

THE TASER DEVELOPMENT PROGRAM

INTRODUCTION - the search for an electric waveform that could be used in a weapon to capture suspects or public defense began in 1966. The discovery of the pulsed wave which became the basis for the weapon called "TASER" did not occur until 1969 and was preceded and followed by extensive testing on both men and animals to establish that it is nonlethal and non-injurious as well as powerfully subduing and rapidly incapacitating.

The years between 1970 when the first pre-production prototypes were made and 1975 when Taser was first marketed were filled with carefully planned tests and many demonstrations to government agencies, industry and private parties. From the beginning, it was realized that a new type of weapon would be subject to coverage by the news media and especially vulnerable to law suits. Taser was not a toy and we had to exercise every possible precaution and try to consider the many possible situations and circumstances of use.

This report is motivated by the continuing criticisms of the Taser leveled by people in several groups - sometimes well-meaning but ignorant, sometimes coming from certain lobbies with vested interests that have attempted to have the Taser banned since 1975. It is a summary, not a detailed report, which will focus upon the charges frequently heard, to wit: 1) it can be lethal, 2) it causes burns, 3) it was not adequately tested to prove nonlethality and 4) it is a torture device.

The enclosures have been selected from our files to show that in fact tests were run and it is safe and effective. Actually, the real proof lies in the unbelievable results obtained by thousands of uses by police departments over the past 15 years. This is further augmented by its equally amazing performance in animal control.

EARLY RESEARCH concentrated primarily upon literature surveys to find out what was known about the effects upon humans of electric shocks. UCLA and UCI (Irvine) were the main sources. The enclosure "Medical Bibliography and Summary", prepared in 1970 covers the more important findings. Jack Cover, the inventor and Taser developer, made the searches, studied the reports and reviewed them with one or more of his MD associates. In this early time period, Dr's John Kalbfleisch and Toby Freedman were his main consultants.

Medical work included animal tests on fibrillation of the heart which is perhaps the most critical danger to humans receiving even 'mild' electric shocks. As it turned out, one of the most important studies was performed by the Underwriter Labs on electric fences (under the auspices of the U.S. Government) in the time period of 1936 - 39. U.L. not only reviewed medical work but also ran tests and derived a safety standard for electrified fences still used today.

In this work I thought I perceived a possibility and I focused on it as I went through other studies such as John Hopkins and Dalziel of Berkely. Tests run by the researchers followed a strict format of shock delivery to the heart of various animals, i.e. a single shock of measured time duration and current magnitude was delivered and if the heart did not fibrillate, a second shock of greater magnitude followed keeping the time interval the same. This program of step-up continued until the animals heart fibrillated. Then another animal was tested changing the time interval and repeating the current incremental change.

The important conclusion reached and stated by the U.L. and others (Dalziel coined it an electrocution value) was that there was a relationship between shock strength and time duration which was expressed as an equation of current-time product. If the shock was kept below this value (UL's value was 4m.a. - secs; see the Encl. "Pulsed Electrical Shock Criteria") there was no danger of causing fibrillation. All of our electrified fences abide by this standard!

Other references of interest and value shown were shock accident history which seemed to indicate that humans could survive enormous jolts if they were of very short duration. This was partly born out by tests on rats and other animals which reached values of 200KV and 400 amps; dogs survived 1000 joule shocks at 4 microseconds.

Also, ECT - electroconvulsivetherapy - had been used on humans for years and provided more information concerning shock values when the head was involved. Another enclosure cites some of the experts I consulted with in this field.

It was now 1969 and I was about to find the 'breakthrough'. Using a capacitor of about 1/4uFarad and charged to 100 volts, I passed the shock through my lower body (avoiding the heart area). The resulting JOLT was so different from previous shocks that I knew I was on the right track. Aside from a strong muscular contraction, the shock did something else that is best described by saying that I was conscious of an attitude change. It was not only subduing, it affected my mood so strongly that I turned off my power supply and sat and thought about what I was doing.

After a short time it came to me - this was it! This was exactly the effect I had been looking for and I then devised a program of progressively testing the capacitor discharge shocks at various levels on different parts of my body.

The point here is that I was now deliberately testing capacitor discharges upon myself and began to extrapolate the I vs delta time backwards on the enclosed graph. I found that as the discharge energy increased so did the physiological effect (see enclosed test results). Note that I avoided transthoracic shocks but I had now graduated to multiple shocks. I could adjust my test equipment to vary the prf - pulse repetition frequency - as well as voltage and the number of coulombs. I very quickly determined that pulses containing as little as 0.1 joule repeated only 3 times per second were very disconcerting!

Also, while it was comforting to know that my power supply was like a defibrillator, I knew that I still had to cross the Rubicon and prove that this waveform, especially the repeated pulses, would not cause fibrillation. So, as 1970 rolled around, the time had come to run tests on hearts - first animal and then human.

Animals were fairly easy to obtain and the results of the July 11, 1970 test on a pig are enclosed. The results were 100% successful. Not only was the pig frozen at appropriate levels, but the full output with multiple pulses passed right through the heart were harmless. Dr. Toby Freedman and the other MD present were absolutely amazed at the effectiveness - we were all amazed when, tests complete, the pig was released and raced off to join the others for lunch!

Continued Animal and Volunteer Tests - tests on pigs, cattle and a dog were stepped up in 1971. Tests run at Ontario, CA, on cattle ranging from 250 to 2000 pounds in which the current input points were varied to include the heart, spine and brain were all successful causing no injuries, but now I began to realize that animals required substantially more energy per pulse than did humans. (later tests on Rhesus monkeys at an Army Research facility in Aberdeen, MD, really underscored this - the 1 lb animals were hardly bothered by the full output of the Taser Std. prototype that could easily down the most powerful man!).

In Feb. 1971 I signed contracts with Advanced Chemical Technology Inc. who agreed to pay the costs involved in getting the Taser into production, including "all up" instrumented tests of paid volunteers. These tests would be the first in which the Taser's pulsed waveform would be passed through the chest of human beings. At first, it appeared that we would not be able to do what was needed - run the tests in a hospital under the supervision of MD's and using medical instrumentation to monitor the heart. Of course it was also necessary to have emergency equipment and procedures ready to go if necessary.

The problem was that neither the hospitals or the MD's we talked to wanted to be part of this - they all feared law suits. That's when Dr. Frank Summers came on the scene. Through a friend he had heard about the Taser. He is an anesthesiologist with a BSEE and had been quite interested in work done on electrical anesthesia. Frank was all for the Taser from the start and quickly arranged for the tests to be run at St. Joe's.

Al Fraser was the first to be tested - end of June 1971; Richard Roper on Sept. 30, 71; John B. Cover (with production units) on Sept. 28, 1974. All of these were uniquely successful as well as being very impressive. There have also been a number of other volunteer tests done 'in person' before various committees and medical authorities across the country. And of course, we have demonstrated the Taser on TV shows such as "That's Incredible" (1981).

Again, the extensive field use by police provides the best records of all. However, here again we have had the problem of persons, sometimes MD's, making statements to the media that are totally wrong because they know nothing about the Taser and all of it's background and testing. The enclosures cover some of the incidents such as the one involving the Sutter Memorial Hospital in Sacramento, CA, which had very positive results.

It was certainly inevitable that there would be deaths of some suspects arrested and upon whom the Taser (and usually other forces) were used. In many cases the suspects were heavily drugged and even had illnesses - serious heart problems - that could have caused their death without any interaction with police. The problem that arose was that it was often impossible for medical personnel present at the time of death - or the Coroners Staff during autopsy - to determine the true cause of death. But, our legal system requires them to list the Taser as a possible contributing cause in the absence of knowledge of the cause.

The enclosure cites two cases (Oct. 88) in which Taser had been a suspect but was cleared (also shows confusion with the Stun Guns which do not project, have closely spaced probes which do cause burns and which are primarily pain-compliance devices, i.e., they do not have the effectiveness of the Taser). Another more recent (3/91) Coroners' Finding published in the Forensic Science Journal (also enclosed) basically absolves Taser from contributing to any of the 15 deaths occurring during the past 10 - 11 years the LAPD has used them.

Animal Control and Husbandry - several enclosures report upon special animal tests involving different species. As stated earlier, animals require more 'power' than humans. The Co. has built several prototype rifles capable of greater range than the basic Taser and having variable power outputs up to 30 times the basic Taser output. Personnel from the U.S. Wildlife Service and the California Fish and Game have conducted tests and written articles citing it's performance. Unfortunately, the company does not have funds to put these into production at the moment.

Summary: - we believe that the Taser is nonlethal and basically also non-injurious. The basic understanding of effects of electrical shocks in heart fibrillation and the extensive tests performed to arrive at the safe-value for electric fences was the basis for considering the Taser waveform safe. The extrapolation of safe current versus time duration to shorter - much shorter time durations - had been proposed and more or less accepted as valid before Taser research began.

Our testing on animals, especially pigs, included shocks directly through the heart region - some of which were 10 times greater than the Taser output. There were no deaths and no injuries. The same is true of our tests run on volunteers who were medically supervised and instrumented. In addition the company has Tasered some 20 other volunteers during demonstrations.

DESCRIPTION OF THE TASER ELECTRIC WAVEFORM

Background - during the development of the Taser nonlethal weapon (1966 -74), it was discovered that very short duration (microsecond), high energy, predominantly d.c. pulses were nonlethal and non-injurious, but had a profound physiological and psychological effect upon both men and animals. When the pulses were rapidly repeated - at 3 or more pulses per second - complete incapacitation resulted within a few seconds.

In the 1971 - 74 period, tests on volunteers were done under the supervision of Dr. Frank Summers with two cardiologists, a physiologist, EKG and other instrumentation plus two 16mm movie cameras, at St. Joseph's Hospital in Orange, CA. In addition to the almost instantaneous, complete incapacitation - resulting collapse to the floor - it was observed that the volunteers' facial contortions indicated extreme pain, yet the test subjects denied feeling any pain. This was an unexpected finding!

During the ensuing years there have been thousands of uses, mostly by police on suspects, but also other volunteers and animal tests. The following additional effects of the Taser have been observed.

A) Subduing and Mood Changes - people apparently mentally deranged or drugged engaging in violent actions exhibit a complete "personality" change after being Tasered and incapacitated for 3 - 5 seconds. The mood 'swing' from the unreasonable and uncontrollable is to a totally different one displaying reasonableness and willingness to cooperate.

B) Calming Effect Upon Animals - many tests have been performed upon different animals (goats, sheep, deer, pigs, cattle, lions, hippos, black bear and one grizzly bear plus 8 - 9 bison/buffalo, to name a few!) often in conjunction with the U.S. Fish and Wildlife Service, California Fish and Game, the Smithsonian National Zoological Farm (lions), and veterinarians, farmers and ranchers. These tests showed that the Taser waveform (TWF) had a calming effect even upon bison and cattle, to the extent that many did not want to get up off the ground after it was over!

Note, however, that animals require greater energy in the TWF pulses to achieve the same results - presumably due to the greater sophistication and sensitivity of the human central nervous system. This was first noted during tests on pigs and later (1973) strongly confirmed with tests upon 1 lb Rhesus monkeys at Aberdeen, MD. Wildlife Biologists and Vets are very enthusiastic about the ability of the TWF to capture and control animals, both wild and domestic, and unlike other techniques, such as nets, lasso's or drug darts, calm them at the same time.

C) Effect of the TWF on PCP'ers - police in the Los Angeles area found that suspects drugged with PCP "came off their high" almost immediately after being Tasered. Normally they require confinement for 24 - 48 hours alternately exhibiting violent and cataleptic behavior.

Discussion - the most obvious manifestation of the physiological effect of the Taser TWF on the human body is the cyclical, alternating contractions and relaxations, or clonic, motion of the skeletal muscles in response to the excitation of the neuromuscular system involved in the current flow path. Total incapacitation occurs almost immediately including physical collapse, blackout and unconsciousness. This sequence of reactions to the impact of the TWF energy pulses typically takes only 1 - 3 seconds.

The Taser waveforms are shown in the attached scope photos and are seen to have a duration of a few microseconds (it has been shown that the biological and physiological effectiveness of the TWF pulses is proportional to the electrical energy (joules) contained therein. Since the energy is

proportional to the square of the voltage level, most of the energy is contained in the first portions of the pulse wave).

In Taser tests upon humans and animals, the energy per pulse has been varied from .0001 to 20 joules. The standard production model Taser develops about .3 joules per pulse with a 12 - 14pps repetition rate giving about 3 - 4 watts average power output. The Police Special developed 0.7 joules per pulse and 10 watts average power.

For those who have worked with radar or similar fields, it is interesting to note that the peak power (energy divided by the time duration) per pulse of the standard production Taser is 10 Kilowatts! The actual voltage output is of course dependent upon the impedance of the external 'pathway' - including clothing, skin/hide, flesh and air gaps in the two wire mode. In the one-wire mode the 'ground' return path usually represents the biggest resistance. The voltage ranges from a few hundred to 60KV.

The 60 KV was a requirement in order that the electrical pulses would be able to penetrate winter clothing rather than depending upon the kinetic energy of the dart-contactors to penetrate clothing and flesh. The electric current peaks produced by this voltage range from a few amperes to 8 - 10 amps depending upon the impedance. These values at first appear frighteningly large, but please note that the National Bureau of Standards long ago measured currents arising from shocks from auto ignitions systems as high as 60 - 80 amperes!

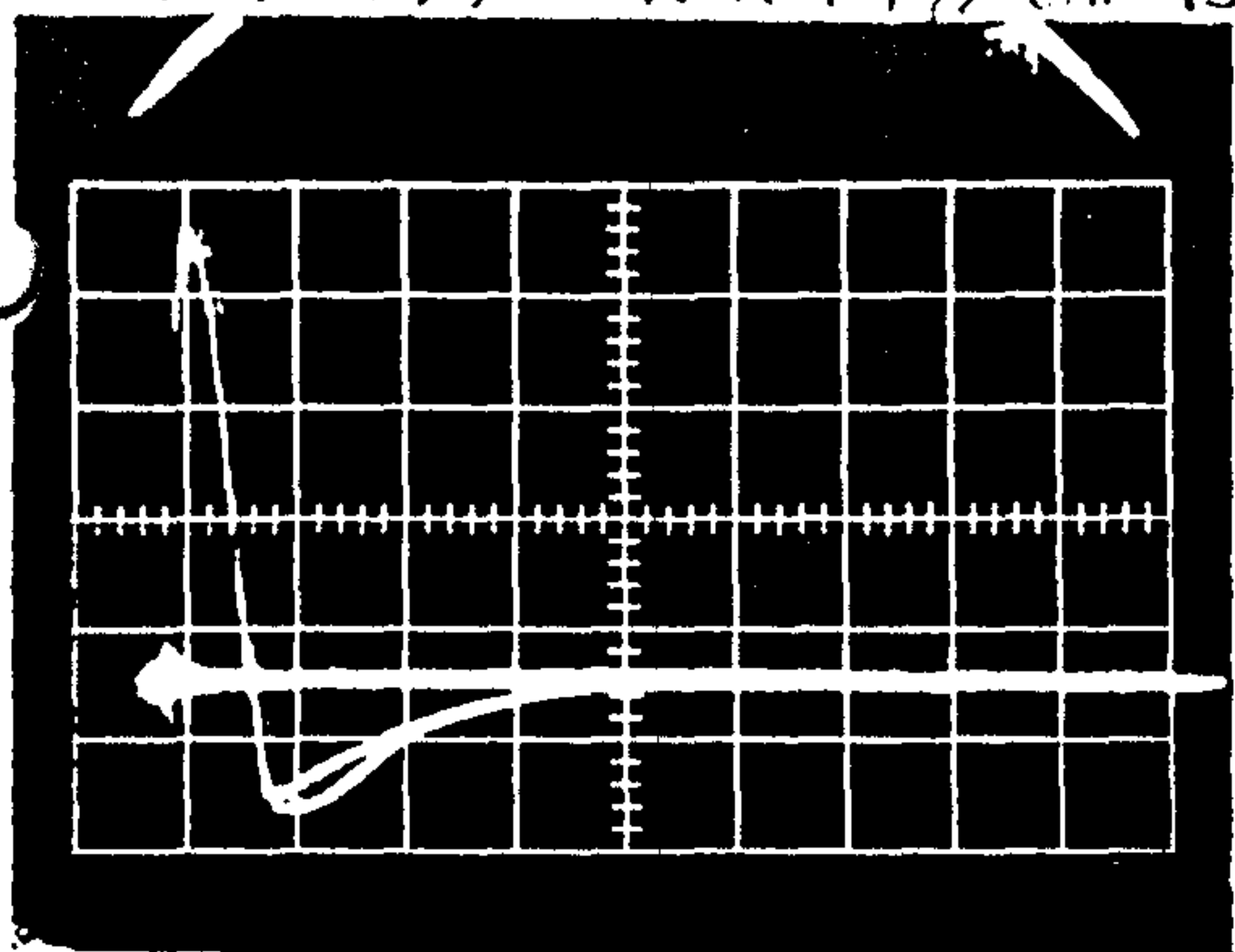
Organic trauma - tissue damage or skin burns - have never been found in either the controlled volunteer tests or in the thousands of field uses of the Taser. There are two reasons for this - first, the Taser projection contacting system spreads the darts about 1 foot apart at impact on the body; secondly, the relatively good conductivity of the nerves and capillaries, plus the spread, results in the formation of parallel electrical paths through the body, each one carrying only a few milliamps of current.

It is these almost infinite number of current branches through the corporeal volume of the body that accounts for the total domination of the central nervous system stimulating not only the neuromuscular but virtually all nerves in it's pathway. The electrical energy contained in the TWF pulse is sufficient to produce the bioelectric changes in membranes, tissues and cells. Electrochemistry plays a role in biochemical reactions and it is hypothesized that the pulsed energy can cause bioelectric changes ranging from polarization of atoms or molecules to the reversal or dissipation of ions and their associate bonds.

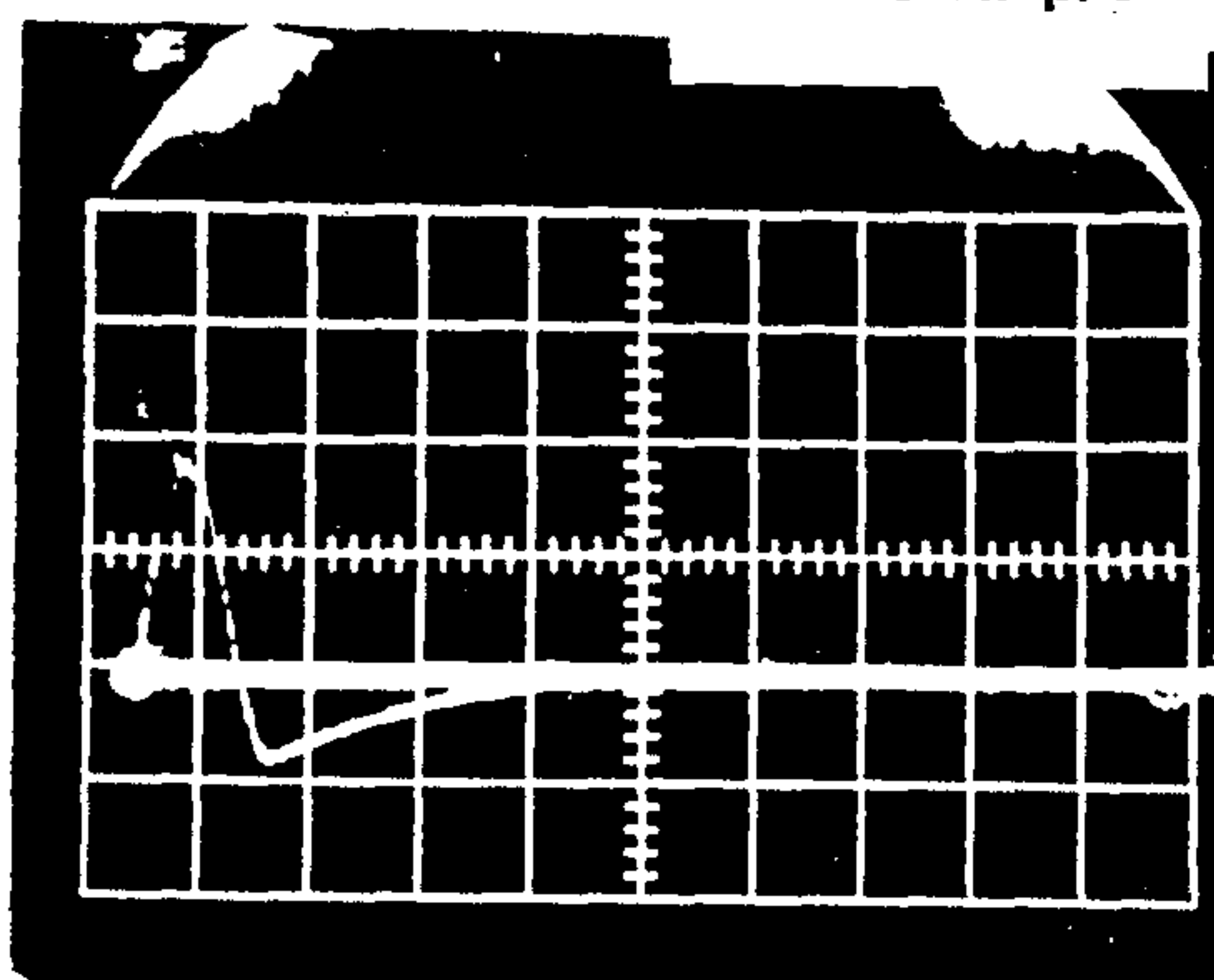
Such changes appear to be transient in most cases, but may be 'permanent' if an abnormal bioelectric condition existed, such as PCP molecules binding with protein molecules in nerve cell membranes in the brain. In this case, the 'permanent' change is the breaking of the PCP bonds releasing the drug and restoring normal functioning. We will refer to this hypothetical action as BioElectric Shock Transient, or BST.

Considering the suggested effects of BST - changes in ionization, attraction and bonding values - it appears possible that 'foreign' substances such as poisons, drugs and alcohols, that depend upon electrical 'affinities', for their action upon organic molecules, may in fact be neutralized or dispersed by the TWF action.

The apparent blocking of conscious recognition of pain (see background) by the Taser observed during Hospital tests on volunteers, is a direct parallel to the action of an anesthesia (some of which block neural conduction in peripheral nerves; others affect the central nervous system preventing subjective interpretation of afferent impulses from reaching the 'conscious' brain). BST appears to have the latter effect since the Tasered subjects are not aware of pain caused by the excitation of sensory nerves.



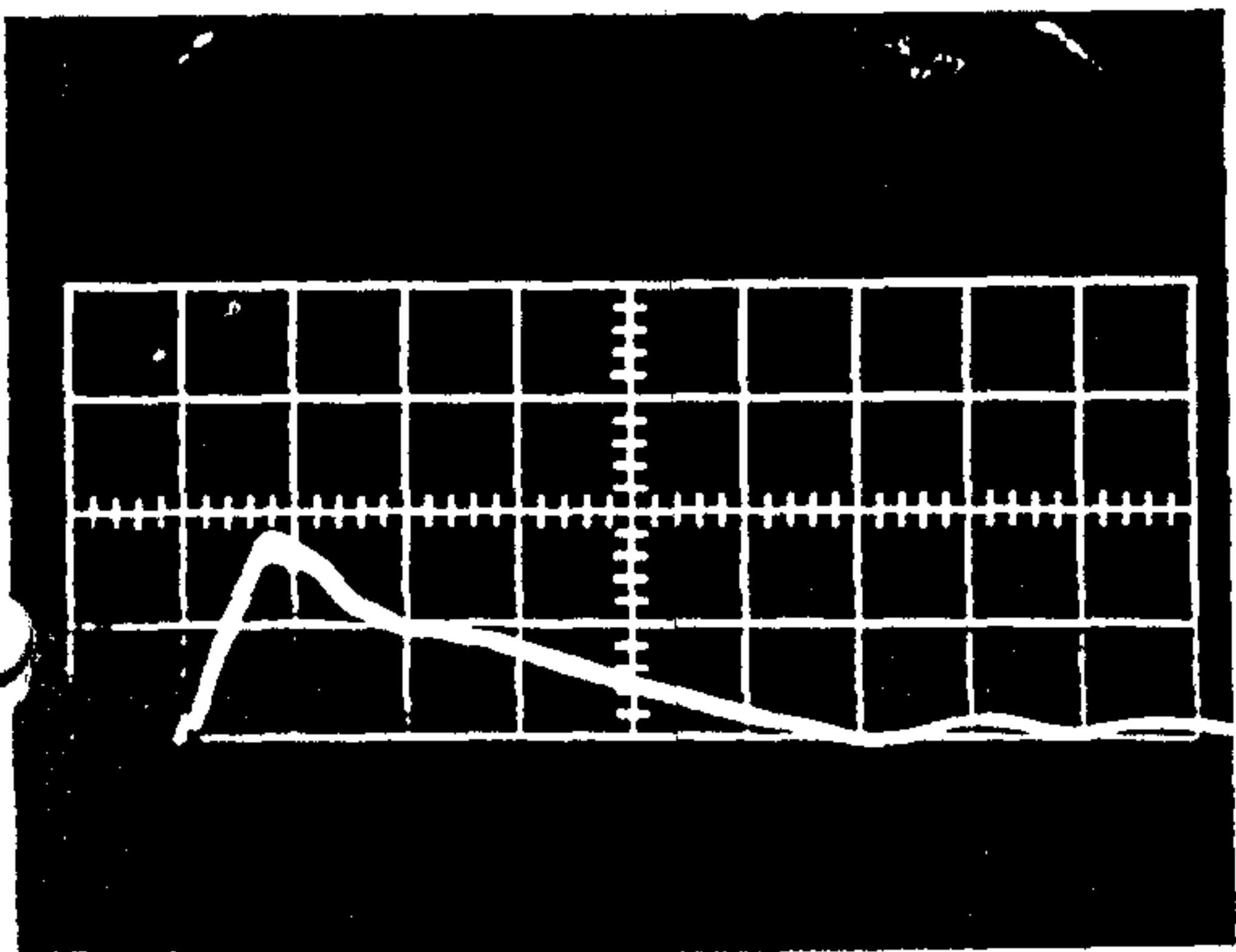
40KV Pulse (5usec/cm) thru 10Kohm resistor & small air gap (1/2").



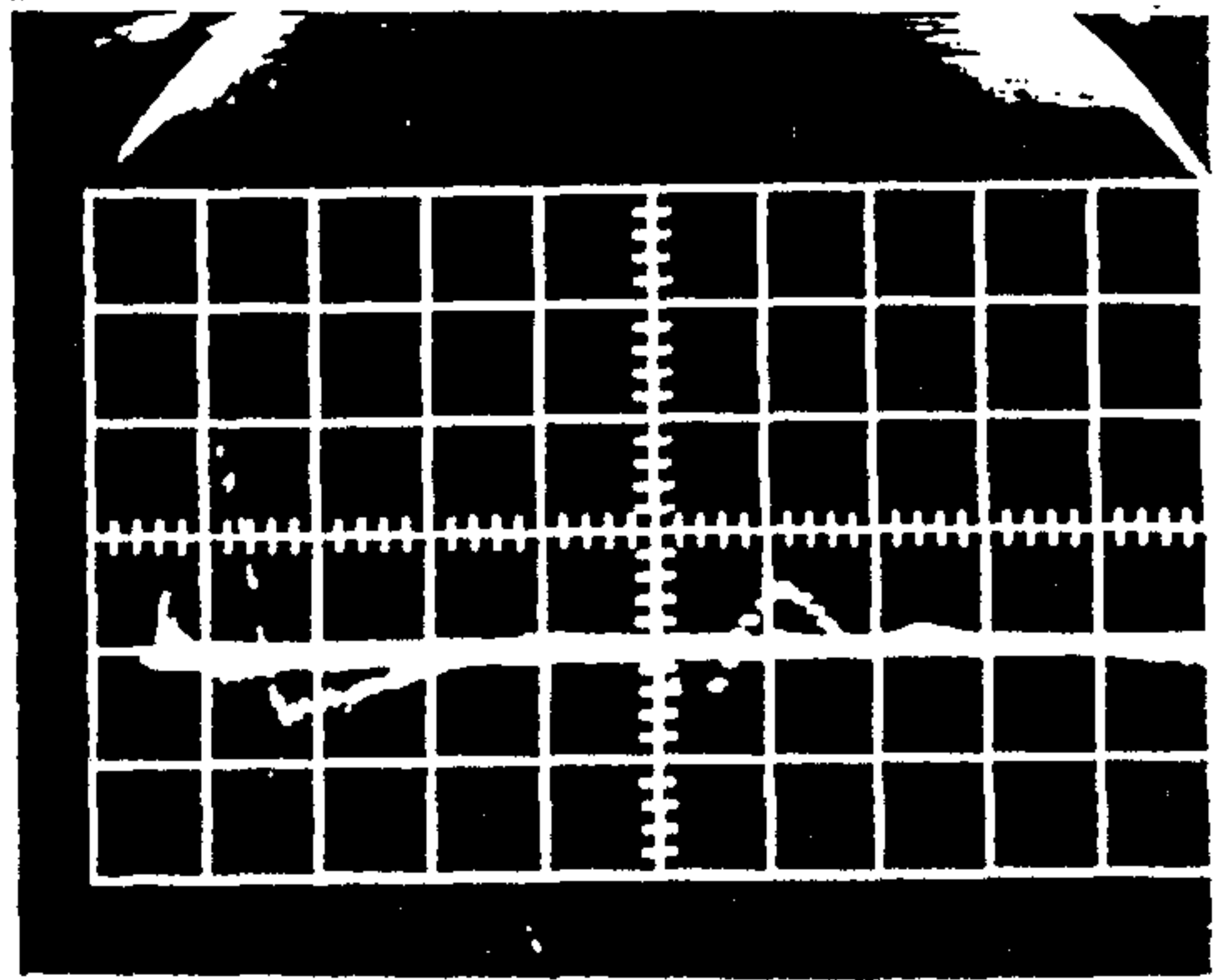
18KV Pulse (thru 10Kohms & 1" gap).

Scope Photos of the Taser Output Waveforms under conditions cited (1971-72 time period). Work done in Santa Ana, CA, Lab.

60KV Pulse, 7 microsecs duratn. (2usec per cm), thru 10Kohm load (4/13/71). Note damped (overdamped), non-cyclic waveform.



Measurement of body & skin resistance to spark penetration = 14,400 ohms (30KV-4 usecs). In this case, the path was thru J. Cover's leg (thigh to ankle) via spark penetration of clothes & skin.



THRU IN CIRCUIT #2

TASER DEVELOPMENT PROGRAM CONCLUSIONS

In the Introduction, Pg. 1, we stated that Taser has been criticized on occasion but also serious, unwarranted charges have been made by seemingly authoritative persons. Specifically, it has been stated 1) it can be lethal, 2) it has not been adequately tested to establish in fact that it is nonlethal, 3) it causes skin burns, 4) Taser tortures it's victims = suspects.

Nonlethality - the primary basis for it's nonlethality come from A) extensive medical testing done on electrified cattle fences B) extensive testing performed by the Taser Company on both animals and humans, and C) it's extensive use in the field by police and others during the past 17 years. Let's examine these statements in detail.

A) Independent background tests on dangerous electrical shocks - primarily dealt with fibrillation of the heart because this is by far the "Achilles Heel" for mammals! Refer to the enclosure "Pulsed Electrical Shock Criteria". Numerous studies and tests on animal's hearts were conducted over many years (at least 1920 on) by many institutions and in many different countries. Two reports are listed under 'Notes' on the graph. The Underwriter Labs. Research Bulletin No. 14 is one of the best organized and most comprehensive. The UL survey was sponsored by the U.S. Government because electric fences had sprung up all over the country (since 1920) and there were reported deaths from these uncontrolled devices.

At the end of their investigation, UL specified as "SAFE" pulsed shocks whose $I \times T$ (current times the time duration of the shock) was equal to or less than 4 m.a. - seconds (m.a. = milliamps or 1/1000 ampere). This criteria was supported by numerous animal tests such as the ones run by John Hopkins and needless to say the values selected as 'safe' were very conservative!! The proof rests in the fact that this criteria was adopted in the U.S. by 1940 and our cattle fences (there are millions all over the country) are built to this Spec.

Now, how does this relate to Taser's nonlethality? Taser's pulse generating circuits were designed to produce outputs that fall well below the Electrified Fence Criteria, as shown by the point marked on the graph. (The original test work on animals was done varying both the shock time duration and it's current amplitude. In early work, time deltas ranged from about .001 to 3 secs). If you follow the criteria formula - a safe pulse has an $I \times T$ product equal to or less than .004 ampere-seconds. That means that if the time duration is .01 sec the current pulse can equal 0.4 amps; and if the time delta is 1/1000 of a second, the current - safe peak current - is 4 amperes.

Referring to the Criteria Chart again, the Taser nominal peak current output is about 2.5-3 amps (this is a value determined by the resistance of the human body - internal resistance). NOTE that the Taser output is **THREE ORDERS OF MAGNITUDE BELOW THE MAX SAFE LEVEL** (of the more conservative 1969 formula, Curve #2). In other words, the peak current could be raised to 3000 amps in a 3 microsecond pulse and it would not cause fibrillation!!

In some of the shock accident reports and some of the animal tests, peak currents have exceeded 1000 amps without killing the recipients. The Taser output was selected to be extremely conservative and we submit that it has proven itself Safe and Nonlethal over the years it has been in use in this country.

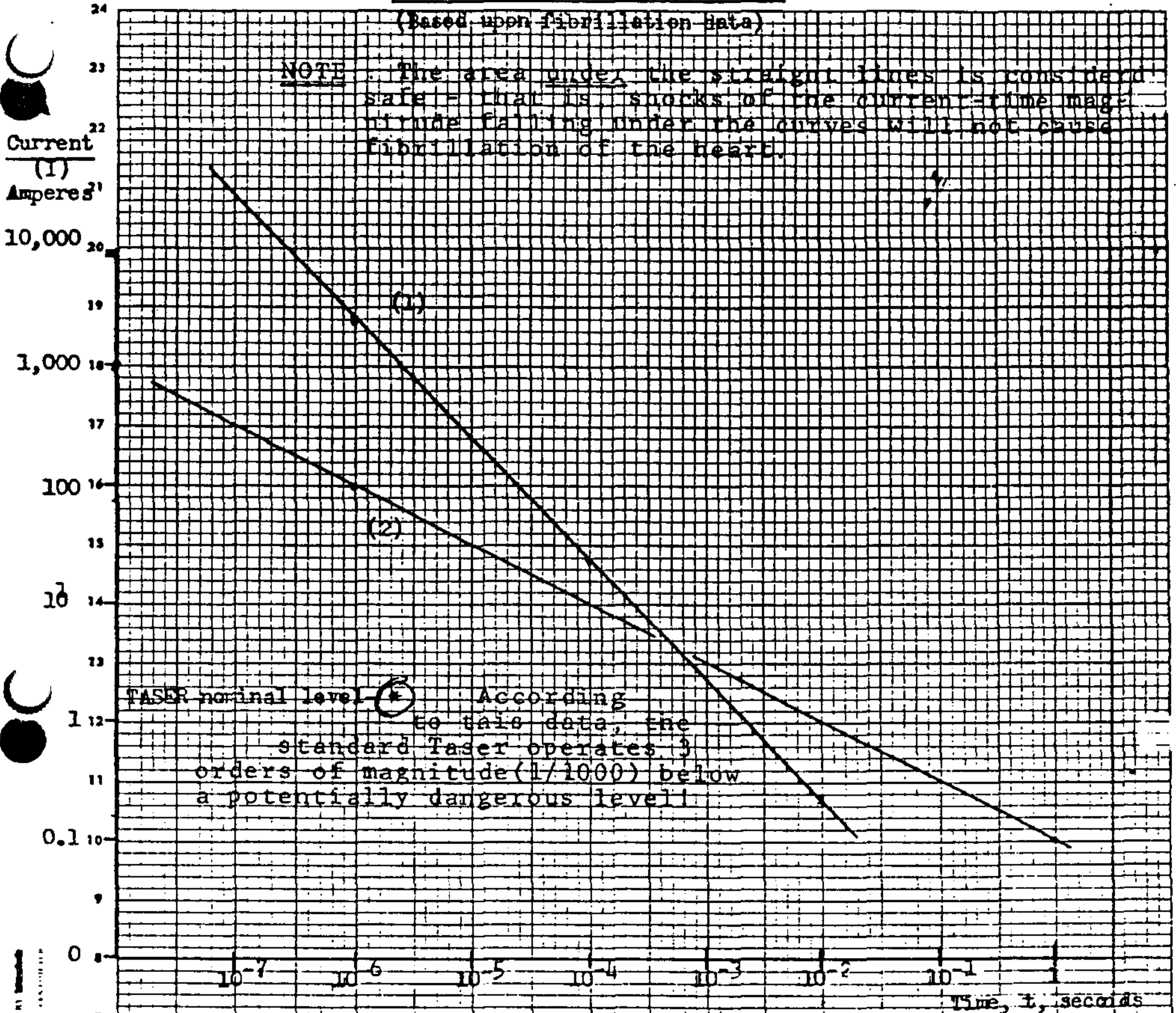
B) The Taser Company tests were conducted initially over the time period 1966-1974 and have been delineated earlier in this report. To summarize, we performed many tests to test Taser's safety re-heart fibrillation. Most of the early tests were performed on pigs and calves (staying in the human weight range) - currents were passed through the heart region up to 10 times the recognized 'safe' level without inducing fibrillation or causing any injuries.

TASER systems

Pulsed Electrical Shock Criteria

(Based upon fibrillation data)

NOTE: The area under the straight lines is considered safe - that is, shocks of the current-time magnitude falling under the curves will not cause fibrillation of the heart.

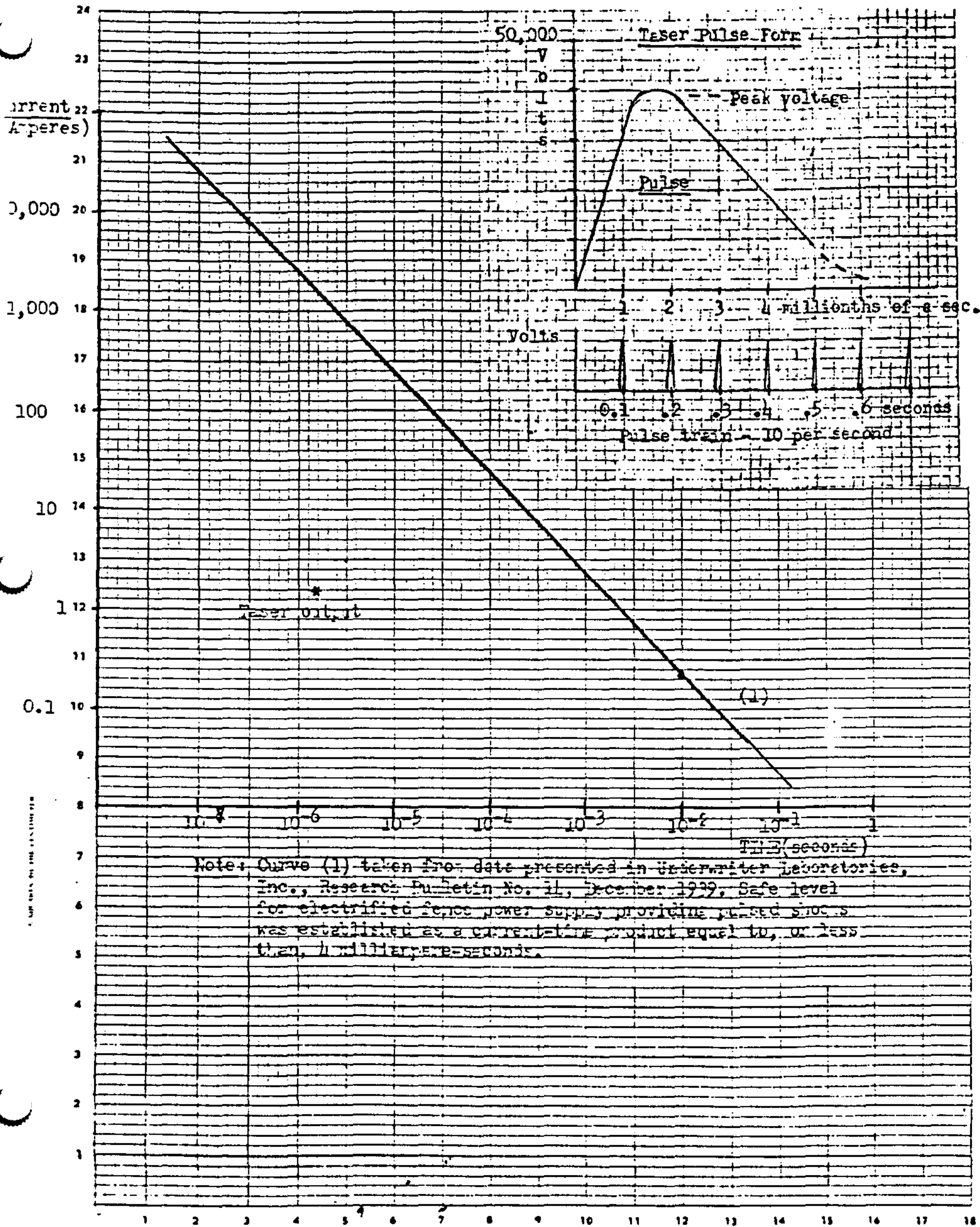


TASER nominal level. According to this data, the standard Taser operates 3 orders of magnitude (1/1000) below a potentially dangerous level.

Notes: (1) Underwriter Laboratories, Inc., Research Bulletin No. 11, December 1939. Safe levels for electrified fences was established as a current time product (Ixt) being equal to, or less than, 1m.a.-seconds.

(2) IEEE Spectrum, February 1969, "Lethal Electric Currents", derived an 'electrocution' equation based upon animal fibrillation test data and suggests that the maximum safe non-fibrillating shock is given by $I\sqrt{t} \leq 20.1$ for a 125 lb. animal or man.

TASER SYSTEMS - Chart A - Pulsed Electrical Shock Criteria



Note: Curve (1) taken from data presented in Underwriter Laboratories, Inc., Research Bulletin No. 11, December 1939. Safe level for electrified fence power supply providing pulsed shocks was established as a current-time product equal to, or less than, 1 milliamperes-seconds.