UNIVERSITY OF WISCONSIN-MADISON

DEPARTMENT OF ELECTRICAL
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February 12, 1976

Mr. Neil P. Zylich
Hazard Analysis Engineer, BES
Consumer Product Safety Commission
5401 Westband Avenue, Room 918
Bethesda, Maryland 20207

Dear Mr. Zylich:

I have completed my analysis of the information you sent me with your letter of February 4 concerning the Taser Public Defender electric gun. The primary emphasis in my study was to determine whether the Taser electrical output can be lethal. I did not deal with other possible hazards that would probably be non-lethal such as electrical burns or physical injury caused by the darts.

The electrical output for a device is a function of the load on that device. The Taser output was tested with resistance loads of 200, 500 and 1000 ohms as well as higher resistance loads. I performed none of these tests but have evaluated the test results. With the Taser darts fully inserted into tissue, the exposed dart area per dart would be about 5.5 mm^2. Geddes and Baker show impedances between pairs of needle electrodes to be approximately 1000 ohms for 5.6 mm^2 exposed area electrodes and approximately 300 ohms for 73 mm^2 electrodes. [L.A. Geddes and L.E. Baker, Principles of Applied Biomedical Instrumentation. New York: John Wiley, 1975, pg. 248.] Since the Taser electrodes have barbs and are forcefully inserted, it would seem that local trauma would increase the effective area of the barb and thus decrease electrode resistance to the 200 to 1000 ohm range.

Tests were conducted to determine the Taser output into 200, 500 and 1000 ohm resistive loads. The output consisted of a train of damped sinusoids with a frequency for the pulses of 13 Hz. One possible means for evaluating the safety for the Taser output is to compare the output to the output of a device that provides shocks that are considered safe for humans. Appendix F supplies a summary for the maximum output for an electric fence controller into a 500 ohm load as specified by Underwriters Laboratories. It is seen that pulses with an energy of approximately 90 mJ per pulse is maximum. The maximum pulse repetition rate is about 1 Hz - off period must be greater than 0.75 seconds. In Appendix A, the energy per pulse for the Taser was calculated for 200, 500 and 1000 ohm loads. The results were:

R_L (Ω)	W (mJ)
200	53.6
500	102.2
1000	140

Thus, the Taser output energy per pulse is somewhat higher than the allowable output for an electric fence. A more important point, howev[illegible] is that the Taser pulses occur 13 times per second compared to the once per second for the fence. The power into the load is then 13 times greater for the Taser output than for the electric fence. These result indicate that the Taser output is more hazardous than an electric fence output.

Because the Taser output consists of a pulse train, it appears best to compare this output to the known effects of steady state sinusoidal currents. Much work has been done on the effects of different values of effective, rms, currents and on the effect of different frequencies. In Appendix B, the effective value for the Taser output current is calculated. The results are:

R_L (Ω)	I_{rms} (mA)
200	60
500	51.6
1000	42.7

For 60 Hz, alternating current, the current that will cause ventricu[illegible] fibrillation in one out of two hundred individuals is greater than approximately

$$I_{rms} = \frac{150}{\sqrt{T}} \text{ mA}$$

where T is in seconds. This expression is valid for 8.3 ms < T < 5s with the value of current from 5 to 20 seconds about the same as for 5 seconds. The constant, ~~150 is sometimes~~ reduced to 100 when consic[illegible] ing safe current levels for children. The effective current output [illegible] the Taser appears to be close to the level that can cause ventricula[illegible] fibrillation and death except for the fact that the heart does not r[illegible] pond readily to higher frequency currents. The lethal level for 60 H[illegible] current cannot be compared directly to the total effective current output of the Taser because the Taser output has high frequency compo[illegible] ents that have negligible effect on the heart.

To include the response of the heart to the frequency of the electric current, the frequency spectrum for the Taser output was ca culated in Appendix C. Appendix D provides a calculation for the effective value for each of the frequency components for the Taser ou[illegible] put; in addition, compensation is included in the calculations to include the fact that higher frequency components have less effect o[illegible] the heart. It is shown in Appendix D that a conservative approach, [illegible] that maximizes any danger, is to assume that the heart responds equa[illegible]y to all frequencies of current to 13 kHz and does not respond to frequencies above this value. Taking equal magnitudes for all frequenc[illegible] components below 13 kHz in the Taser output and with a 13 kHz cut-of[illegible], the following effective currents were calculated:

R_L	I_{rms} (mA)
200	8.9
500	8.7
1000	10.9

Thus it appears that the maximum Taser output current is approximately 10% of the lethal value. The current is about twice the 5 mA let-go current level which seems to explain why the shocks are effective in incapacitating an individual.

Appendix E includes a discussion of the Taser provided test results and references.

<u>Conclusions</u>

1. The Taser electrical output is not lethal.

2. As with any electric shocking device, there may be cases of lethality because of individual susceptibility.

3. The hazard in the output would be increased if the pulse repetition rate should increase or the amplitude of the output increased.

Sincerely,

T. Bernstein

Dr. Theodore Bernstein
Professor

TB:aeh

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TECHNICAL ANALYSIS DIVISION

UNITED STATES GOVERNMENT

Memorandum

U.S. CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, D.C. 2020

TO : Joesph Z. Fandey, TAD/OSCA

DATE: February 10, 1976

THRU : Albert F. Esch, M.D., Director, OMD *Albert F. Esch*

FROM : Leo T. Duffy, M.D., Deputy Director
Office of the Medical Director *Leo T. Duffy*

SUBJECT: TASER TF-1, CP-76-5

The Office of the Medical Director has reviewed the material submitted by your Office concerning the subject petition. Although this reply will concern itself only with the medical aspects of this subject, we recognize at the start that this product is manufactured as a "dangerous weapon", and should be so treated. As such, its effectiveness depends on the creation of some measure of injury in order to fulfill its intended purpose. Therefore, it appears that the role of this Office is more concerned with assessing the "risk of unreasonable injury" rather than the "unreasonable risk of injury". This memorandum will not address the social, moral and philosophical issues which are necessarily bound to be raised in the discussion and consideration of the use of this product.

From the electrical data supplied as the design output, and our survey of the literature (references attached), it is apparent that the stated available electrical current (50,000 V/0.3 joules/10 pps) is non-lethal when the weapon is used as directed on the "average, healthy" adult. The current-related injury sustained with the intended use of the TASER is related to the neuromuscular system, and is exhibited as an abnormal, tetanic or sustained contraction of muscle groups which has the effect of immobilizing the recipient. This reaction is induced by the action of the electric current passing through the skin, and then following nerve pathways by means of the nerve fibrils (cells) and their myelin sheaths, both of which are excellent conductors. The current is then continued through nerve endings (synapses) which are attached to muscle. The transference of the charge to the muscle cells causes them to contract. This injury process, ordinarily, is temporary and reversible when used as indicated on the healthy human. The level of current is comparable to that of U.L. approved electric wire fences as far

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as the "freezing" action is concerned. However, a major difference exists in that the electric fence pulsed charge of approximately 4.0 mAmp has OFF and ON periods which would allow the ability to "letgo", and get free from the fence. With the TASER the "let-go" is dependent on the user interrupting the flow of current by releasing the release bar.

With exposure to the stated amount of TASER current, there is a wide margin of safety as related to causing severe cardio-vascular reactions. An alternating current of 60-120 mAmperes, 120 Volt, 60 Hz can result in ventricular fibrillation. This is an asynchronous, uncoordinated rhythm of the heart beat which is incompatible with survival unless the normal rhythm is restored by means of a defibrillator device. The TASER current of 0.3 joules (watts/second) is well below the 10 to 50 joule threshold above which ventricular fibrillation can occur. This safety margin would be diminished in a person who has existing cardio-vascular disease. For example, an elderly person with arteriosclerotic heart disease would be subject to the precipitation of heart failure under the stress of convulsive seizures associated with Electric Shock Therapy. The margin of safety would also be reduced with a prolonged continuation of TASER current.

Injuries related to the impact of the barbed darts causing puncture wounds of the external surface of the body would be relatively minor, except for impact on the eye. The chance for initiation of events leading to a total loss of vision in the affected eye would be extremely high should such contact occur. Electric energy applied in the vicinity of the eye has also resulted in delayed cataract formation.

There is no evidence that adverse psychological, or neurological, effects, stemming purely from the electric current charge of a TASER, would be induced.

Injuries, resulting from falls involving an incapacitated, inert human body, are speculative depending upon the activity of the recipient at the time of impact, and on contact with external hazards, such as the head striking the sharp corner of a table. The likelihood of injuries, such as fractures, is increased in the case of the aged or physically handicapped.

In general, the severity of systemic effects from the passage of electric current through the body depends on several factors. These are: 1) type of circuit,

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2) voltage, 3) value of the current, 4) duration of flow, 5) resistance of specific tissue, 6) area of contact, and 7) pathways followed through the body. In addition, people with chronic cardio-vascular disease, the elderly and children would be increasingly susceptible to adverse effects. Therefore, this Office agrees with the conclusions stated by the manufacturer in his summary of May 10, 1972, page 3, which reads ---"the conclusions reached as a result of these studies and special tests is that the TASER is non-lethal at the design output to normally healthy people. However, it must be emphasized that neither this feature nor the non-injury or no harmful after-effect aspects can ever be guaranteed. There is no weapon, technique or procedure for subduing, constraining or dispersing that does not involve some risk of injury to healthy persons or of death especially if the individual has a heart ailment."

UNITED STATES GOVERNMENT

Memorandum

U.S. CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, D.C. 20207

TO : Joseph Z. Fandey
Technical Analysis Division

DATE:

FROM : Neil P. Zylich, Hazard Analysis Engineer NPZ
Special Engineering Studies Division

SUBJECT: TASER Evaluation and Analysis

The Bureau of Engineering Sciences was requested by the Office of Standards Coordination and Appraisal to evaluate the TASER Public Defender for potential for injury.

DESCRIPTION

The TASER is a battery operated device the size of a large flashlight (dimensions are 9"x3"x2" and weighs 1-1/4 pounds). It contains a cartridge-like insert that when actuated by a small charge of powder, propels two small darts. Each dart is connected by a wire 18 feet in length to a transformer power source within the TASER. When the darts are propelled, if they strike either skin or clothing they will imbed themselves in it. If both darts imbed themselves in either skin or clothing on a person, the person can be subjected to an electrical shock. Note, the darts do not have to make physical contact with a person but just attach themselves to a person's clothing in order for the person to receive an electrical shock. The holder of the TASER depresses a switch on the TASER after the darts have been fired and imbedded in order to transmit an electrical shock to the intended victim. The electrical shock lasts as long as the switch is depressed. Approximately two to three minutes is the maximum time duration the electrical shock can be applied continuously before the battery is discharged and the TASER becomes ineffective.

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Subject: TASER Evaluation and Analysis

BACKGROUND

BES through CSCA obtained two TASERS, a circuit description of the TASER, and test and operational literature on the TASER. After an initial review and analysis of the TASER by BES (which included taking photographs of the TASER output waveform at various impedances which simulated body impedance; see Attachment 3) it was decided to concentrate on the electrical aspects of the TASER only. The injury effect of the pointed darts was considered. It is concluded that the barbs will penetrate human skin to a maximum depth of approximately 5/16". The most obvious serious injury which could result from the dart itself would be an injury to the eye.

BES contracted with Dr. Theodore Bernstein of the University of Wisconsin, a recognized authority in the field of electric shock effects, to evaluate and analyze the TASER electrical output. The TASER output waveforms were measured at the National Bureau of Standards by CPSC personnel and photographed. This information, a TASER, and literature made available by the TASER manufacturer concerning the testing and safety of the device were supplied to Dr. Bernstein for evaluation.

BES has reviewed Dr. Bernstein's analysis, a copy of which is attached. Attachment 2 contains specific comments and/or clarification concerning this analysis.

RESULTS

The calculated effective current to which an individual would be subjected is approximately ten milliamperes. This current is above the threshold of the "let go" current value in the literature for which test data is available. Professor Dalziel* reported on tests conducted on volunteer subjects: 40% of the women tested and 15% of the men tested could not let go of a current in excess of 10 ma. While this value caused pain, no permanent injury resulted. These tests were conducted at 60 hz. It should be noted however that the effect of let go is a function of frequency as well as current. At frequencies above 100 hz the effects of current decrease such that the let go current increases. For example the fifty percentile let go threshold for men at 60 hz is 17 ma while the fifty percentile let go threshold for men at 10 khz is 74 ma. Thus the 10 khz threshold is over four times as high as for 60 hz.

*Professor Charles Dalziel of the University of California, the recognized leading authority in this field prior to his recent retirement.

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Subject: TASER Evaluation and Analysis

Dr. Bernstein states that the "maximum TASER output is approximately 10% of the lethal value". This relates the value of rms current for all frequency components up to 13 khz of approximately 10 ma to the commonly accepted value of 100 ma for ventricular fibrillation of a normal adult human. Professor Kouwenhoven in his paper on "Effect of Electric Shock" in the Transaction of A.I.E.E. V.49, January 1930, p. 381 stated that 100 milliamperes may cause death and that for normal persons the current should not exceed 30 milliamperes. Ferris, Spence, Williams and King stated in their report, "Effect of Electric Shock on the Heart" in Electrical Engineering, V. 55, May 1936, p. 498 that the maximum current to which man may safely be subjected for shocks of one second or more in duration is about 100 milliamperes. Dalziel and Lee have shown with tests on dogs in their report "Lethal Electric Currents" in the February 1969 IEEE Spectrum on Page 48 that the average 100 pound or more animal requires approximately 100 milliamperes for ventricular fibrillation. H. Spencer Turner in his report on "Human Responses to Electricity A Literature Review", Ohio State University Research Foundation, 1972 on Page 43 states that sinusoidal currents in excess of 100 ma at 60 hz from hand to foot will be dangerous for shock durations of three seconds or more for man.

With regard to establishing a standard for such a device; simply stated, a standard would address such devices for both AC and DC operation.

The energy output of such devices would have to be defined in terms of frequency, pulse height, pulse width, on and off time of pulses. The maximum energy would then have to be determined for various frequency bands such that at least the 3σ dispersion of the population would be covered. The definition of the energy levels would depend on medical judgements, and whatever data may be available in the literature.

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Subject: TASER Evaluation and Analysis

CONCLUSION

In conclusion, BES agrees with the finding that the TASER should not be lethal to a normal healthy person. This is based on a comparison of Dr. Bernstein's engineering results with the known engineering data in the literature. Additionally a standard could be developed but not without a costly and time consuming program to do so.

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EVALUATION OF THE ELECTRIC SHOCK HAZARD FOR THE NOVA XR 5000 STUN GUN

T. Bernstein

Theodore Bernstein, Ph.D.
Professor of Electrical and Computer Engineering
University of Wisconsin-Madison

January 22, 1985

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ABSTRACT

The electric shock hazard for the XR 5000 is determined by comparing the shock delivered to the known effects of a 60 Hz shock. With 60 Hz shocks a current of 1 mA is at the threshold of perception, 5 mA is at the let-go current level where shocks are painful but not dangerous, and 50 mA is the level where ventricular fibrillation and death can occur. The XR 5000 output is a train of damped, sinusoidal pulses with an approximate 10 μs time constant. The true r.m.s. value of the output is not a valid indication of the hazard because the output contains frequency components well above the 1 kHz frequency above which the effect for a given frequency component is reduced. When these factors are considered, the output for the XR 5000 is in the 3 to 4 mA range of an equivalent 60 Hz shock and is not dangerous. The fact that the shock is delivered between two probes 2 inches apart adds to the safety because the current is concentrated in the region of the body between the two probes and only a negligible current can reach the heart.

INTRODUCTION

The design of most electrical equipment ensures that an individual should rarely contact energized parts and be subjected to electric shock. For such equipment electrical safety is provided primarily by insulation or guarding to prevent contact and by suitable grounding. Any contact with energized parts is considered hazardous. There are other equipment where, even though it may not be intended, contact with energized parts is expected so that the electrical safety must be provided by ensuring that any possible electric shock will not be hazardous or lethal. Examples of such electrical devices are the electric fence, medical electrical nerve stimulators, welder, cattle prod, and fly electrocuter. The Nova XR 5000 stun gun is an example of a new device where individuals are deliberately subjected to electrical shock.

The XR 5000 is a small, hand-held device powered by a 9V battery. There are two small probes extending from the front approximately 5 millimeters, 2 inches apart. The probes are intended to be pressed into an attacker's body so that an electrical shock can be delivered to incapacitate the attacker. It is important that the attacker not be injured, as this is one of the major advantages of the device.

This report evaluates the safety of the shock delivered by the XR 5000. This is done by analyzing the output current waveform and comparing this shock to known safe and hazardous shocks. Safety criteria for the electric fence are used to compare the shock delivered to that delivered by the XR 5000.

SINUSOIDAL, 60 Hz SHOCKS

Electrical shocks involving alternating current have been investigated since before 1890 (Bernstein, 1975). Most of the recent studies have involved sinusoidal, 50 or 60 Hz currents, though the effects of other frequencies and waveforms have also been studied. This report compares the shock delivered by the XR 5000 to an equivalent 60 Hz shock. In order to do this, the effects of 60 Hz shocks are reviewed.

Threshold of Perception

For 60 Hz shocks, the lowest level of current that can be a problem is the threshold of perception level. This level, where some people may feel a slight tingle but should have no extreme startle reaction, is usually considered to be 0.5 mA r.m.s. for 60 Hz currents and is the maximum allowable leakage current for appliances (ANSI, 1973). Dalziel and Mansfield (1950) have determined that the median threshold of perception current at 60 Hz was 1.067 mA for 28 men and 1.18 mA for four women. Shocks near but above the threshold of perception current may be a hazard because of injury caused by the startle reaction producing a dangerous body motion.

Ventricular Fibrillation

At the other extreme is the level of current where the heart may be thrown into ventricular fibrillation and death occurs. For shocks between any two limbs, Biegelmeier and Lee (1980) have re-evaluated experimental data on ventricular fibrillation induced by electrical shock in animals and related the results to the physiological response to electrical shocks. For short duration shocks shorter than a cardiac cycle, the electrical current to cause fibrillation must be large and occur during the vulnerable period, T wave. Shocks longer than a cardiac cycle can cause premature ventricular contractions that lower the shock threshold current to a minimum after four or five premature ventricular contractions. Using these concepts, a safe current limit has been established as 500 mA for shocks less than 0.2 seco. in duration and 50 mA for shocks longer than 2 seconds. For shocks between 0.2 and 2 seconds, the safe current is given by the expression

$$I = 100/T \text{ mA r.m.s.} \qquad (1)$$

where T is in seconds and $0.2 \text{ s} \leq T \leq 2 \text{ s}$.

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Let-Go Current

The let-go current level of shock is not immediately lethal as is the ventricular fibrillation level. At this level of shock, with a current path through the arm, the individual cannot let go of an energized conductor. This level is hazardous in that a person is receiving a very painful shock from electrical equipment that he cannot release. Such a long duration shock may eventually become hazardous because of evoked heart arrhythmias or a decrease in contact resistance because of perspiration or burns allows greater currents. Dalziel and Massoglia (1956) have determined that the 60 Hz let-go current level where 0.5% of the individuals cannot let-go is 9 mA for men and 6 mA for women. The median let-go level is 16 mA for men and 10.5 mA for women. The let-go level where 99.5% of the individuals cannot let-go is 23 mA for men and 15 mA for women. Underwriters Laboratories (1972) requires that the ground fault circuit interrupter trip with long duration shocks greater than 6 mA as most people can let-go at currents less than 6 mA. The electric fence controller (Underwriters Laboratories 1980) is designed so that any single controller failure will not produce a continuous current greater than 5 mA because of the let-go problem. Currents above an individual's let-go current level could be hazardous and painful because the individual would be frozen to the circuit.

EFFECT OF FREQUENCY

The frequency of the electrical current is important in determining the effect on the human body of a given magnitude of current. When testing appliances or medical devices for leakage current, test loads have been devised which are supposed to simulate the response of the human body to the various frequency components in the leakage current. In order to do this, an electronic voltmeter is connected across the simulated load in such a fashion that a given reading of the voltmeter at any frequency is equivalent to the same effect shock. Underwriters Laboratories (1976) specifies a test load to measure leakage current such that the allowable leakage current is the same for all frequencies to 1 kHz. The allowable leakage current is increased directly proportional to the frequency for frequencies higher than 1 kHz up to 100 kHz. Above 100 kHz the allowable leakage current is the same as at 100 kHz--100 times the value at 1 kHz. The equivalent dc shock

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current for the same effect is taken as 40% larger than the 60 Hz current. The ANSI/AAMI (1978) test load is similar.

There is a question as to whether the effect on the human body of a shock from a non-sinusoidal, periodic waveform can be considered the same as the effect of each individual frequency component effect summed appropriately. Until further data are available, there is no other way to analyze a non-sinusoidal, periodic waveform.

THE ELECTRIC FENCE TRAIN OF PULSE SHOCKS

The electric fence controller (Underwriters Laboratories, 1980) provides a basis for determining what is considered a safe electric shock for a train of pulses. The electric fence has been used for many years with the realization that humans will contact the fence but must not be injured. The controller delivers a pulse type output with the output during the "on time" being of the peak discharge-type output or of the 60 Hz sinusoidal-type output. All tests for the controller are performed with a 500 ohm load.

The "off period" for the controller must be greater than 0.9 s for a sinusoidal type output or greater than 0.75 s for a peak discharge-type output. This "off period" is essential to allow an individual to get off the fence as the output during the "on period" is greater than the let-go current level. Continuous output is not permitted. Any single failure in the controller must not produce a continuous current greater than 5 mA.

The "on period" for peak discharge-type controllers must be less than 0.2 seconds. For this peak discharge-type controller, the output delivered to a 500 ohm load during the "on time" is limited to a given value of milliampere-seconds, charge, depending on the length of the "on period." The curve for the "on period" for peak discharge-type controllers provides allowable milliampere-second values for the time period from 0.03 s to 0.1 s. For "on periods" from 0.1 to 0.2 seconds the allowable output is 4 mA-s. The allowable output is reduced to 2 mA-s for a 0.03 second "on period."

For sinusoidal-type output the "on period" must be less than 0.2 s. For "on periods" between 0.025 s and 0.2 s, the allowable current must be less than

$$I = 75 - 350T \text{ mA r.m.s.} \qquad (2)$$

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where T is the "on period" in seconds. For "on period" between 0.025 s and 0.2 s, equation (2) allows sinusoidal type r.m.s. currents between 65 and 5 mA. These values are well below the 500 mA level considered dangerous for a single shock of such duration. It is important to note, however, that the fence controller produces a train of pulses rather than a single pulse.

Noting that the pulse repetition frequency for the sinusoidal-type pulse is approximately 1 Hz, the true r.m.s. current can be calculated for different pulse "on periods" when the r.m.s. value of the current during the pulse is given by equation (2). The results for pulse width between 0.025 s and 0.2 s are given in Table 1.

TABLE 1 True r.m.s. Current Related to Pulse Width

Pulse Width (T) (s)	True r.m.s. Current (mA)
0.025	10.47
0.05	12.84
0.07	13.34 (max)
0.10	12.62
0.15	8.65
0.2	1.9

This indicates that the highest output current is about 13 mA which is above the 60 Hz let-go current for some individuals. The current should not electrocute a person at this level. There still is a question as to whether the true r.m.s. current given in Table 1 can be equated to the effect of 60 Hz currents. The pulse train will have frequencv components above 1 kHz.

To study the frequency components for the pulse train the Fourier spectrum (Cooper, 1967) for a single pulse is calculated. Because the pulses are periodic with a frequency of 1 Hz, the amplitudes for the individual harmonics are proportional to the value of the Fourier spectrum at discrete frequencies--starting at 1 Hz and at all higher frequencies separated by 1 Hz. The peak discrete frequency component is $2/\tau$ times the Fourier spectrum value at that frequency where τ is the period for the pulses in seconds. Above 1 kHz the effect of the frequency components on the human body decrease inversely proportional to the frequency. Using the Fourier spectrum and the decrease in effect of the shock for frequencies above 1 kHz, the effective r.m.s. current for the n'th harmonic is given in equation (3)

$$I_n = (75-350T)\ T\left[\frac{\sin(n-60)\pi T}{(n-60)\pi T} + \frac{\sin(n+60)\pi T}{(n+60)\pi T}\right] \cdot \frac{[1+(n/10^5)^2]^{1/2}}{[1+(n/10^3)^2]^{1/2}}\ \text{mA r.m.s.} \qquad (3)$$

where n is the harmonic and, in this case, its frequency (n = 1,2,3, ---); T is the "on period" in seconds; and the frequency of the sinusoidal output during the pulse is 60 Hz. Above 1 kHz, equation (3) indicates that the harmonics are small and falling off rapidly so that the frequency components below 1 kHz are the most prominent. Thus, the true r.m.s. current values in Table 1 are equivalent to the 60 Hz values as far as effect on the human body is concerned.

NOVA XR 5000 SHOCKS

The Nova XR 5000 has an output consisting of a train of damped sinusoidal pulses. The current output depends on the electrical resistance between the probes. This will vary depending on the type of contact and whether the shock is delivered through clothes.

In comparing current levels between the output of the XR 5000 and the previously discussed physiological effects it is important to take into account the path of the current. Ventricular fibrillation is caused by current traversing the heart. The XR 5000 has a very well defined path between the two closely spaced probes. The current delivered to the heart will be negligible. This makes discussing lethality using the total current a technique that provides an extra margin of safety. Medical inspection of volunteers undergoing XR 5000 shocks revealed no clinically sygnificant changes to their E.K.G.

The action of the XR 5000 in causing muscle contraction shows an action much like the let-go phenomenon. In the arm currents of 5 to 10 mA cause this effect.

The XR 5000 is battery operated and ungrounded. Any electrical current will only travel between the two probes. A user holding the device and contacting ground with his other hand will receive no shock, as he is not in the current path between the probes.

Output Voltage Waveform and Parameters

The output voltage waveform for the XR 5000 consists of a train of damped sinusoidal pulses where each pulse is of the form

$$v(t) = V_o e^{-t/T} \sin \omega_d t \quad V \tag{4}$$

the pulse repetition frequency is 16 Hz. From oscilloscope traces of the output voltage for various resistance loads, the parameters in equation (4) can be evaluated. The time constant T, and the frequency, ω_d, can be measured directly from the trace. V_o is calculated by finding the time, t_p, for the first voltage peak and the magnitude of the first voltage peak, V_p, from the trace and then using

$$V_p = V_o e^{-t_p/T} \sin \omega_d t_p \quad V \tag{5}$$

to find V_o.

Using the output voltage traces for loads of 200, 460, and 1020 Ω, the parameters shown in Table 2 were determined.

TABLE 2 XR 5000 Output Parameters

	Load Resistance (Ω)			
	200	460	1020	1700
V_p (V)	1500	4000	8000	13,000
t_p (μs)	*	2.5	*	2
T (μs)	*	10	*	8
V_o (V)	2000	5000	10,000	17,600
ω_d (rad/s)	*	7×10^5	*	6.28×10^5
f_d (kHz)	*	111.4	*	100

Effective Output Current

Using the values from Table 2, the r.m.s. output current for a pulse train of damped sinusoids with a repetition frequency of 16 Hz can be calculated and are shown in Table 3.

TABLE 3 Calculated Effective Currents

Load Resistance (Ω)	$I_{r.m.s.}$ (mA)
200	62.6
460	68.0
1020	61.4
1700	57.4

The effective current shown in Table 3 could be hazardous if they were at 60 Hz; however, the output pulses contain high frequency components which are much less lethal than 60 Hz currents. It is necessary to consider all the frequency components for the pulses using a suitable weighting factor.

Frequency Components in XR 5000 Output

The XR 5000 output is a train of damped sinusoidal pulses of the form

$$v\ (t) = V_o e^{-at} \sin \omega_d t \ V \tag{6}$$

The Fourier series frequency components for the train of damped sinusoidal pulses are obtained from the Fourier spectrum (Cooper, 1967) for the single damped sinusoidal pulse of equation (6) and is:

$$F(j\omega) = V_o\omega_d/\{(j\omega)^2 + 2a(j\omega) + (a^2 + \omega_d^2)\} \tag{7}$$

where $a = 1/T = 10^5 s^{-1}$. Equation (7) can be recognized as a second order system with the following parameters

Undamped natural frequency $(\omega_n) = (a^2+\omega_d^2)^{1/2} = 7.07 \times 10^5$ rad/s or

Undamped natural frequency (f_n) = 112.5 kHz

and Damping ratio $(\zeta) = a/\omega_n - 0.14$

Since the bandwidth for such a system is approximately 172 kHz, the spectrum has significant high frequency components within the bandwidth, but these are above the 1 kHz frequency so the effects of electric shock on the human body for a given magnitude current are reduced.

Because the damped sinusoidal pulses are periodic with a frequency of 16 Hz, the r.m.s. values for the Fourier series harmonics are proportional to the value of the Fourier spectrum at the harmonic frequency. For this case the Fourier series has its fundamental frequency of 16 Hz with the higher harmonics all the multiples of 16 Hz.

Using equation (7), the r.m.s. value for the harmonic at each discrete harmonic frequency, ω, is

$$I(j\omega) = \left[\frac{\sqrt{2}f}{R}\right]\left[\frac{V_o\omega_d}{a^2+\omega_d^2}\right]\left[\frac{1}{\{1-[\omega^2/(a^2+\omega_d^2)]\}+j\{2a\omega/(a^2+\omega_d^2)\}}\right] \text{ A r.m.s.} \quad (8)$$

where $f = 16$ Hz $\quad a = 1/T = 10^5 s^{-1}$

$\omega_d = 7 \times 10^5$ rad/s

and ω has discrete values at $\omega = 2\pi\,(16n)$ where n = 1,2,3, ---.

The true r.m.s. value for the current including the first n harmonics is the square root of the sum of the squares for the first n harmonic values from equation (8).

The harmonics from equation (8) must be reduced by introducing the frequency response for the human body when the effects for shock currents are reduced proportional to frequency for frequencies between 1 kHz and 100 kHz. This can be accomplished by multiplying the magnitude for a given harmonic, n, found in equation (8) by the factor:

$$G(jw) = [1 + (f/10^5)^2]^{1/2}/[1 + (f/10^3)^2]^{1/2}$$

$$= (1 + 2.56 \times 10^{-8}n^2)^{1/2}/(1 + 2.56 \times 10^{-4}n^2)^{1/2} \quad (9)$$

Combining equations (8) and (9) the r.m.s. values for the current to the 600th harmonic, 9600 Hz, have been calculated and are show in Table 4.
Including higher harmonics would not increase the value significantly because of the attenuation at the higher frequencies.

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TABLE 4 Effective XR 5000 Output for Frequency Components to 600th Harmonic, 9600 Hz

Load Resistance (Ω)	$I_{r.m.s.}$ (mA)
200	3.03
460	3.29
1020	2.97
1700	3.43

PRIOR STUDIES RELATING TO XR5000 TYPE SHOCKS

In a report prepared for the U.S. Consumer Product Safety Commission (Bernstein, 1976), another device intended to be used on people and to deliver a train of damped sinusoidal pulses at a frequency of 13 Hz was evaluated. This report indicates that the output was equivalent to an approximate 9 mA, 60 Hz shock. A later study where the effects of the different frequency components were more accurately calculated showed that the device output was equivalent to an approximate 3 mA, 60 Hz shock (Bernstein, 1983). These techniques were used in this report.

The XR5000 is certainly as safe as the device evaluated for the U.S. Consumer Product Safety Commission. In fact, it is safer because the well defined current path between the closely spaced probes of the XR5000 will significantly reduce the current delivered to the heart.

CONCLUSIONS

1. Table 4 shows that the output for the XR 5000 is about equivalent to a 3 mA, 60 Hz shock. Such a shock is not dangerous.
2. The 3 mA shock is at about the let-go current level. The shock may be more intense than that caused by such a 3 mA let-go current in the arm because the current density at the probes is greater and because of the sensation caused by the spark from the electrode to the skin.

3. Because the shocking current is only in the path between the electrodes about 2 inches apart, the current that might reach the heart is much less than in a limb-to-limb or an across-the-chest shock. This adds to the safety.
4. The units can be used in a damp or wet environment without hazard to the user. The unit may not work well because leakage between electrodes, but the operator should not be shocked if he keeps his hand in its usual position.

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#226

UNITED STATES GOVERNMENT

Memorandum

U.S. CONSUMER PRODUCT SAFETY COMMISSION WASHINGTON, D.C. 20207

RECEIVED OFFICE OF ... Nov 7 2 32 PM '75 CONSUMER PRODUCT SAFETY COMMISSION

TO : Tom McKay, OCR

THRU : Margaret Freeston, Asst. General Counsel MMF

FROM : Jeanette Michael, OGC

SUBJECT: Jurisdiction over the Taser Public Defender

The Consumer Product Safety Act gives the Consumer Product Safety Commission jurisdiction over all consumer products. The term "consumer product" excludes "...any article which, if sold by the manufacturer, producer, or importer, would be subject to the tax imposed by section 4181 of the Internal Revenue Code of 1954...or any component of any such article..." (15 U.S.C. 2052 (a)(1)(E)). Section 4181 includes pistols, revolvers, <u>firearms</u>, shells and cartridges. (Emphasis added)

The question is whether the "Taser" is a firearm within the meaning of section 4181 of the Internal Revenue Code (26 U.S.C. 4181). The term firearm has been defined in 18 U.S.C. 921 (Gun Control Act of 1968), 15 U.S.C. 901 and 26 U.S.C. 5848. It is not clear which definition is applicable, however 18 U.S.C. 921 is the most comprehensive.

> (3) The term "firearm" means (A) any weapon (including a starter gun) which will or <u>is designed to or may readily be converted to expel a projectile by the action of an explosive</u>; (B) the frame or receiver of any such weapon; (C) any firearm muffler or firearm silencer; or (D) any destructive device. Such term does not include an antique firearm. (Emphasis added)
>
> (4) The term "destructive device" means-
>
> (A) any explosive, incendiary, or poison gas -
>
> (i) bomb,
>
> (ii) grenade,
>
> (iii) rocket having a propellant charge of more than four ounces,

(iv) missile having an explosive or incendiary charge more than one-quarter ounce,

(v) mine, or

(vi) device similar to any of the devices described in the preceding clauses;

(B) any type of weapon (other than a shotgun or a shotgun shell which the Secretary finds is generally recognized as particularly suitable for sporting purposes) by whatever name known which will, or which may be readily converted to, expel a projectile by the action of an explosive or other propellant, and which has any barrel with a bore of more than one-half inch in diameter; and

(C) any combination of parts either designed or intended for use in converting any device into any destructive device described in subparagraph (A) or (B) and from which a destructive device may be readily assembled.

In response to an inquiry from Mr. J.E. Rogers of Rogers, Mirabelle' & Berlanti dated 10-12-73 concerning the classification of the "Taser" under the provisions of the Gun Control Act of 1968, Mr. A. Atley Peterson, Assistant Director, Technical and Scientific Services, Bureau of Alcohol, Firearms and Tobacco, Department of the Treasury concluded the following:

The "Taser" is not a firearm as defined in 18 U.S.C. 921. Rationale- Although the "Taser" wires are expelled by the explosion or expansion of gases generated by the ignition of 4/5 of a grain of smokeless powder, the wires and appropriate wire contacts do not meet the definition of a projectile. The determination is based on the fact that the muzzle velocity is well below the standards established by

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> the Office of the Surgeon General, Department of Army. Research studies conducted by that office indicate that an impact velocity of from 125 to 170 feet per second, contingent on the composition and shape of the projectile, is necessary to cause a break in the skin in an unclothed area. These findings reinforce the finding of ATF that the net or barbs are not projectiles since they deploy over a strictly limited area and are still attached to the basic component by means of the wires which convey the electric charge.

This office agrees with the findings of the Alcohol, Tobacco and Firearms Division of the Department of the Treasury and concludes that the "Taser" does not fall within the purview of section 4181 of the Internal Revenue Code of 1954 (26 U.S.C. 4181). Since the "Taser" is not specifically excluded under the Consumer Product Safety Act, the Commission can exercise jurisdiction over the product under that Act.

While the views expressed in this opinion are based on the most current interpretation of the law by this office, they could subsequently be changed or superseded.

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STATEMENT

The Consumer Product Safety Commission has today received the opinion of the Bureau of Alcohol, Tobacco and Firearms (within the Department of the Treasury) regarding their decision to regulate the TASER under the Gun Control Act of 1968.

The Commission is presently reviewing ATF's opinion in view of an earlier CPSC vote declaring the TASER a consumer product which could be regulated by the Consumer Product Safety Act. It is too soon to determine what the implication of ATF's decision will be regarding the Commission's earlier decision.

The Commission will delay action on a currently pending petition from Mr. Michael Lubin, Washington, D.C., requesting the Commission to set standards or ban the TASER under the authority of the Consumer Product Safety Act.

No timetable has been set for a Commission decision on either the ATF opinion or the Lubin petition.

-30-

3/18/76

UNITED STATES GOVERNMENT

Memorandum

U.S. CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, D.C. 20207

TO : Joseph Z. Fandey
Technical Analysis Division

DATE:

FROM : Neil P. Zylich, Hazard Analysis Engineer NPZ
Special Engineering Studies Division

SUBJECT: TASER Evaluation and Analysis

The Bureau of Engineering Sciences was requested by the Office of Standards Coordination and Appraisal to evaluate the TASER Public Defender for potential for injury.

DESCRIPTION

The TASER is a battery operated device the size of a large flashlight (dimensions are 9"x3"x2" and weighs 1-1/4 pounds). It contains a cartridge-like insert that when actuated by a small charge of powder, propels two small darts. Each dart is connected by a wire 18 feet in length to a transformer power source within the TASER. When the darts are propelled, if they strike either skin or clothing they will imbed themselves in it. If both darts imbed themselves in either skin or clothing on a person, the person can be subjected to an electrical shock. Note, the darts do not have to make physical contact with a person but just attach themselves to a person's clothing in order for the person to receive an electrical shock. The holder of the TASER depresses a switch on the TASER after the darts have been fired and imbedded in order to transmit an electrical shock to the intended victim. The electrical shock lasts as long as the switch is depressed. Approximately two to three minutes is the maximum time duration the electrical shock can be applied continuously before the battery is discharged and the TASER becomes ineffective.

U.S. GOVERNMENT PRINTING OFFICE: 1974 733-333/3604 1-3

Subject: TASER Evaluation and Analysis

BACKGROUND

BES through CPSC obtained two TASERS, a circuit description of the TASER, and test and operational literature on the TASER. After an initial review and analysis of the TASER by BES (which included taking photographs of the TASER output waveform at various impedances which simulated body impedance; see Attachment 3) it was decided to concentrate on the electrical aspects of the TASER only. The injury effect of the pointed darts was considered. It is concluded that the barbs will penetrate human skin to a maximum depth of approximately 5/16". The most obvious serious injury which could result from the dart itself would be an injury to the eye.

BES contracted with Dr. Theodore Bernstein of the University of Wisconsin, a recognized authority in the field of electric shock effects, to evaluate and analyze the TASER electrical output. The TASER output waveforms were measured at the National Bureau of Standards by CPSC personnel and photographed. This information, a TASER, and literature made available by the TASER manufacturer concerning the testing and safety of the device were supplied to Dr. Bernstein for evaluation.

BES has reviewed Dr. Bernstein's analysis, a copy of which is attached. Attachment 2 contains specific comments and/or clarification concerning this analysis.

RESULTS

The calculated effective current to which an individual would be subjected is approximately ten milliamperes. This current is above the threshold of the "let go" current value in the literature for which test data is available. Professor Dalziel* reported on tests conducted on volunteer subjects: 40% of the women tested and 15% of the men tested could not let go of a current in excess of 10 ma. While this value caused pain, no permanent injury resulted. These tests were conducted at 60 hz. It should be noted however that the effect of let go is a function of frequency as well as current. At frequencies above 100 hz the effects of current decrease such that the let go current increases. For example the fifty percentile let go threshold for men at 60 hz is 17 ma while the fifty percentile let go threshold for men at 10 khz is 74 ma. Thus the 10 khz threshold is over four times as high as for 60 hz.

*Professor Charles Dalziel of the University of California, the recognized leading authority in this field prior to his recent retirement.

Subject: TASER Evaluation and Analysis

Dr. Bernstein states that the "maximum TASER output is approximately 10% of the lethal value". This relates the value of rms current for all frequency components up to 13 khz of approximately 10 ma to the commonly accepted value of 100 ma for ventricular fibrillation of a normal adult human. Professor Kouwenhoven in his paper on "Effect of Electric Shock" in the Transaction of A.I.E.E. V.49, January 1930, p. 381 stated that 100 milliamperes may cause death and that for normal persons the current should not exceed 30 milliamperes. Ferris, Spence, Williams and King stated in their report, "Effect of Electric Shock on the Heart" in Electrical Engineering, V. 55, May 1936, p. 498 that the maximum current to which man may safely be subjected for shocks of one second or more in duration is about 100 milliamperes. Dalziel and Lee have shown with tests on dogs in their report "Lethal Electric Currents" in the February 1969 IEEE Spectrum on Page 48 that the average 100 pound or more animal requires approximately 100 milliamperes for ventricular fibrillation. H. Spencer Turner in his report on "Human Responses to Electricity A Literature Review", Ohio State University Research Foundation, 1972 on Page 43 states that sinusoidal currents in excess of 100 ma at 60 hz from hand to foot will be dangerous for shock durations of three seconds or more for man.

With regard to establishing a standard for such a device; simply stated, a standard would address such devices for both AC and DC operation.

The energy output of such devices would have to be defined in terms of frequency, pulse height, pulse width, on and off time of pulses. The maximum energy would then have to be determined for various frequency bands such that at least the 3σ dispersion of the population would be covered. The definition of the energy levels would depend on medical judgements, and whatever data may be available in the literature.

Subject: TASER Evaluation and Analysis

CONCLUSION

In conclusion, BES agrees with the finding that the TASER should not be lethal to a normal healthy person. This is based on a comparison of Dr. Bernstein's engineering results with the known engineering data in the literature. Additionally a standard could be developed but not without a costly and time consuming program to do so.

530959:76:NPZylich:pc

DEPARTMENT OF ELECTRICAL
AND COMPUTER ENGINEERING

1425 Johnson Drive
Madison, Wisconsin 53706
Telephone: 608/262-3940

February 12, 1976

Mr. Neil P. Zylich
Hazard Analysis Engineer, BES
Consumer Product Safety Commission
5401 Westband Avenue, Room 918
Bethesda, Maryland 20207

Dear Mr. Zylich:

I have completed my analysis of the information you sent me with your letter of February 4 concerning the Taser Public Defender electric gun. The primary emphasis in my study was to determine whether the Taser electrical output can be lethal. I did not deal with other possible hazards that would probably be non-lethal such as electrical burns or physical injury caused by the darts.

The electrical output for a device is a function of the load on that device. The Taser output was tested with resistance loads of 200, 500 and 1000 ohms as well as higher resistance loads. I performed none of these tests but have evaluated the test results. With the Taser darts fully inserted into tissue, the exposed dart area per dart would be about 5.5 mm^2. Geddes and Baker show impedances between pairs of needle electrodes to be approximately 1000 ohms for 5.6 mm^2 exposed area electrodes and approximately 300 ohms for 73 mm^2 electrodes. [L.A. Geddes and L.E. Baker, Principles of Applied Biomedical Instrumentation. New York: John Wiley, 1975, pg. 248.] Since the Taser electrodes have barbs and are forcefully inserted, it would seem that local trauma would increase the effective area of the barb and thus decrease electrode resistance to the 200 to 1000 ohm range.

Tests were conducted to determine the Taser output into 200, 500 and 1000 ohm resistive loads. The output consisted of a train of damped sinusoids with a frequency for the pulses of 13 Hz. One possible means for evaluating the safety for the Taser output is to compare the output to the output of a device that provides shocks that are considered safe for humans. Appendix F supplies a summary for the maximum output for an electric fence controller into a 500 ohm load as specified by Underwriters Laboratories. It is seen that pulses with an energy of approximately 90 mJ per pulse is maximum. The maximum pulse repetition rate is about 1 Hz - off period must be greater than 0.75 seconds. In Appendix A, the energy per pulse for the Taser was calculated for 200, 500 and 1000 ohm loads. The results were:

R_L (Ω)	W (mJ)
200	53.6
500	102.2
1000	140

Thus, the Taser output energy per pulse is somewhat higher than the allowable output for an electric fence. A more important point, however is that the Taser pulses occur 13 times per second compared to the once per second for the fence. The power into the load is then 13 times greater for the Taser output than for the electric fence. These results indicate that the Taser output is more hazardous than an electric fence output.

Because the Taser output consists of a pulse train, it appears best to compare this output to the known effects of steady state sinusoidal currents. Much work has been done on the effects of different values of effective, rms, currents and on the effect of different frequencies. In Appendix B, the effective value for the Taser output current is calculated. The results are:

$R_L (\Omega)$	I_{rms} (mA)
200	60
500	51.6
1000	42.7

For 60 Hz, alternating current, the current that will cause ventricular fibrillation in one out of two hundred individuals is greater than approximately

$$I_{rms} = \frac{150}{\sqrt{T}} \text{ mA}$$

where T is in seconds. This expression is valid for $8.3 \text{ ms} < T < 5\text{s}$ with the value of current from 5 to 20 seconds about the same as for 5 seconds. The ~~constant, 150 is~~ sometimes reduced to 100 when considering safe current levels for children. The effective current output for the Taser appears to be close to the level that can cause ventricular fibrillation and death except for the fact that the heart does not respond readily to higher frequency currents. The lethal level for 60 Hz current cannot be compared directly to the total effective current output of the Taser because the Taser output has high frequency components that have negligible effect on the heart.

To include the response of the heart to the frequency of the electric current, the frequency spectrum for the Taser output was calculated in Appendix C. Appendix D provides a calculation for the effective value for each of the frequency components for the Taser output; in addition, compensation is included in the calculations to include the fact that higher frequency components have less effect on the heart. It is shown in Appendix D that a conservative approach, one that maximizes any danger, is to assume that the heart responds equally to all frequencies of current to 13 kHz and does not respond to frequencies above this value. Taking equal magnitudes for all frequency components below 13 kHz in the Taser output and with a 13 kHz cut-off, the following effective currents were calculated:

R_L	I_{rms} (mA)
200	8.9
500	8.7
1000	10.9

Thus it appears that the maximum Taser output current is approximately 10% of the lethal value. The current is about twice the 5 mA let-go current level which seems to explain why the shocks are effective in incapacitating an individual.

Appendix E includes a discussion of the Taser provided test results and references.

Conclusions

1. The Taser electrical output is not lethal.
2. As with any electric shocking device, there may be cases of lethality because of individual susceptibility.
3. The hazard in the output would be increased if the pulse repetition rate should increase or the amplitude of the output increased.

Sincerely,

T. Bernstein

Dr. Theodore Bernstein
Professor

TB:aeh

APPENDIX A

Energy Content in Damped Sine Wave Pulse

Consider the voltage waveform as in Figure A1 across an R ohm load

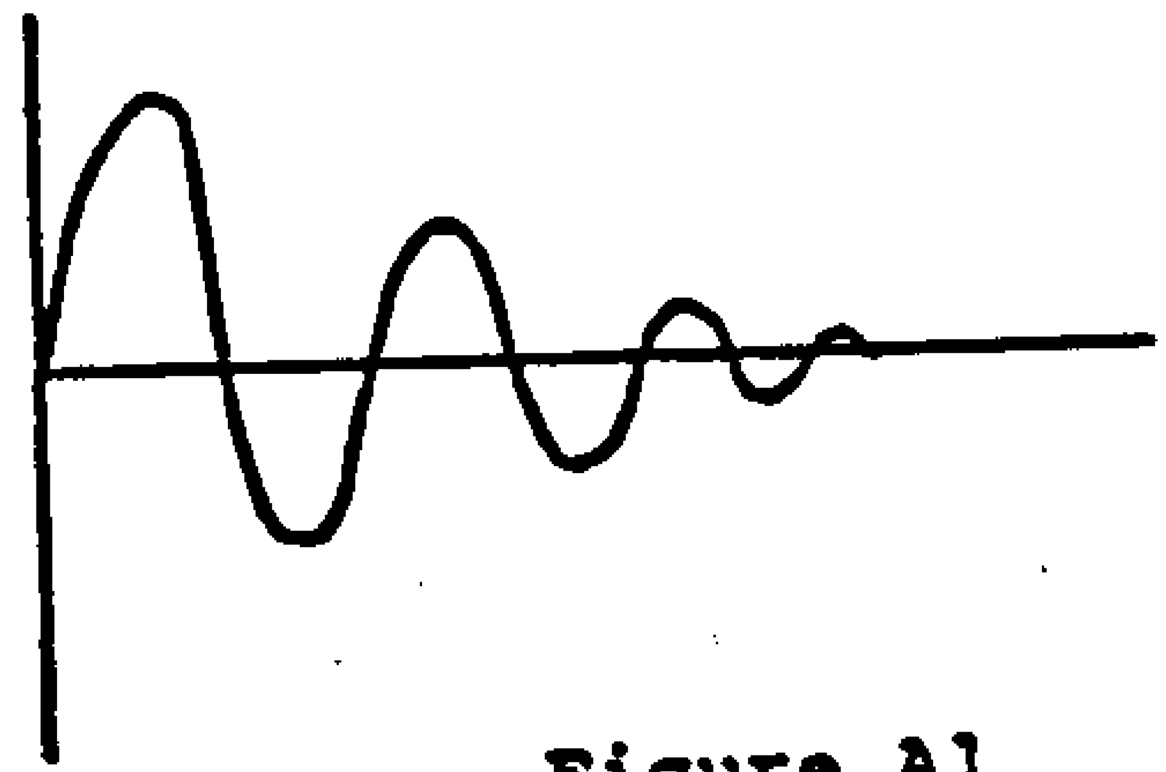


Figure A1

this curve can be approximated by

$$v(t) = V_o e^{-\frac{t}{\tau}} \sin \omega_d t \quad V \tag{A1}$$

where τ is the time constant for the damping term in seconds and ω_d is the damped natural frequency in radians per second.

The instantaneous power delivered to the resistor is

$$p(t) = \frac{v^2(t)}{R} = \frac{V_o^2}{R} e^{-\frac{2t}{\tau}} \sin^2 \omega_d t \quad W \tag{A2}$$

while the energy dissipated in the resistor is

$$W = \int_o^\infty p(t)dt = \int_o^\infty \frac{V_o^2}{R} e^{-\frac{2t}{\tau}} \sin^2 \omega_d t \, dt \quad J \tag{A3}$$

Since $\sin^2 A = \frac{1}{2}(1-\cos 2A)$ [Dwight 404.12]

$$W = \frac{V_o^2}{2R} \int_o^\infty (e^{-\frac{2t}{\tau}} dt - e^{-\frac{2t}{\tau}} \cos 2\omega_d t \, dt) \tag{A4}$$

From Dwight, 577.2

$$\int e^{ax} \cos \mu x \, dx = \frac{e^{ax}}{a^2+\mu^2} (a \cos \mu x + \mu \sin \mu x)$$

So

$$W = \frac{V_o^2}{2R}\left[-\frac{\tau}{2}e^{-\frac{2t}{\tau}} - \frac{e^{-\frac{2t}{\tau}}}{\frac{4}{\tau^2}+4\omega_d^2}\left(-\frac{2}{\tau}\cos 2\omega_d t + 2\omega_d \sin 2\omega_d t\right)\right]_o^{\infty}$$

$$W = \frac{V_o^2}{2R}\left[\frac{\tau}{2} - \frac{e^{-\frac{2t}{\tau}}}{\frac{4}{\tau^2}+4\omega_d^2}\cdot\frac{2}{\tau}\right]$$

$$W = \frac{V_o^2\tau}{4R}\left[1 - \frac{\tau}{1+\omega_d^2\tau}\right] \quad J \qquad \text{(A5)}$$

To evaluate V_o, find the time, t_p, for the first voltage peak and the magnitude of the first voltage peak, V_p, from the voltage trace. Then

$$V_p = V_o\, e^{-\frac{t_p}{\tau}} \sin \omega_d t_p \quad V \qquad \text{(A6)}$$

where V_p is the first peak voltage. Thus measuring V_p, t_p, τ, and ω_d from the voltage trace permits the calculation of V_o.

When, in equation (A5)

$$\frac{1}{\frac{1}{\tau}+\omega_d^2} \ll 1$$

$$W = \frac{V_o^2\,\tau}{4R} \quad J \qquad \text{(A7)}$$

For Taser 1

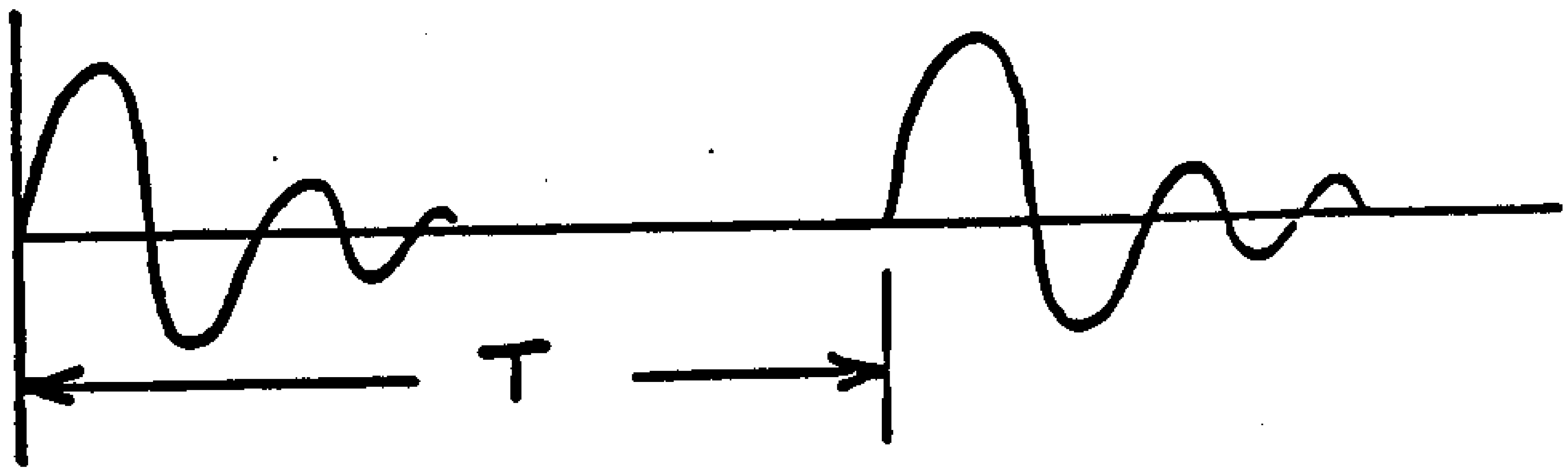
	R(Ω)		
	200	500	1000
V_p(V)	1250	3000	6000
$\omega_d = \frac{2\pi}{T}$ (rad/s)	4.83×10^{5}	4.83×10^{5}	4.83×10^{5}
τ(s)	20×10^{-6}	15×10^{-6}	5×10^{-6}
t_p(s)	3×10^{-6}	3×10^{-6}	2.5×10^{-6}
V_o(V)	1463	3692	10,583
W(J)	53.6×10^{-3}	102.2×10^{-3}	140×10^{-3}

APPENDIX B

Effective Value for Damped Sinusoidal Pulses

Consider a train of damped sinusoidal pulses as shown

Figure B1



For this train the time constant for the pulse, τ, is much less than the pulse repetition rate, T. If

$$i = \frac{V_o}{R} e^{-\frac{t}{\tau}} \sin \omega_d t \qquad \text{A} \qquad \text{(B1)}$$

then

$$I_{rms} = \left[\frac{1}{T} \int_o^{\infty} \frac{V_o^2}{R^2} e^{-\frac{2t}{\tau}} \sin^2 \omega_d t \, dt \right]^{1/2} \qquad \text{A} \qquad \text{(B2)}$$

for

$$\tau << T \quad .$$

Using the same technique as used for solving equation (A3)

$$I_{rms} = \left[\frac{V_o^2 \tau}{4R^2 T} \left(1 - \frac{\tau}{1+\omega_d^2 t} \right) \right]^{1/2} \qquad \text{A} \qquad \text{(B3)}$$

As in A(7)

$$I_{rms} \cong \frac{V_o}{2R} \left(\frac{\tau}{T} \right)^{1/2} \qquad \text{A} \qquad \text{(B4)}$$

For a frequency of 13pps, $T = \frac{1}{13} = 7.69 \times 10^{-2}$s.

	R (Ω)		
	200	500	1000
I_{rms} (A)	60×10^{-3}	51.6×10^{-3}	42.7×10^{-3}

APPENDIX C

Frequency Components in Taser Output

For the Taser output shown in Appendix B, Figure B1, each of the pulses has the form

$$v(t) = V_o e^{-at} \sin \omega_d t \qquad V \qquad \text{(C1)}$$

The pulses occur at a frequency with a period of T seconds. The Fourier Transform for the single pulse is given by

$$F(j\omega) = V_o \frac{\omega_d}{(a+j\omega)^2 + \omega_d^2} \qquad \text{(C2)}$$

that has a frequency spectrum as shown in Figure C1.

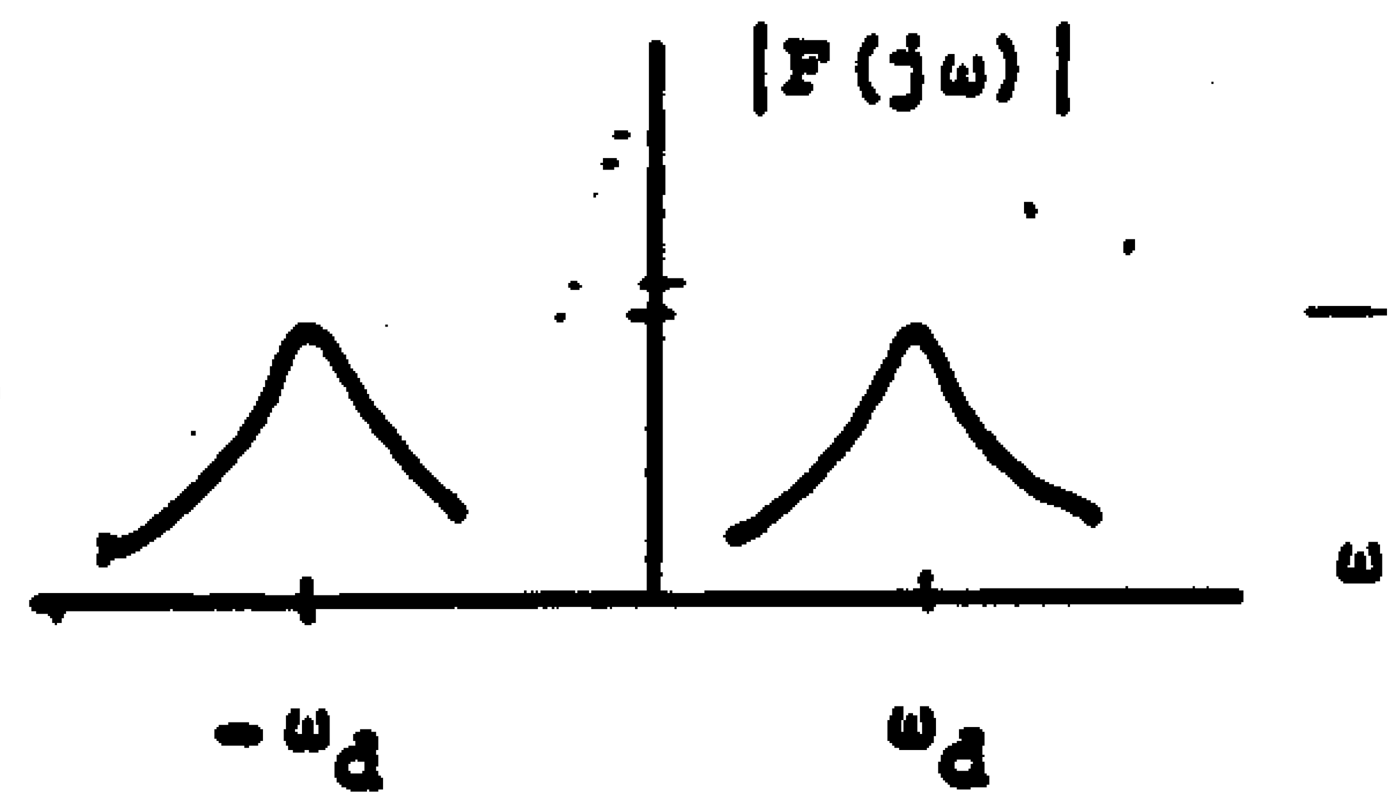


Figure C1

[G.R. Cooper and C.D. McGillem, Methods of Signal and System Analysis. New York: Holt, Rinehart and Winston, 1967, pg. 121].

The discrete values for the discrete frequency components for the periodic signal with period T are proportional to the magnitude of the frequency spectrum at discrete intervals of

$$\omega_T = \frac{2\pi}{T} \text{ rad/s} \qquad \text{(C3)}$$

[Reference Data for Radio Engineers, sixth edition, pp. 44-10 and 44-11].

For the output of Taser 1

	R(Ω)		
	200	500	1000
ω_d (rad/s)	4.83×10^5	4.83×10^5	4.83×10^5
$f_d = \frac{\omega_d}{2\pi}$ (kHz)	76.9	76.9	76.9
τ (μs)	20	15	5
$a = \frac{1}{\tau}$ (s^{-1})	5×10^4	6.67×10^4	20×10^4
f (Hz)	13	13	13
$T = \frac{1}{f}$ (s)	0.077	0.077	0.077
$\omega_T = \frac{2\pi}{T}$ (rad/s)	81.7	81.7	81.7

Rewriting equation (C2)

$$F(j\omega) = V_o \frac{\omega_d}{(j\omega)^2 + 2a(j\omega) + (a^2+\omega_d^2)} \tag{C4}$$

or

$$F(j\omega) = \frac{V_o\ \omega_d}{a^2+\omega_d^2}\ \frac{1}{\frac{(j\omega)^2}{a^2+\omega_d^2} + \frac{2a}{a^2+\omega_d^2}(j\omega) + 1}$$

$$F(j\omega) = \frac{V_o\ \omega_d}{a^2+\omega_d^2}\ G(j\omega) \tag{C5}$$

where

$$G(j\omega) = \frac{1}{\frac{(j\omega)^2}{a^2+\omega_d^2} + \frac{2a}{a^2+\omega_d^2}(j\omega) + 1} \tag{C6}$$

Equation C6 can be recognized as the frequency response characteristic for a simple second order system with an undamped natural frequency of

$$\omega_n = (a^2 + \omega_d^2)^{\frac{1}{2}} \quad \text{(C7)}$$

and a damping ratio of

$$\zeta = \frac{a}{\omega_n} \quad \text{(C8)}$$

Substituting for the values for a and ω_d for each of the loads,

	R(Ω)		
	200	500	1000
ζ	0.1	0.14	0.38
ω_n(rad/s)	4.86×10^5	4.88×10^5	5.23×10^5
$f_n = \frac{\omega_n}{2\pi}$ (kHz)	77.3	77.7	83.2

APPENDIX D

Relationship Between the Frequency Components in the Taser Output and Human Lethality Currents

The Fourier transforms in Appendix ~~E~~ C show that the Taser output has a frequency response spectrum corresponding to an un-damped second order system. Figure D1 shows the frequency response spectrum for the damped sinusoidal pulse with a 200Ω load on the Taser. Figure D2 shows the frequency response spectrum for a 1000Ω load. Because of the 13 Hz repetition rate for the pulses, the actual output contains discrete frequencies with an amplitude read from the frequency spectrum curve at discrete frequencies 13 Hz apart.

If the rms current for the nth harmonic is $I_{n\,rms}$, then the rms current for the first N harmonics is given by

$$I_{rms}(f<\tfrac{N}{T}) = \left[\sum_{n=0}^{n=N} I_{n\,rms}^{2}\right]^{1/2} \qquad \text{(D1)}$$

where T is the repetition period ($T = \frac{1}{13}$ s) and $f<\frac{N}{T}$ shows that the rms current is for all frequency components to the N'th harmonic of the repetition frequency.

Observing Figures D1 and D2, it is seen that the frequency response for G(jω) is relatively flat to about 40 kHz. It is known that the human body is less sensitive to higher frequency currents so that current components at higher frequencies must be larger for the same effect as for lower frequency components. The Association for the Advancement of Medical Instrumentation (AAMI) made use of this when they developed a test load to test equipment. This load

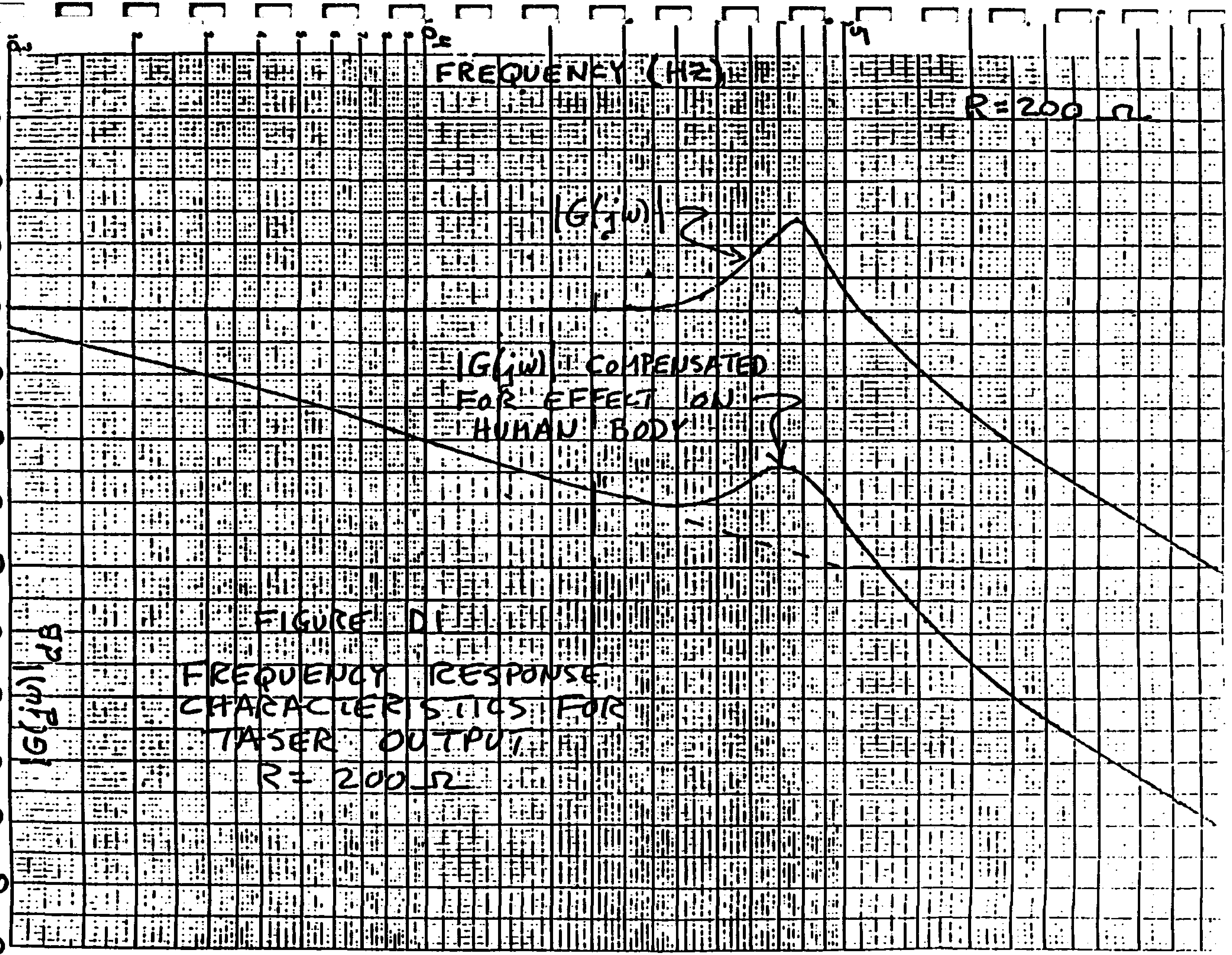


FIGURE D1
FREQUENCY RESPONSE CHARACTERISTICS FOR TASER OUTPUT
R = 200 Ω

FIGURE D2
FREQUENCY RESPONSE CHARACTERISTICS FOR TASER OUTPUT
R = 1000 Ω

simulated the human body by having a frequency response for current that was flat, did not attenuate currents, to 1 kHz. The input currents were attenuated inversely proportional to frequency from 1 kHz to 100 kHz; at 100 kHz a current had to be 100 times larger than at 1 kHz fc the same effect. From 100 kHz and higher the current was attenuated at the same value as at 100 kHz. This attenuation characteristic is shown added to G(jω) in Figures D1 and D2 to provide an overall indication of the effect of frequency on the hazard current. Both of these curves show that any frequency components greater than 10 kHz are attenuated by greater than 0.1. [The AAMI load was discussed by Denes Roveti, "The Changing Face of Electrical Safety: Test Loads," Medical Electronics and Data, Vol. 6, No. 3, May-June 1975, pp. 42-45.]

Because of the rapid attenuation of effect of currents above 10 kHz, a conservative approach can be used where all frequency components up to 13 kHz are weighted equally while frequency components above 13 kHz are neglected. For the 200Ω load it is assumed that all components to a frequency of 13 kHz have the same magnitude as at low frequency. From equation (C5)

$$I(jo) = \frac{F(jo)}{R} = \frac{V_o \omega_d}{R(a^2+\omega_d^2)} \qquad \text{(D2)}$$

Using the values of

$V_o = 1463$ V, $\omega_d = 4.83\times10^5$ rad/s, R = 200Ω,
and $a = 5\times10^4$

$$I(jo) = 1.537\times10^{-5} \qquad \text{(D3)}$$

From page 44-11 of Reference Data for Radio Engineers, Sixth Edition, the rms value for a frequency component with the magnitude as given in (D3) is

$$I_{n\,rms} = \frac{2}{\sqrt{2}\,T} I(jo)$$

where $\frac{1}{T}$ is 13 Hz. So

$$I_{n\,rms} = 2.82\times10^{-4}\ \text{A}$$

There are 1000 discrete frequency components between 0 and 13,000 Hz so according to equation (D1)

$$I_{rms} = (1000)^{\frac{1}{2}}(2.82\times10^{-4}) = 8.9\ \text{mA}$$

In a similar fashion the rms current for all frequency components of the output to 13 kHz is given below assuming at all frequency components are equally effective to 13 kHz.

$R = 500\Omega$	$I_{rms}(f<13\text{kHz}) = 8.7$ mA
$R = 1000\Omega$	$I_{rms}(f<13\text{kHz}) = 10.9$ mA

Discussion of Physiological References

Supplied by Taser Relating to Safety

In the packet of material supplied by Mr. Neil Zylich with his letter of February 4, 1976 only two of the items relate to the physiological effects of electrical shock as related to safety. These were item 6, Taser related test summary (dated May 10, 1972 for Taser Systems, Inc.) and item 7, A "Medical Bibliography and Summary" (from TSER Systems, Inc.). Other material in the packet such as item 5, A "Summary of TASER Effectiveness" tests (from TSER Systems, Inc.) and item 8, An "Evaluation of TASER Effect on Trained Monkeys" deal primarily with effectiveness and only indirectly relate to safety because of the qualitative manner in which the tests were performed.

In item 6 the statement is made that, "The design output of the TASER is more than 50 times lower than maximum safe level as determined by medical tests." I don't understand what parameter of the output is 1/50 of what safe level. It is stated that the Taser output is close to the operating level of electric fence outputs. One Taser pulse has approximately the energy allowed for an electric fence output but this Taser supplies these pulses at a rate of 13 Hz while the electric fence has a maximum allowable pulse output rate of approximately 1 Hz. In one second the Taser supplied 13 times as much energy as an electric fence output.

In the effectiveness summary, reference was made to a "freezing" level [let-go] of 16 mA at 2.5 W determined at U.C. Berkeley in 1968. This figure refers to 60 Hz tes-- and does not apply directly to the Taser type pulse output. Underwriter Laboratories in their standard for electric fences, U.L. 69, refer to pulses at a repetition rate of approximately one per second or ac output with an on period of less than 0.2 s and an off period of0.9 s. Great care must be used before applying these results for the Taser type output.

In the section on non-lethality summary, reference is made to an expression of $I\sqrt{t} \leq 0.1$ for the current-time relationship for the threshold of non-fibrillating shock. This relationship was determined by Prof. Dalziel and applies only to 60 Hz shock with a valid time range of 8.3 ms to 5 s. It can not be used for periods less than one half cycle of a 60 Hz wave, 8.3 ms. This relationship cannot be used directly for the Taser type output. A mistake has been made in quoting a figure of 4 mA-s output as safe according to Underwriters Laboratories. In U.L. 69, Graph 1 on page 18 shows that a maximum of 4 mA-s is allowed for shocks with a pulse on period of 0.1 to 0.2 s. For shorter duration shocks the allowable value is reduced, i.e., for a pulse duration of 0.03 s, the allowable value is 2 mA-s. The Taser with its very short pulse duration would have an even lower value. Once again it is important to note that the U.L. standard allows about one pulse per second compared to the Taser's 13 pulses per second. The reference to NIH sponsored studies at Statham Labs isn't sufficient for me to find this information. Any tests must include careful measurement of electrical parameters to properly evaluate such tests.

Item 7 has the medical bibliography and summary. In section I on heart fibrillation tests, most tests deal with 60 or 50 Hz tests with shocks of longer duration than for the Taser output. In section II, Dalziel and Lee discussed only continuous 60 Hz and dc with respect to let go current. Dalziel's study of impulse shock, III, dealt with capacitor type discharges rather than a continuous train of pulses. The electro convulsive therapy in section IV relates to shocks across the head and are unlike the usual points of application for the Taser. In section V, the U.L. electric fence history is useful except for the lower repetition rate for the pulses that must be considered. The ground fault circuit interrupter tests listed in section VI have little direct application in this case as they apply to a continuous 60 Hz current.

The summary in item 7 seems to infer more than is proper from the references. The heart fibrillation and let-go current studies were for 60 Hz so they must be applied with great care for the Taser type output. The electrical shock accident history dealt primarily with single capacitor discharge type accidents so once again great care must be exercized in applying these data to Taser type outputs. Electro convulsive therapy applies shocks to the head, usually 60 Hz, so these results have little application to Taser type output. The requirements for electric fences and ground fault circuit interrupters must be used with great care because of the type of electrical output of the Taser.

ELECTRIC FENCES

References

1. U.L. Bulletin of Research No. 14, "Electric shock as it pertains to the electric fence", Sixth Printing, December 1969 (Basically original report of September 1939).

2. U.L. 69, Standard for Safety, "Electric Fence Controllers", 3rd Edition, May 1, 1972.

U.L. 69

The standard for the electric fence provides a good basis for allowable, safe, intentional electric shocks.

¶93 500 Ω load for tests
(Lowest value for body resistance)

¶98 "Off" period greater than 0.9 s for sinusoidal-type output

Greater than 0.75 s for peak discharge-type output

(Since shocks are above let-go level, this gives person chance to get off the fence. Continuous output is not permitted.)

¶100 Any single failure in the controller will not produce a continuous current greater than 5 mA.

(This level should be below let-go current.)

¶108 For peak discharge type output "Off" period not less than 0.75 s.

"On" period not more than 0.2 s.

A curve is provided for the maximum allowable output in mean milliampere seconds versus time of the "on" period. This actually specifies an allowable energy in the shock pulse.

$$P = i^2R \quad W(J/s) \tag{1}$$

$$W = i^2Rt \quad J \tag{2}$$

$$W = (it)^2 \frac{R}{t} \; J \tag{3}$$

The curve is for "on" period times from approximately 0.03 s to 0.1 s. From 0.1 s to 0.2 s the allowable output is a constant 4 mA-s. Using the value of T of 500 Ω and equation (3), the following energies can be calculated:

t(s)	it(A - s)	W(J)
0.03	2×10^{-3}	66×10^{-3}
0.04	2.5×10^{-3}	78×10^{-3}
0.06	3.25×10^{-3}	88×10^{-3}
0.08	3.75×10^{-3}	89×10^{-3}
0.10	4×10^{-3}	80×10^{-3}
0.20	4×10^{-3}.	40×10^{-3}

¶110 For sinusoidal output

"On" time less than 0.2 s

"Off" time not less than 0.9 s.

A straight line curve of maximum allowable rms current versus "on" time of the shock is given for time of shocks from 0.03 s to 0.2 s. This curve has the equation

$$I_{rms} = -350\,t + 75 \text{ mA} \qquad (4)$$

The allowable current from equation (4) is compared to the value that could cause ventricular fibrillation derived from the following equation.

$$I_{rms} = \frac{100}{\sqrt{t}} \text{ mA}$$

t is in seconds.

t	$I_{rms} = -350 + 75$ (mA)	$I_{rms} = \frac{100}{\sqrt{t}}$ (mA)	$W = 500\, I^2_{rms}\, t$ (J)
0.025	65	632	52.8×10^{-3}
0.05	57.5	447	82.6×10^{-3}
0.10	40	316	80×10^{-3}
0.15	22.5	258	37×10^{-3}
0.20	5	223	25×10^{-3}

U.L. Bulletin of Research No. 14

Much useful data but a little old. C[illegible]lated currents when a light bulb in series with 120V line and the fence are actually higher than shown in the report as the cold resistance of a bulb is about 10% of the operating hot resistance.

ATTACHMENT 2

The following comments concern Dr. Bernstein's analysis of the TASER.

1. On Page 1 in Paragraph 2 the impedance between pairs of needle electrodes has been found to be on the order of 200 ohms. J.C. Heesey, M.D. and F.S. Letcher, M.D. of the Naval Medical Research Institute in their report "Minimum Thresholds for Physiological Responses to Flow of Alternating Electric Current Through the Human Body at Power-Transmission Frequencies" have determined that the minimum resistance likely to be encountered with small cuts and needle punctures is approximately 200 ohms. The place where the needle electrodes contact the body does not seem to make much difference as has been verified by tests on dogs by Dr. Bernstein.

2. On Page 11 in Paragraph 1 the reference to "Appendix E" should read "Appendix C".

3. One Page 14, Paragraph 2, 13 khz represents a conservative frequency band and also simplifies the mathematical analysis of the output waveform.

4. On Page 2 and on Page 20 the current that will cause ventricular fibrillation in adults is $I_{rms} = \frac{150}{\sqrt{T}}$ (ma)

   and in children is $I_{rms} = \frac{100}{\sqrt{T}}$ (ma)

   The more conservative children's number has been used.

   This equation is a result of Dr. Dalziel's and Lee's work with dogs and animals and is explained in detail in his report in IEEE Spectrum of February 1969 titled "Lethal Electric Currents".

5. On Page 20 it should be noted that the $W=500\ I^2_{rms}\ t$ (J) energy column relates to the $I_{rms} = -350t+75$ (ma) current column while the $I_{rms} = \frac{100}{\sqrt{T}}$ (ma) current column is shown for reference to indicate the relative allowable 60 hz current. Also please note that the t is missing in current equation $I_{rms} = -350 + 75$ (ma).

ATTACHMENT 3

TASER OUTPUT WAVEFORMS
MADE WITH 7623 TECTRONIX SCOPE AND
P6015 TECTRONIX HI VOLTAGE PROBE

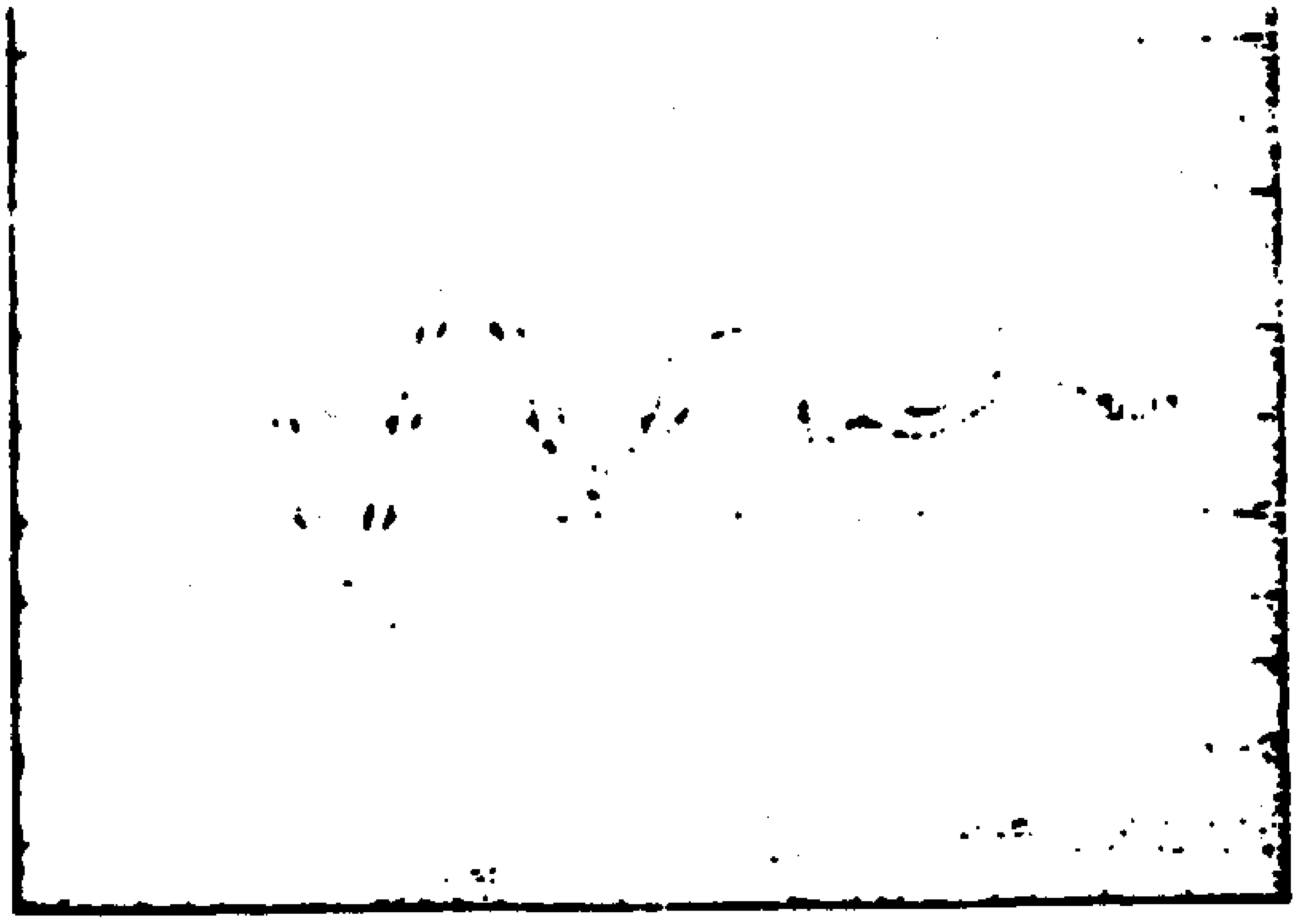
WAVEFORM NUMBER	LOAD ON OUTPUT	SCOPE TRACE NUMBER TASER S/N A2874	SCOPE TRACE NUMBER TASER S/N A3314
1	200Ω	1A	2A
2	500Ω	1B	2B
3	1000Ω	1C	2C
4	6000Ω	1D	2D
5	15900Ω	1E,1F	2E,2F
6	1" Gap	1G	2G
7	1/2" Gap	1H	2H
8	1/4" Gap	1J	2J

Pulses per second — S/N A2874 → 12.7 pps
S/N A3314 → 13.5 pps

Repeatability of waveforms was very good.

[illegible]

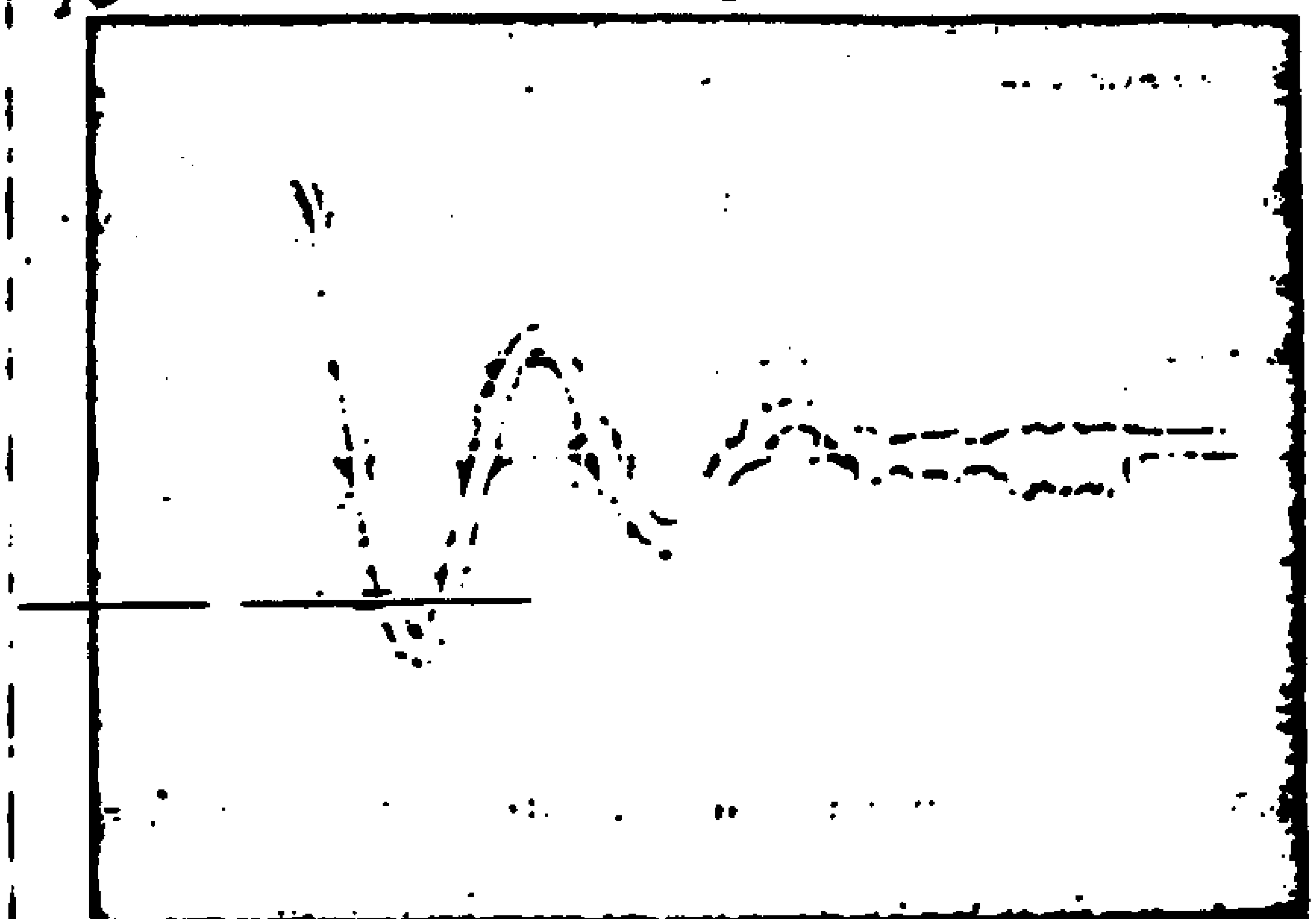
Vert. -5000 V/Div.



1B 500 Ω LOAD

Hor. -5μs/Div.

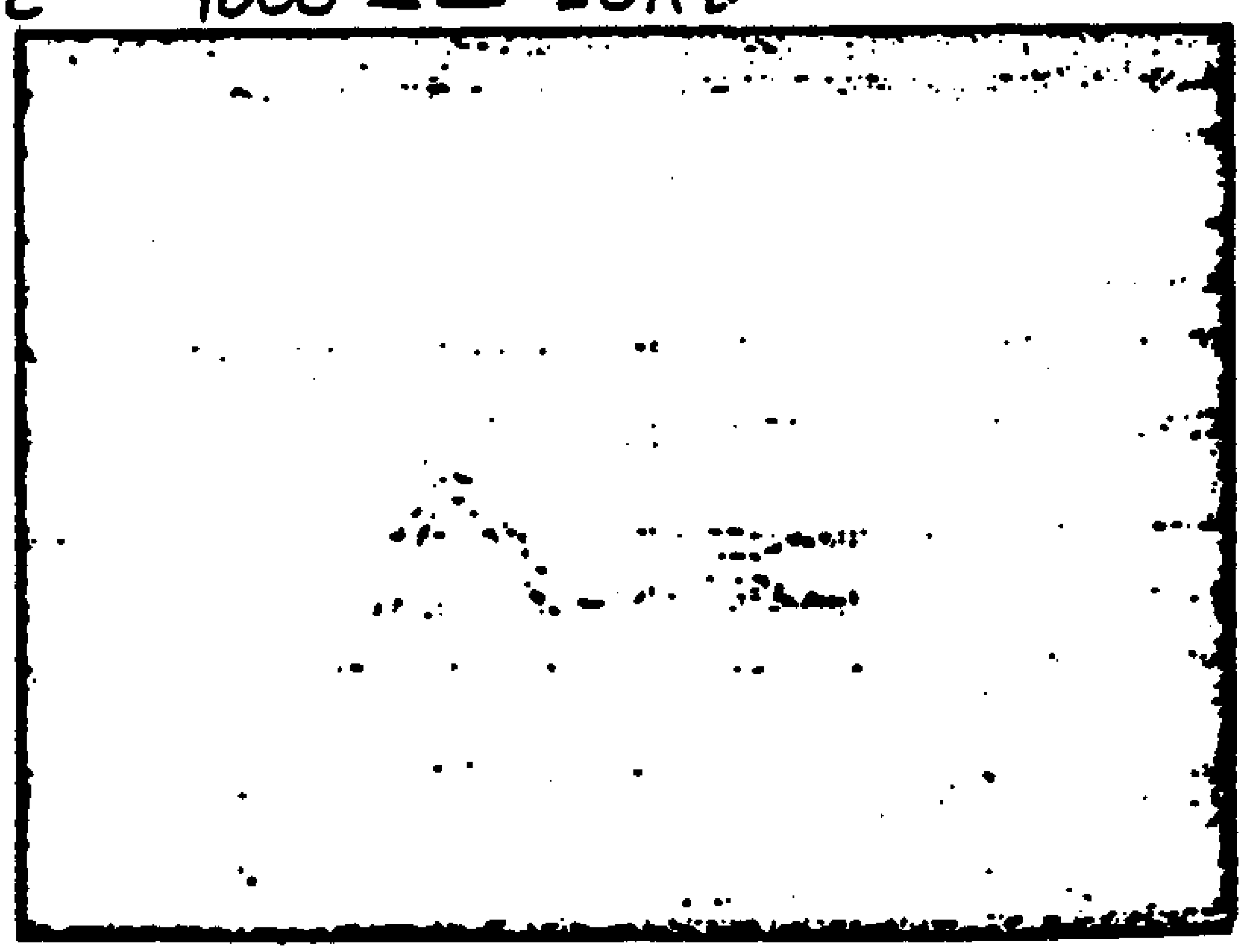
Vert. -1.000 V/Div.



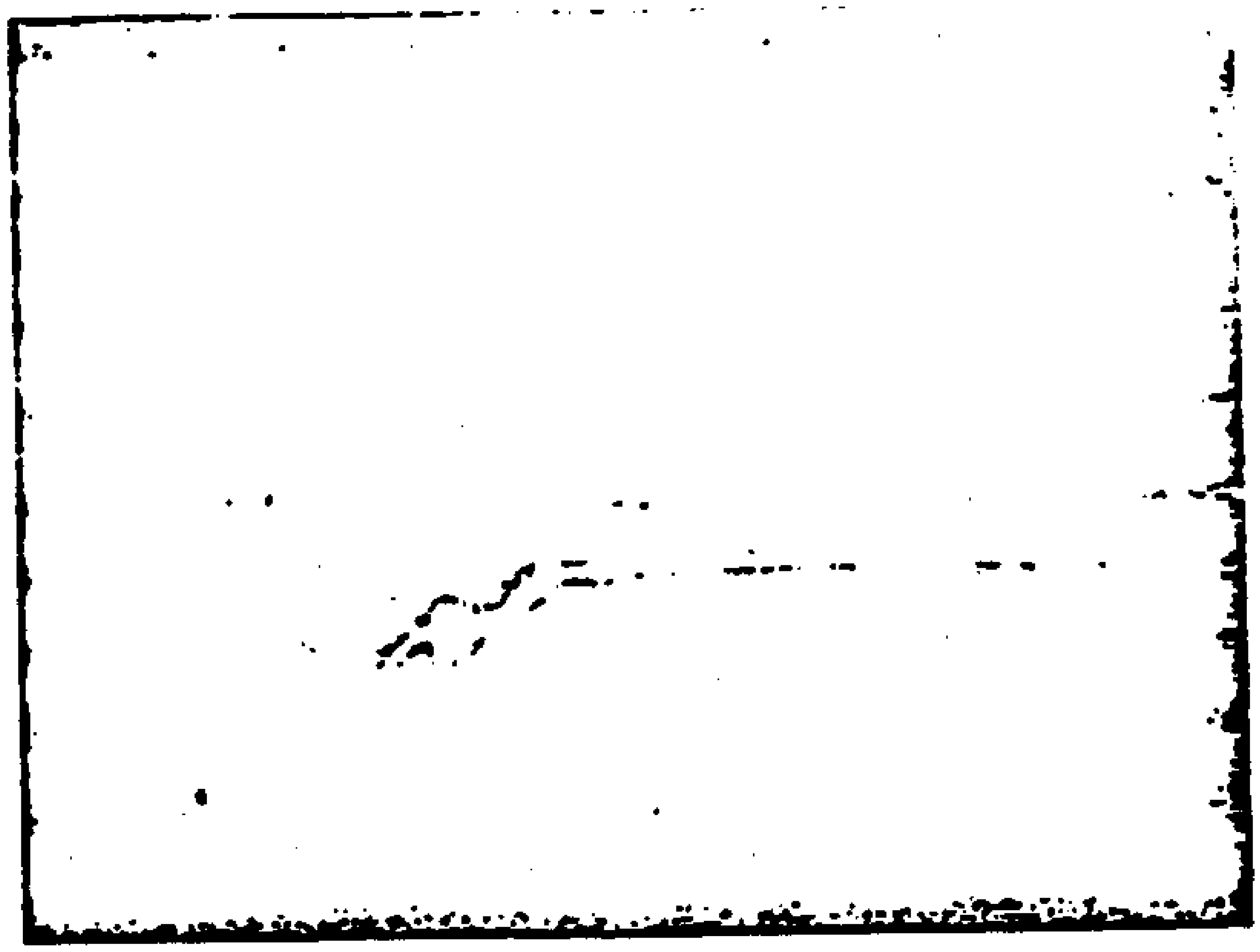
1C 1000 Ω LOAD

Hor. -5μs/Div.

Vert. -2000 V/Div.

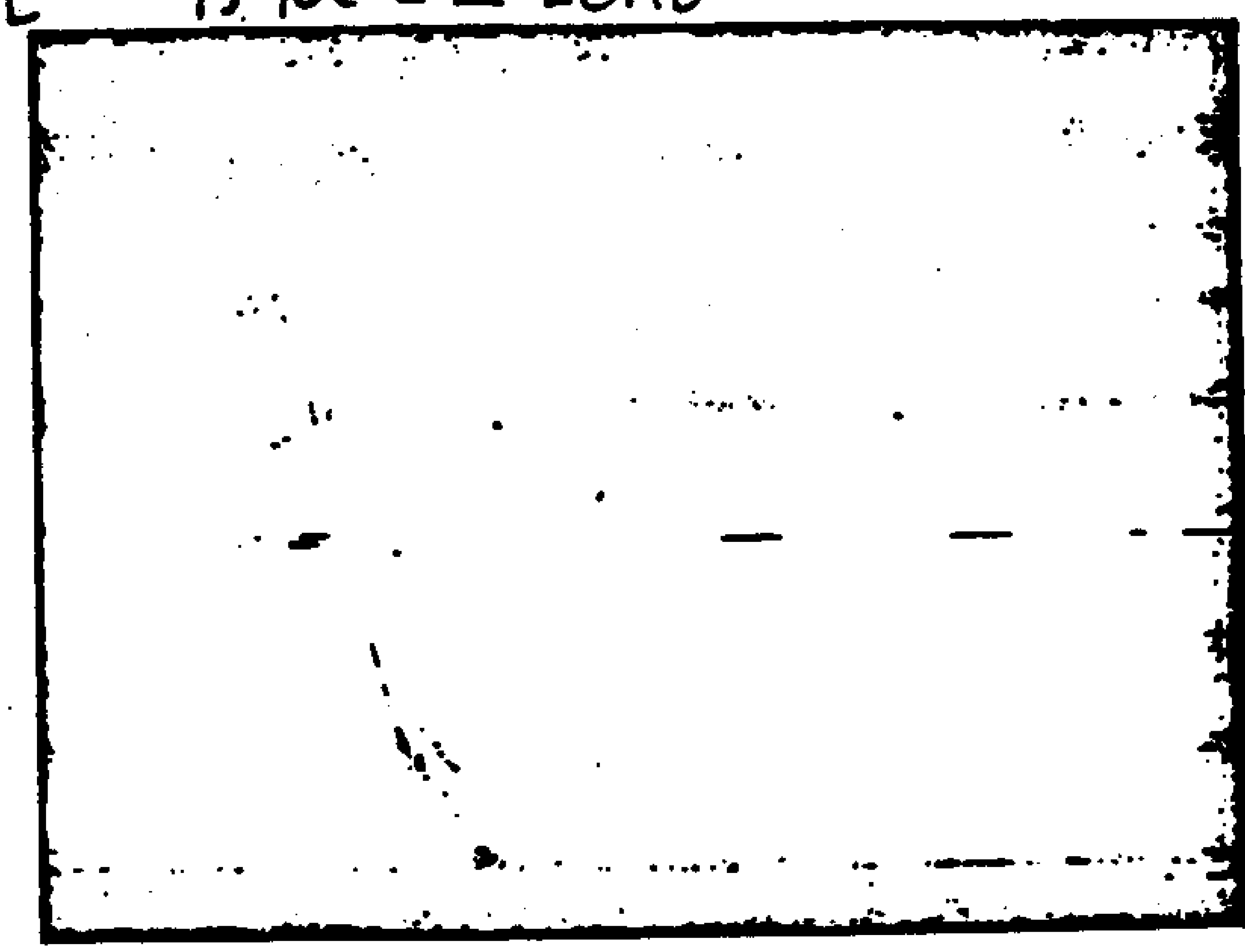


Hor.-5μs/Div.
Vert.-5000 V/Div.



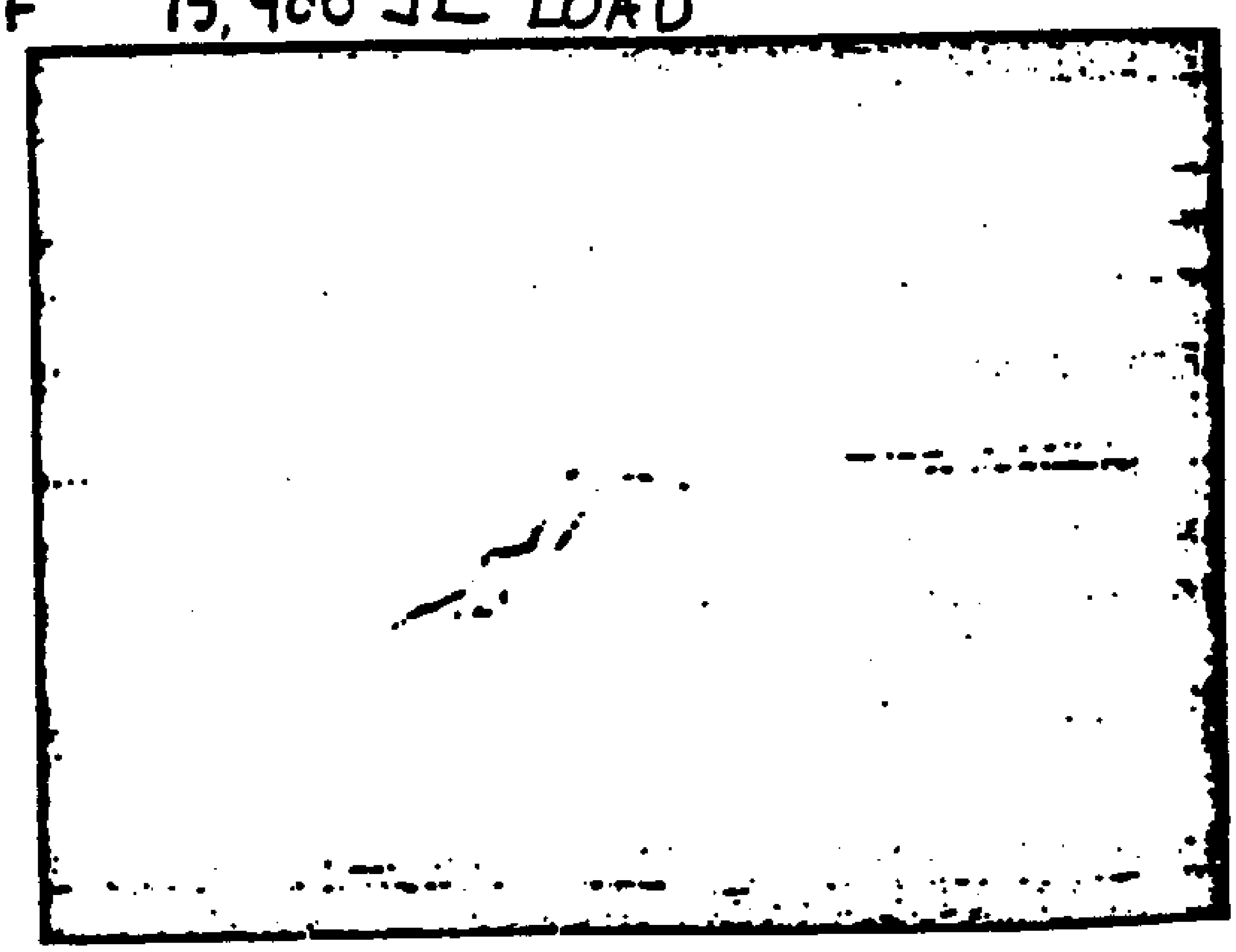
1E 15,900 Ω LOAD

Hor.-2μs/Div.
Vert.-5000 V/Div.



1F 15,900 Ω LOAD

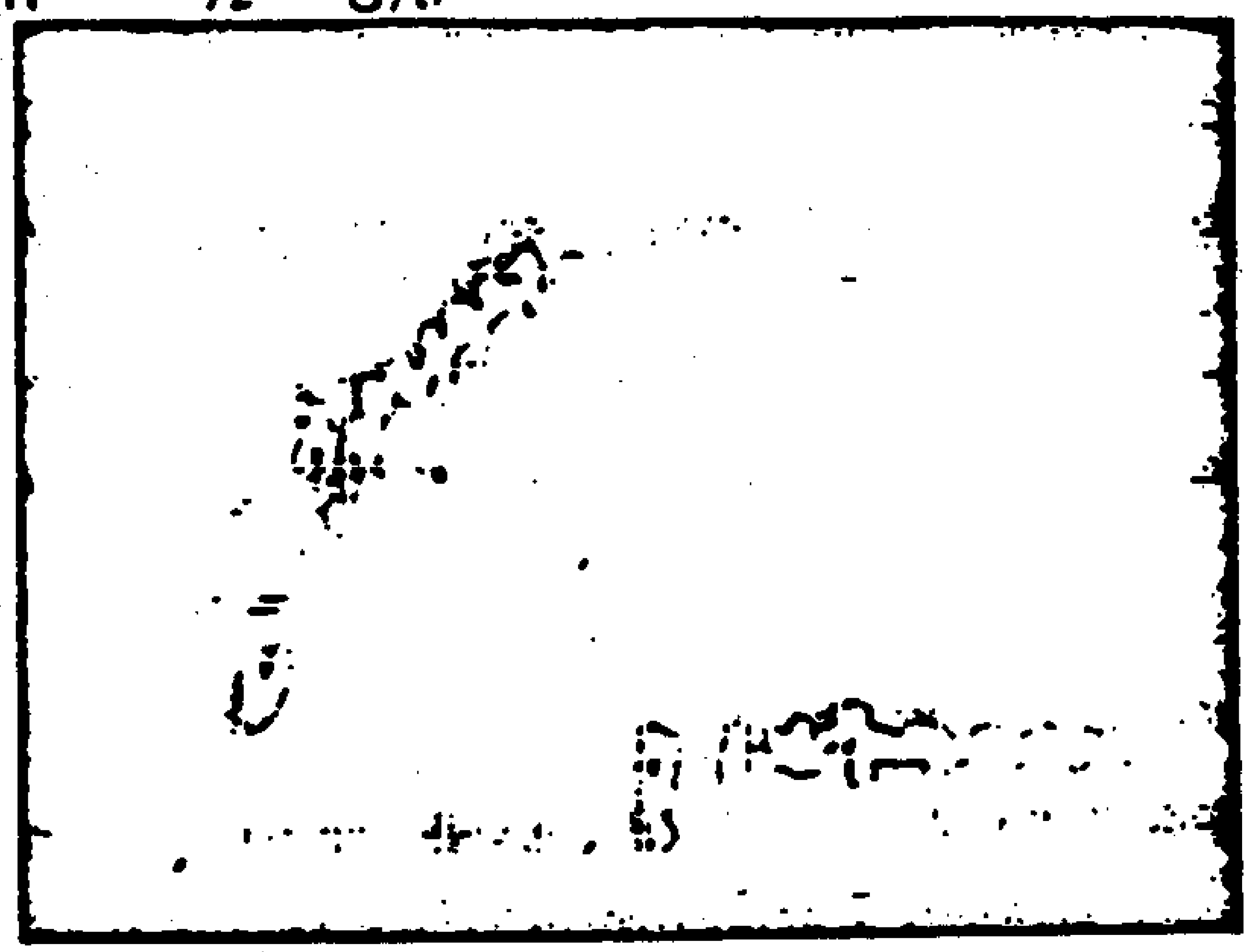
Hor.-5μs/Div.
Vert.-5000 V/Div.



Hor.-0.5μs/Div.
Vert.-5000 v/Div.

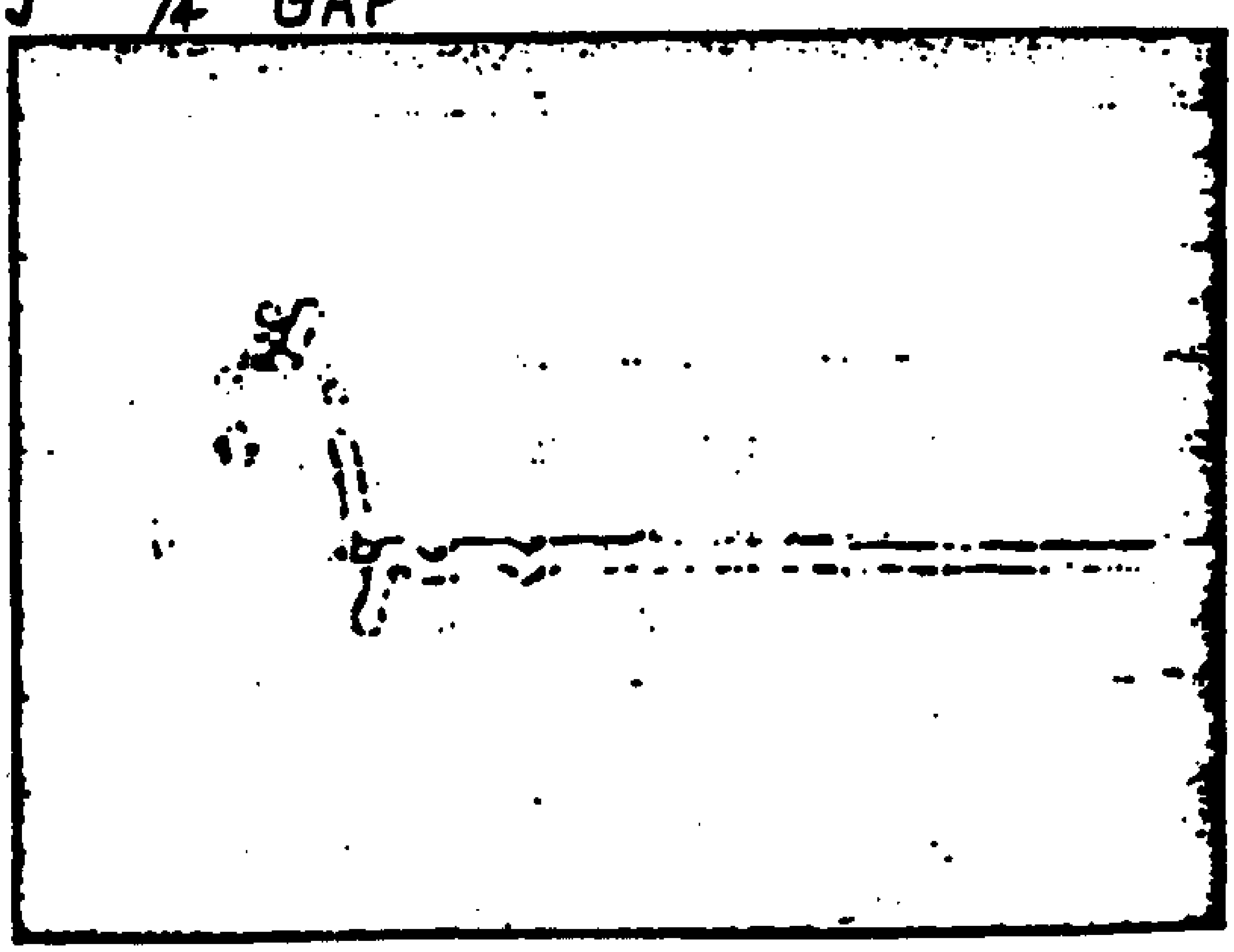
1H ½" GAP

Hor.-0.2μs/Div.
Vert.-5000 v/Div.



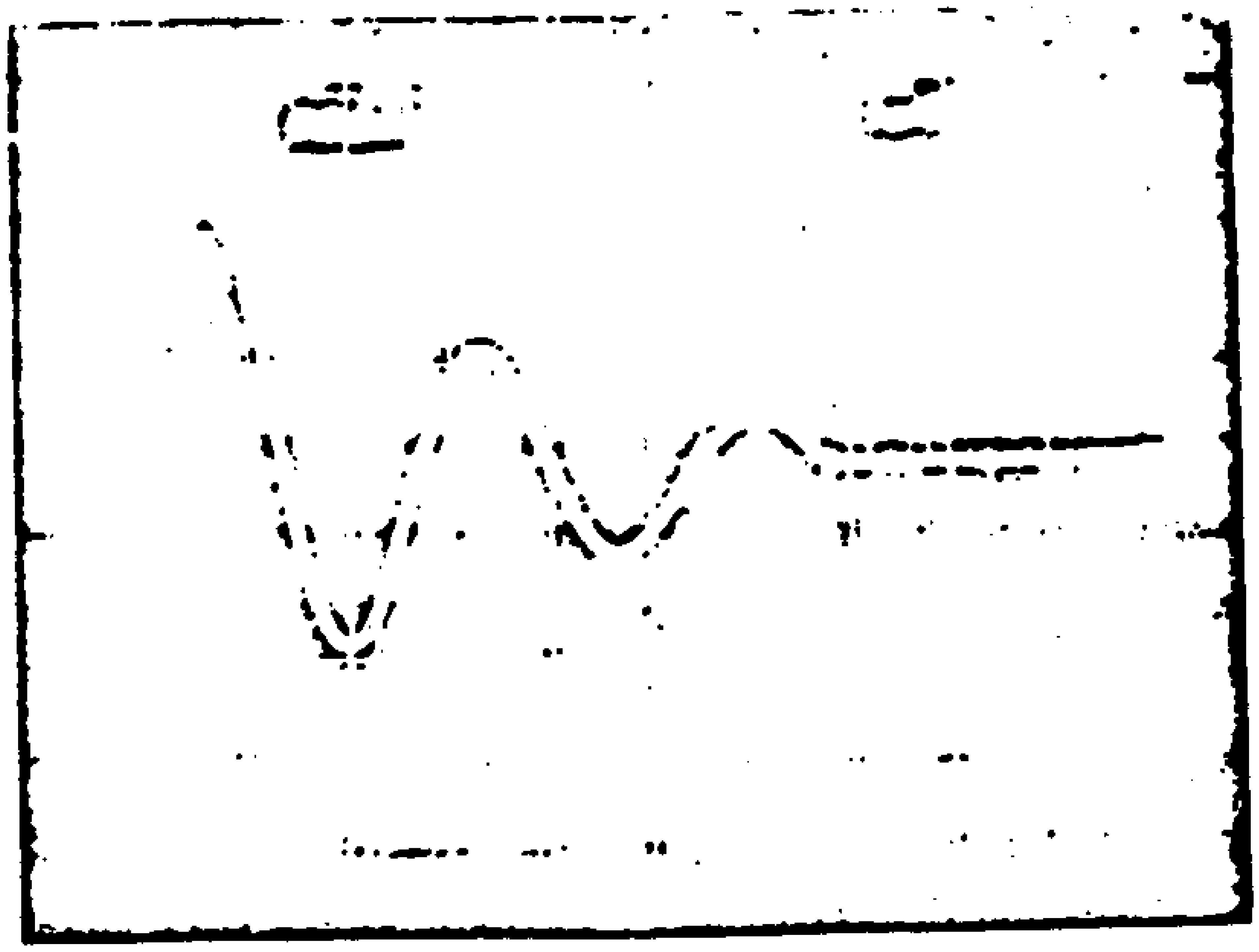
1J ¼" GAP

Hor.-0.2μs/Div.
Vert.-5000 v/Div.



Hor.-5µs/Div.

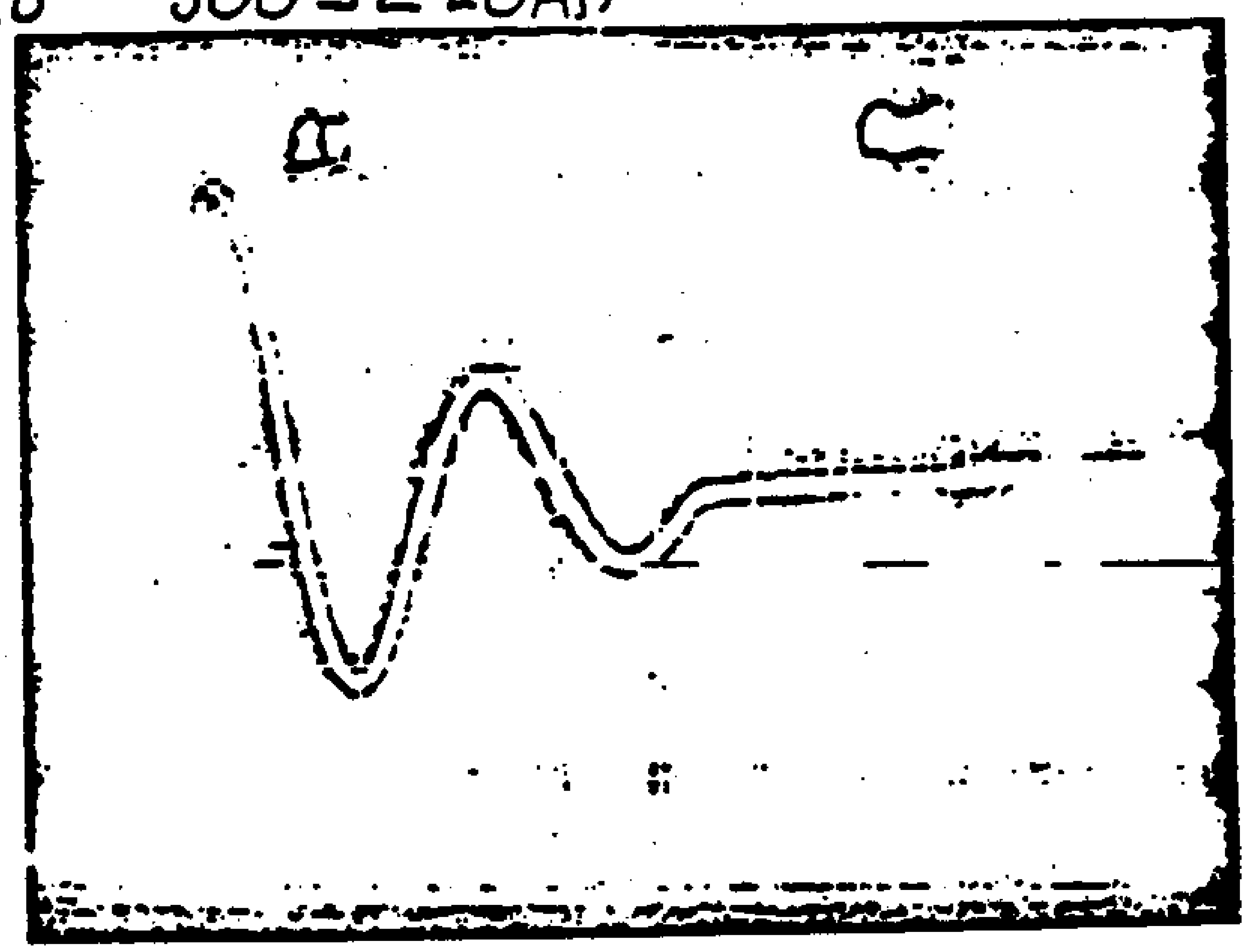
Vert.-500 v/Div.



2B 500 Ω LOAD

Hor.-5µs/Div.

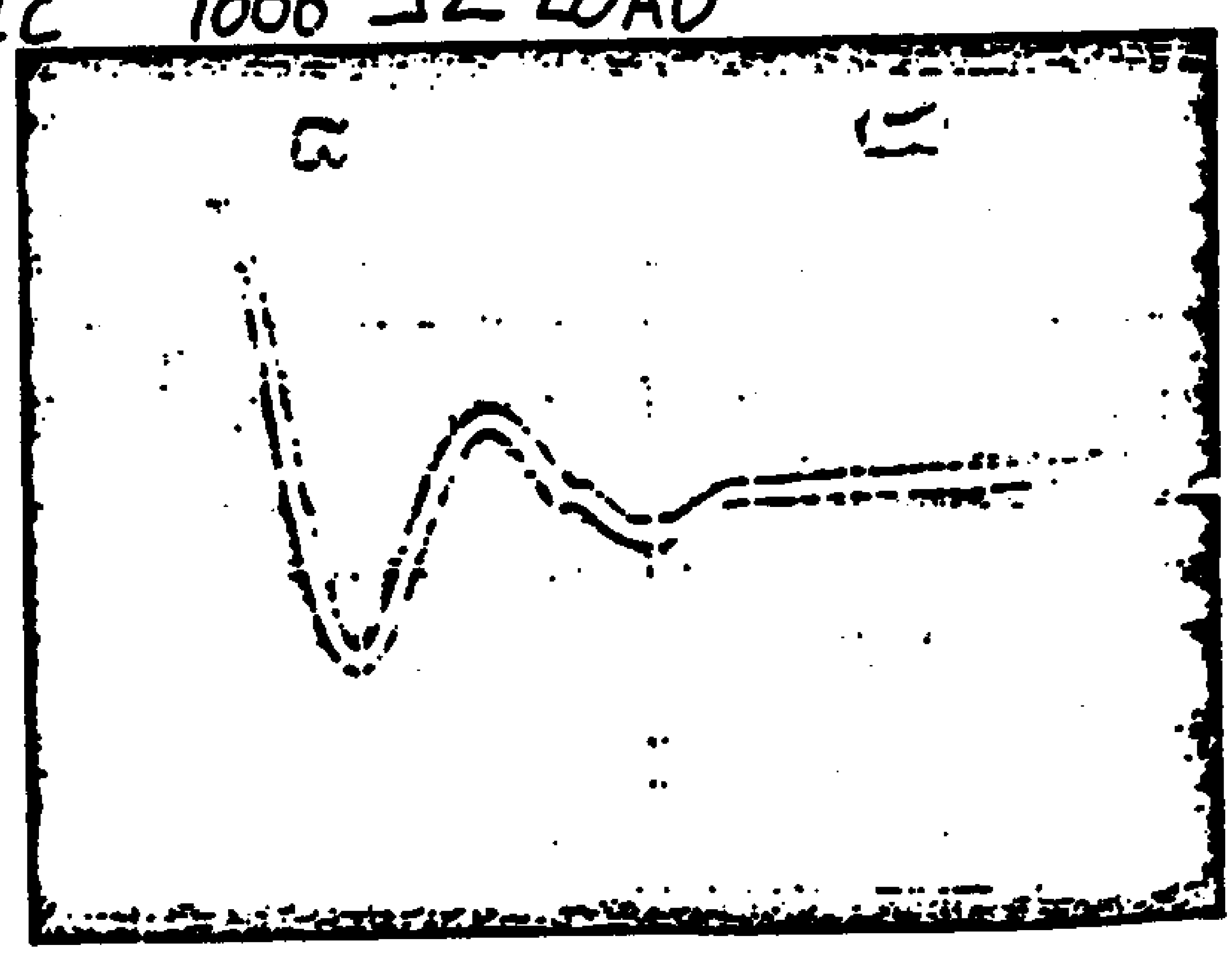
Vert.-1000 v/Div.



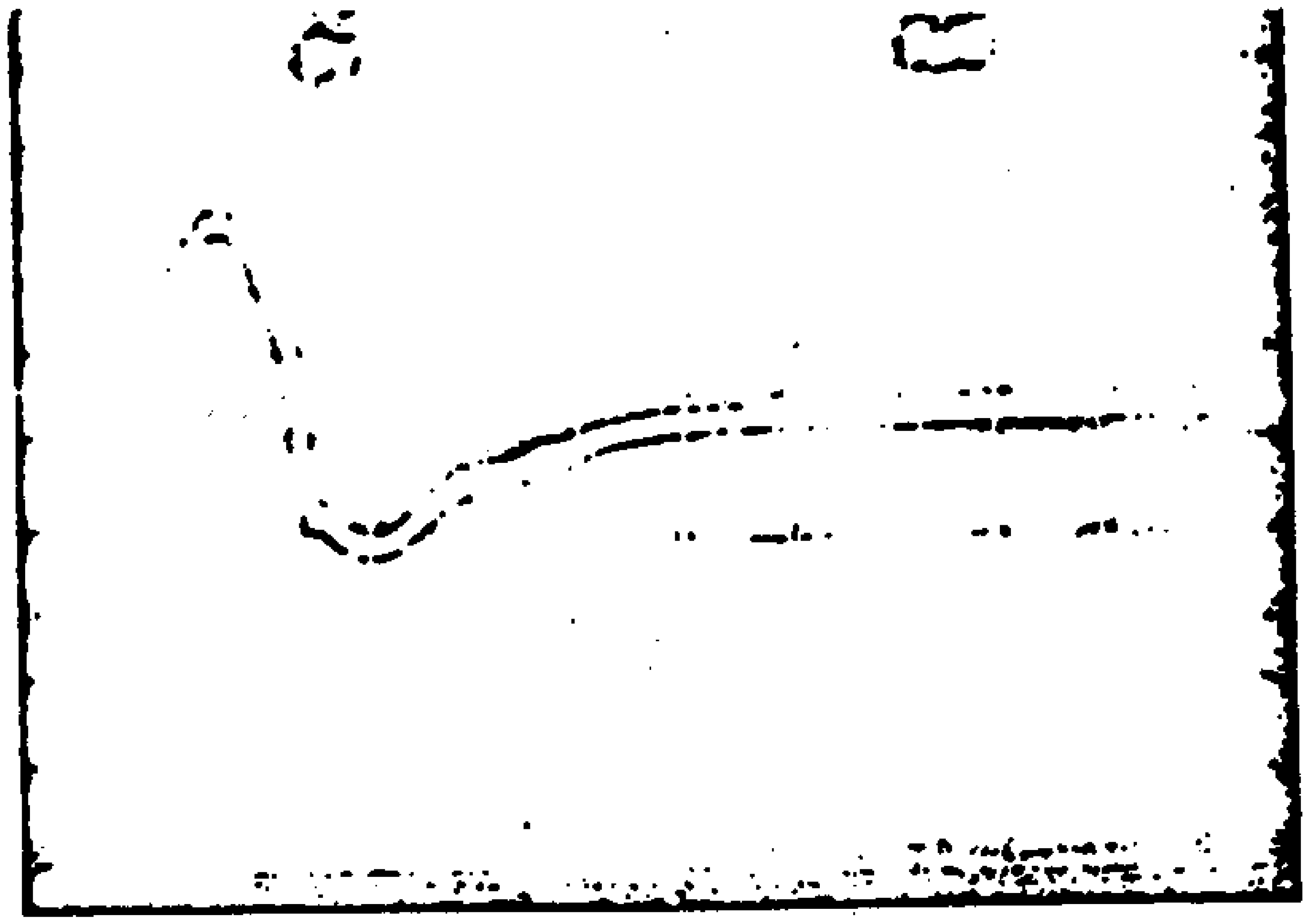
2C 1000 Ω LOAD

Hor.-5µ /Div.

Vert.-2000 v/Div.

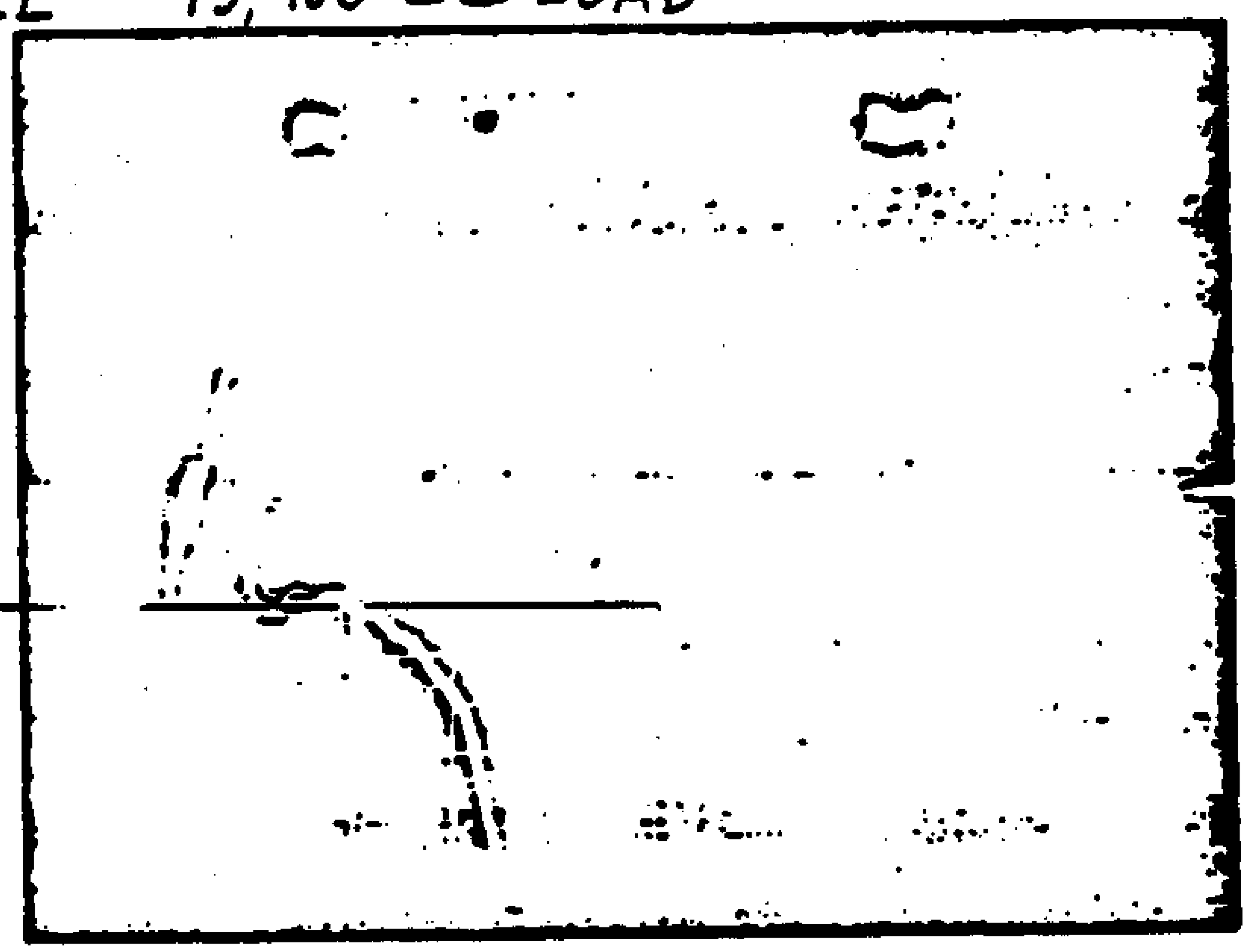


Hor.-5μs/Div.
Vert.-5000 V/Div.



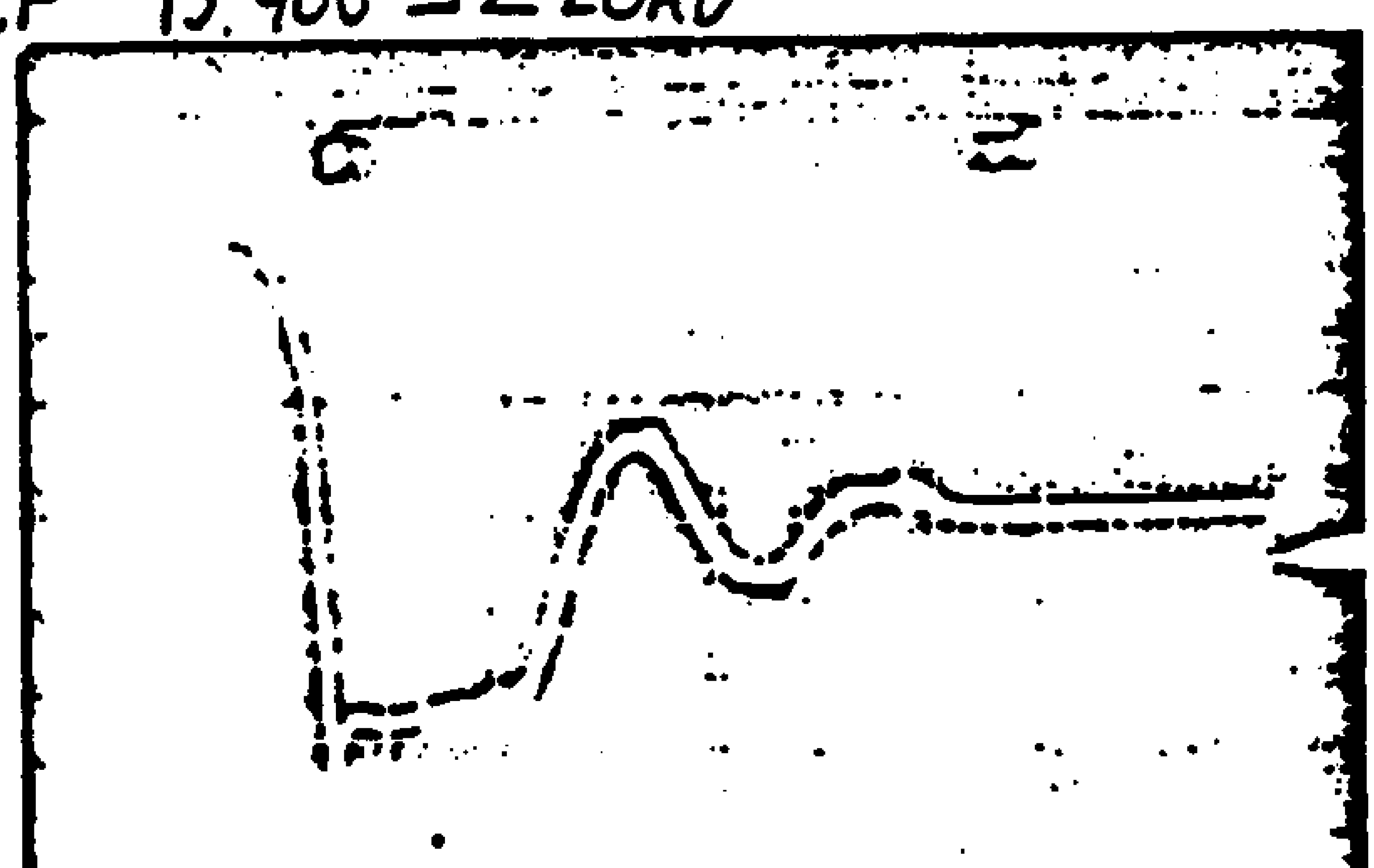
2E 15,900 Ω LOAD

Hor.-2μs/Div.
Vert.-5000 V/Div.

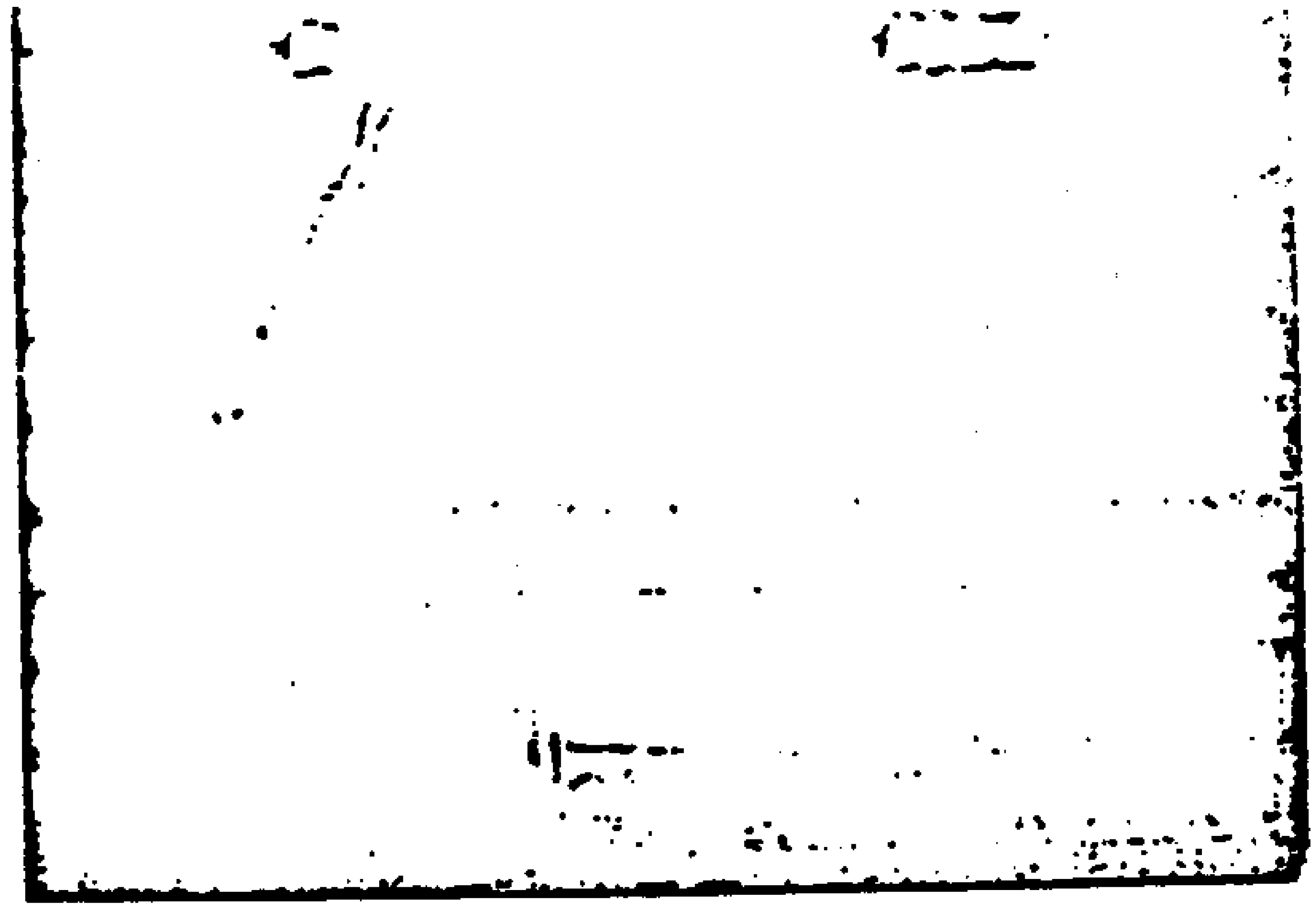


2F 15,900 Ω LOAD

Hor.-5μs/Div.
Vert.-5000 V/Div.

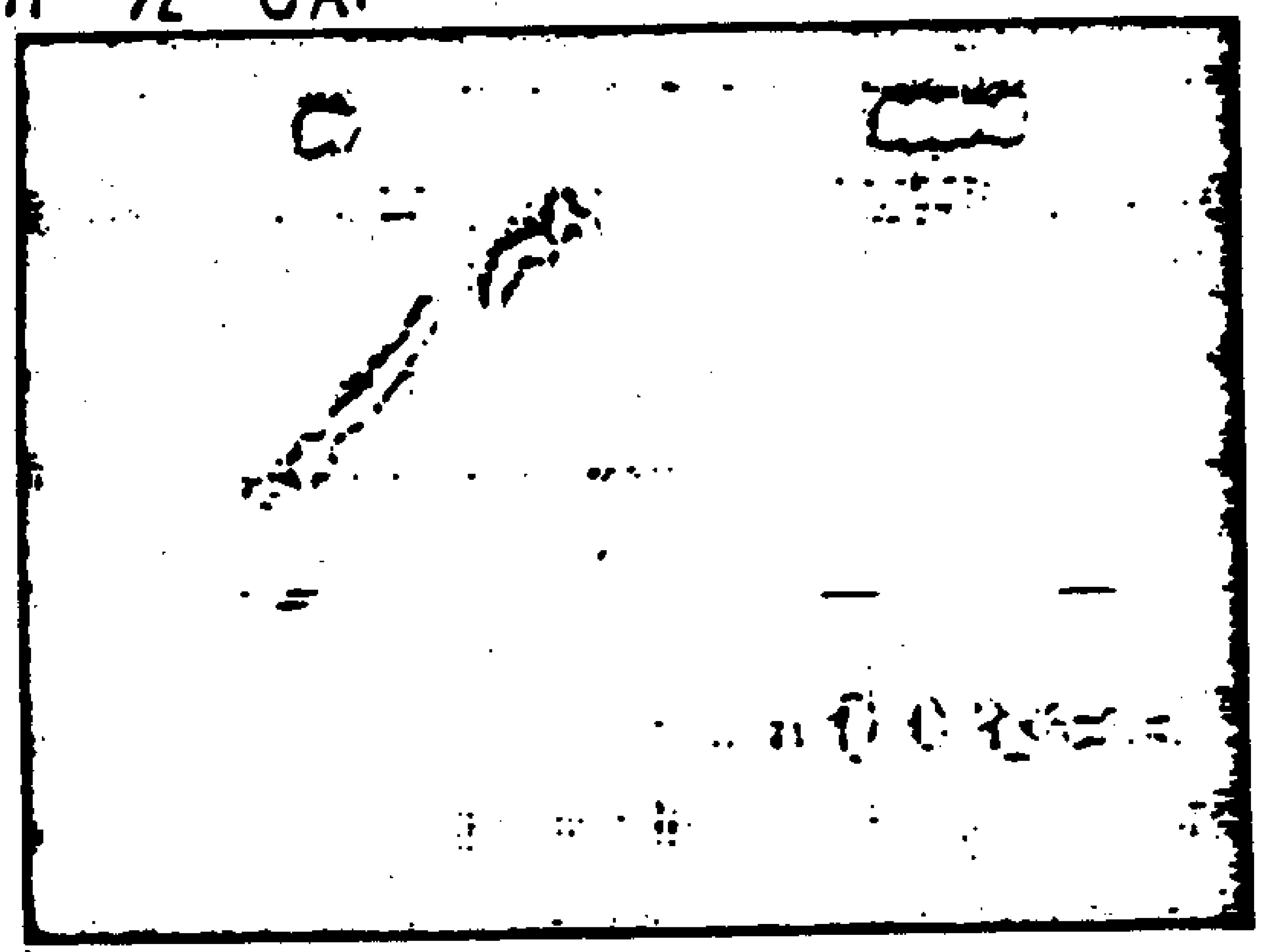


Hor.-0.5μs/Div.
Vert.-5000 V/Div.



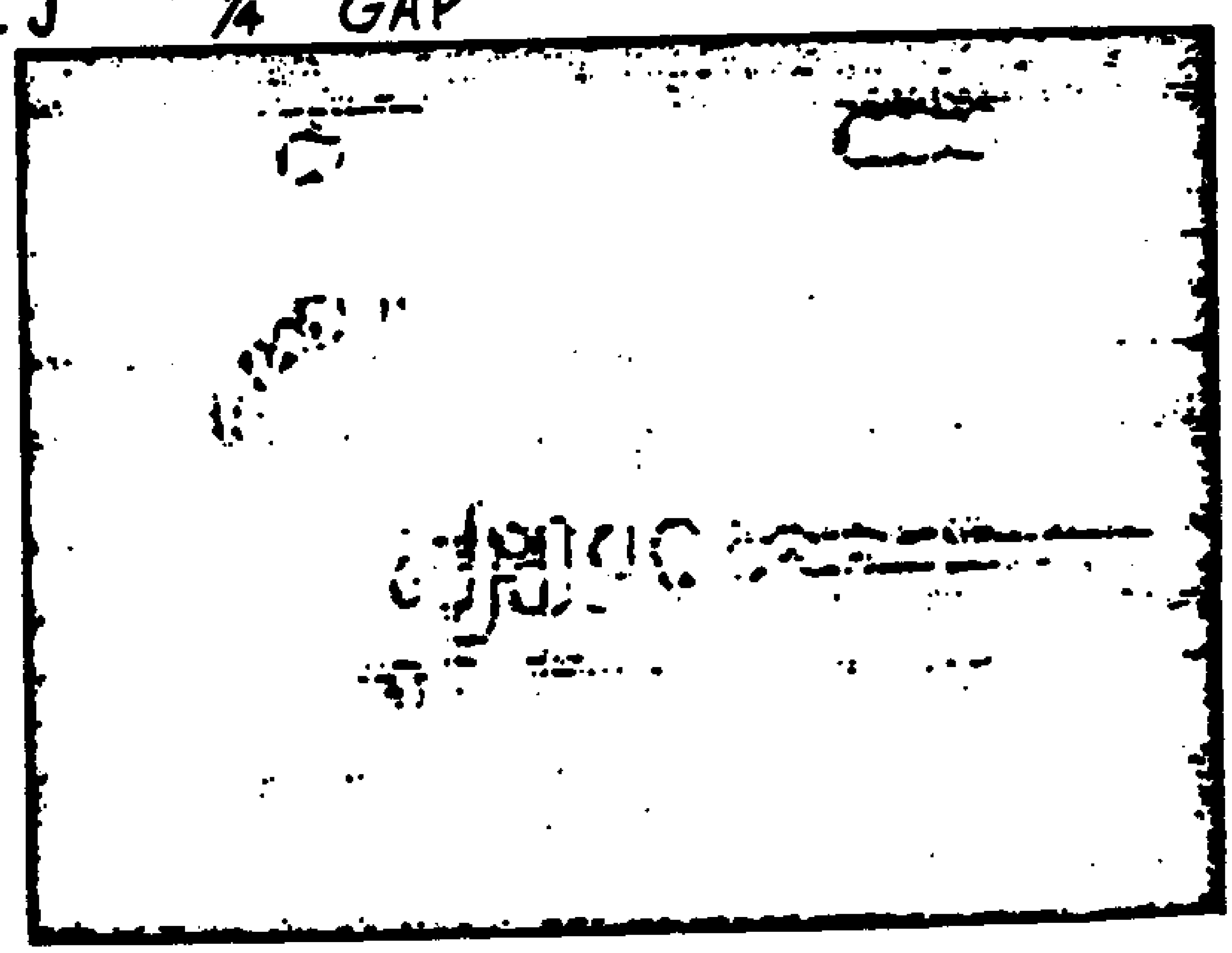
2H ½" GAP

Hor.-0.2μs/Div.
Vert.-5000 V/Div.



2J ¼" GAP

Hor.-0.2μs/Div.
Vert.-5000 V/Div.



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FEB 1[illegible] 1976
TECHNICAL ANALYSIS DIVISION

UNITED STATES GOVERNMENT

Memorandum

U.S. CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, D.C. 20207

TO : Joesph Z. Fandey, TAD/OSCA
DATE: February 10, 1976

THRU : Albert F. Esch, M.D., Director, OMD *Albert F. Esch*

FROM : Leo T. Duffy, M.D., Deputy Director
Office of the Medical Director *Leo T. Duffy*

SUBJECT: TASER TF-1, CP-76-5

The Office of the Medical Director has reviewed the material submitted by your Office concerning the subject petition. Although this reply will concern itself only with the medical aspects of this subject, we recognize at the start that this product is manufactured as a "dangerous weapon", and should be so treated. As such, its effectiveness depends on the creation of some measure of injury in order to fulfill its intended purpose. Therefore, it appears that the role of this Office is more concerned with assessing the "risk of unreasonable injury" rather than the "unreasonable risk of injury". This memorandum will not address the social, moral and philosophical issues which are necessarily bound to be raised in the discussion and consideration of the use of this product.

From the electrical data supplied as the design output, and our survey of the literature (references attached), it is apparent that the stated available electrical current (50,000 V/0.3 joules/10 pps) is non-lethal when the weapon is used as directed on the "average, healthy" adult. The current-related injury sustained with the intended use of the TASER is related to the neuromuscular system, and is exhibited as an abnormal, tetanic or sustained contraction of muscle groups which has the effect of immobilizing the recipient. This reaction is induced by the action of the electric current passing through the skin, and then following nerve pathways by means of the nerve fibrils (cells) and their myelin sheaths, both of which are excellent conductors. The current is then continued through nerve endings (synapses) which are attached to muscle. The transference of the charge to the muscle cells causes them to contract. This injury process, ordinarily, is temporary and reversible when used as indicated on the healthy human. The level of current is comparable to that of U.L. approved electric wire fences as far

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as the "freezing" action is concerned. However, a major difference exists in that the electric fence pulsed charge of approximately 4.0 mAmp has OFF and ON periods which would allow the ability to "letgo", and get free from the fence. With the TASER the "let-go" is dependent on the user interrupting the flow of current by releasing the release bar.

With exposure to the stated amount of TASER current, there is a wide margin of safety as related to causing severe cardio-vascular reactions. An alternating current of 60-120 mAmperes, 120 Volt, 60 Hz can result in ventricular fibrillation. This is an asynchronous, uncoordinated rhythm of the heart beat which is incompatible with survival unless the normal rhythm is restored by means of a defibrillator device. The TASER current of 0.3 joules (watts/second) is well below the 10 to 50 joule threshold above which ventricular fibrillation can occur. This safety margin would be diminished in a person who has existing cardio-vascular disease. For example, an elderly person with arteriosclerotic heart disease would be subject to the precipitation of heart failure under the stress of convulsive seizures associated with Electric Shock Therapy. The margin of safety would also be reduced with a prolonged continuation of TASER current.

Injuries related to the impact of the barbed darts causing puncture wounds of the external surface of the body would be relatively minor, except for impact on the eye. The chance for initiation of events leading to a total loss of vision in the affected eye would be extremely high should such contact occur. Electric energy applied in the vicinity of the eye has also resulted in delayed cataract formation.

There is no evidence that adverse psychological, or neurological, effects, stemming purely from the electric current charge of a TASER, would be induced.

Injuries, resulting from falls involving an incapacitated, inert human body, are speculative depending upon the activity of the recipient at the time of impact, and on contact with external hazards, such as the head striking the sharp corner of a table. The likelihood of injuries, such as fractures, is increased in the case of the aged or physically handicapped.

In general, the severity of systemic effects from the passage of electric current through the body depends on several factors. These are: 1) type of circuit,

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2) voltage, 3) value of the current, 4) duration of flow, 5) resistance of specific tissue, 6) area of contact, and 7) pathways followed through the body. In addition, people with chronic cardio-vascular disease, the elderly and children would be increasingly susceptible to adverse effects. Therefore, this Office agrees with the conclusions stated by the manufacturer in his summary of May 10, 1972, page 3, which reads ---"the conclusions reached as a result of these studies and special tests is that the TASER is non-lethal at the design output to normally healthy people. However, it must be emphasized that neither this feature nor the non-injury or no harmful after-effect aspects can ever be guaranteed. There is no weapon, technique or procedure for subduing, constraining or dispersing that does not involve some risk of injury to healthy persons or of death especially if the individual has a heart ailment."

References (These are available in the Office of the Medical Director)

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