional diagram of the transparent electrode device.

57. Side view of portable high-voltage photographic apparatus, showing

(a) 28 VDC, 3 A power supply; (b) 20 kVAC, 2 mA, 100 kHz power supply;

(c) internal control panel; (d) external (operator's) control panel;

(e) high-voltage transformer; (f) camera; (g) transparent electrode assembly and object positioning control.

58. (a) Circuit diagram of the 20 kVAC, 2 mA, 100 kHz power supply for high-voltage photographic apparatus.

(b) Circuit diagram of the 28 VDC power supply.

59. Fingerpad images associated with repeated replacement of finger in finger holder at fixed spacing.

Single pulse exposure; 9 msec pulse width.

Top: Exposures 1, 3 for first setting at -10 set spacing

59. (cont'd.)

Middle: Exposures 6, 8 for first replacement at -10 set spacing

Bottom: Exposures 11, 13 after second replacement at -10 set setting.

60. Fingerpad images illustrating the electrode spacing effect--spacing decreased 125 μ between each exposure from top left moving right, etc. Single pulse exposure; 9 msec pulse width.

61. Impedance circuit of Kirlian photography system.

62. Effect of primary and secondary circuit coupling on circuit Q and circuit impedance, Z, as a function of frequency f.

63. Experimental (lower) and calculated (upper) curves showing the relationship between breakdown voltage, V_G^* , and pd for air.

64. Plot of V_G^* versus pd for Neon and Neon-Argon mixture. (Courtesy of F. M. Penning⁽³²⁾)

65. Comparison of current growth in air for various overvoltages obtained experimentally (----) by Bandel⁽³⁵⁾ and calculated by Ward⁽³⁶⁾. (Courtesy of S. C. Haydon⁽³⁴⁾)

66. The gap voltage, V_G , and discharge current, I, as a function of time indicating that significant current flow occurs only when V_G exceeds the critical voltage V_G^* .

67. The equivalent electrical circuit for skin.

68. Schematic plot of current decay associated with the abrupt application of a DC voltage to the equivalent circuit of Fig. 67.

69. Essentic forms of emotions; upper trace for each emotion is the vertical component of transient pressure; lower trace is the horizontal component (at 2 x scale).

70. Variation of electrode-insulator-finger impedance $[Z = (R^2 + X^2)^{1/2}]$ at 10 kHz with finger pressure. Curves (a) and (b) show two separate measurements, with different fingers. made with a Hewlett-Packard type 4800A Vector Impedance Meter, with 0.005 inch acetate film as insulator, and postage scale supporting electrode-insulator assembly to measure the pressure of a finger pressing down on the insulator. (Courtesy of H.S. Dakin)
71. Configuration of film and glass plates in an idealized phantom-leaf experiment.
72. Phantom leaf example using spring ivy leaf and proper experimental protocol. (Courtesy of R. Wagner)