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**JULY 16th NUCLEAR EXPLOSION:**

**MEASUREMENT OF DELAYED IONIZATION BY DISTANT RECORDING INSTRUMENTS**

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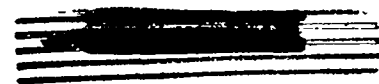
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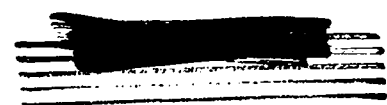
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ABSTRACT

A network of 16 distant-recording ionization "sentinels" was installed, the various stations being at distances of 400, 800, 1500, 4,000, 7,000 and 10,000 yards from the explosion. The instruments consisted, in principle, of an ionization chamber in series with a source of potential difference and an argon discharge tube, the frequency of discharges being a measure of the ionization level. They were battery-driven and recorded their readings automatically within the 10,000-yard shelters

Broadly speaking, the 400-yard and 800-yard stations were damaged by the explosion, while those at greater distances survived; the surviving sentinels showed a strong wave of ionization travelling in the northward direction from the explosion point, with comparatively little in other directions.



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JULY 16th NUCLEAR EXPLOSION:  
MEASUREMENT OF DELAYED IONIZATION BY DISTANT RECORDING INSTRUMENTS

Long before the formal organization of the TR Project it was realized that radiation hazards to personnel entering, or remaining within, the area shortly after the explosion would be greatly reduced by the provision of instruments that transmit to the base shelters records of the ionization levels at a number of stations within the area. With this information available, an observer proposing to enter the area is forewarned of the hazards that he is likely to meet and can select his time and route of entry accordingly.

The essential properties of "sentinels" of this kind were considered to be:

- (1) Reliability, particularly in the sense that damage to an instrument shall be unlikely to result in too low a reading.
- (2) Insensitivity to the mechanical shock and the temporary intense ionization that are to be expected immediately after the explosion.
- (3) A wide range: at least from 1 to 20 roentgens per hour.
- (4) Capability of operating without attention for at least 24 hours.

Since various types of portable ionization meter were already available, it was natural first to consider adapting one of these types to a distant-recording technique; this was found impracticable for two principal reasons: first, the meters known to us required too frequent checking of the zero reading to meet requirement (1), and second, the electrical output signals from these instruments were of unsuitable natures for transmission by radio or by telephone line. An entirely different form of sentinel was therefore developed.

Principle of the Instrument

An ionization chamber having a volume of the order of a liter was connected in series with a source of voltage and an argon discharge tube. When the ionization

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current passing through the chamber has built up a high voltage across the discharge-tube, breakdown occurs and this voltage falls rapidly to the extinction potential of the gap, after which the process repeats at a rate proportional to the ionization current. Since the difference between striking and extinction potential is usually many volts, each discharge (in spite of its short duration) can easily originate a signal suitable for transmission by line or radio. In the instruments to be described, the grid-cathode resistor of a thyratron was placed in series with the discharge tube; the voltage developed across this resistor triggered the thyratron, the anode circuit of which was so arranged that it delivered to the signal line, by way of an appropriate transformer, a voltage pulse that lasted for about 0.1 sec., after which time the thyratron was ready to handle another signal. Such a pulse is ideal for transmission by telephone line and for recording by a simple electro-mechanical counter at the receiving station.

#### Details of Field Unit

The circuit employed is shown in Fig. 1. The unit was battery driven, the chamber voltage being derived from a radio-frequency oscillator the output of which was transformed to about 2,000 V. peak amplitude, rectified and smoothed<sup>1)</sup>. Details of the chamber and of the discharge tube are shown in Figs. 2 and 3.

#### Switching and Protection Arrangements

In order that the unit need not be switched on until after the explosion, and could then be turned on from the recording station, the signal line was initially connected to a relay that, when energised by a voltage applied from the recording station, switched the apparatus on and then connected the signal output to the line. The detailed process of switching was done in two alternative ways. In units that were to be at 4,000 yards or more from the explosion, and were housed in simple wooden boxes, the relay operated the switching circuits directly. At the nearer stations the unit rested on a shelf inside a small shelter (Fig. 4), the heavy steel lid of which

1) This voltage supply was designed by H. H. Hines for another application.

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was pivoted as shown. While the unit was on its shelf, it was kept switched off by pressure between the shelf and micro-switch buttons protruding from the base of the unit. The switching-on relay, on being energised from the recording station, closed a local battery circuit which burned out a steel wire and thereby allowed a tensioned spring to withdraw the bolt which kept the lid in place. The lid then rose, owing to the action of the counter weight, raising the sentinel unit from its shelf and carrying it into the open air. In leaving the shelf, the unit was switched on by the release of the switch buttons, and the output was similarly connected to the signal line.

#### Recording Stations.

Each field station was connected by telephone line (running for most of the distance within rubber-covered cables each containing five pairs) to one of the three main shelters at the 10,000-yard points on the south, north and west roads. Each incoming pair was connected to a separate single-stage pentode amplifier, the output of which operated a mechanical counter. The amplifiers and counters were mounted on a rack, which also carried a synchronous electric clock, a film camera and an industrial timer that operated the camera by way of a solenoid and plunger, the latter being connected to the camera trigger. In this manner photographs of all counter dials and of the clock could be made at predetermined intervals. The rack also carried a source of voltage for temporary application to each line when it was desired to switch the corresponding unit on. Meters were provided to indicate the line current and the output current from any one amplifier, as selected by a rotary switch. The former of these meters enabled the observer to tell whether the line, and the switching relay at the far end of it, were intact, while the latter meter indicated, by the nature and magnitude of the kick corresponding to each discharge of the argon tube, whether the whole apparatus was working normally. It should be mentioned that some, though not all, units regularly gave a few discharges when first switched on, even in the absence

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of ionization. These discharges ceased within a minute and were useful as a check that these particular units were operating normally.

#### Tests and Calibrations.

Each field unit was tested at Los Alamos, and sample units were thoroughly investigated for proportionality between ionization and rate of counting, for duration of operation without attention, and for reproducibility of calibration after temporary exposure to ionization considerably more intense than could be handled by the mechanical counters. Linearity was satisfactory up to counting rates of about 300 per minute, corresponding to about 20 r/h (more or less, depending on the individual characteristics of the discharge tubes, which were made in several batches and did not all have the same value of the difference between striking and extinction voltages; these differences were useful as they enabled the less sensitive instruments to be placed where the highest ionization was to be expected). The response was reproducible, though not linear, up to ionization levels about 50 percent greater; at still higher levels the time constant of the thyratron output circuit reduced the magnitude of the individual kicks too much for reliable operation of the counter, though flickering of the output meter was still observable. The units would operate for at least 40 hours without change of sensitivity, and were unaffected by short exposure to the intense ionization due to 1 1/2 gram of radium placed almost in contact with the ionization chamber. The units were again checked and finally calibrated on arrival at the test site, and checked once more after installation in the field.

The mechanical strength of the units, and the protection afforded by the shelters, had been previously tested by the 100-ton shot, when a unit in a shelter at 75 yards was damaged but one at 150 yards was undamaged. On the basis of this it was decided that a reasonable fraction of the sentinels would survive if the nuclear explosion went well, while a reasonable number would have sentinels to record if it went rather badly, if the nearest units were at 200 yards from the tower with others at

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distances increasing by repeated factors of approximately two. Units were therefore stationed at the following distances along the various roads leading from the zero point:

400	800	1500	4,000	10,000 yards	North and South
1500 yards East					
800	1500	4,000	7,000	10,000 yards	West

Experience with the 100-ton shot had shown that the cutting of the cables by blast or fragments was a serious danger and in consequence all wires were buried up to a distance of 1500 yards from the zero point.

#### Observations.

- 1) Plan of operation: The most distant stations were switched on 2 to 5 minutes after the explosion, followed in succession by the closer stations.
- 2) Survival of stations: N-400, S-400, S-800, W-800 and S-1500 were not operable after the explosion. The remaining eleven stations survived in good condition.
- 3) Reports from recording stations: The following are extracts from station reports.

a) South Station. (P.B. Moon) Units at S-10,000 and S-4,000 at no time indicated as much as  $1/50$  r/hr. E-1500 indicated 0.2 r/hr averaged over the period + 10 to + 16 minutes, 0.08 r/hr from + 16 to + 32 minutes, 0.04 r/hr from + 32 to + 46 minutes with continuous decay thereafter. A plot of ionization vs. time for this station is shown in Fig. 5.

b) West Station. (T/S Max J. Pincus) At plus 2 minutes the sentinel at W-10,000 was turned on. In the first five minutes there were seven counts - most of them probably due to warming up conditions. ~~because there were~~ only four more counts in the next 89 minutes. At plus 3 minutes, ~~W-7,000 was turned on.~~ This unit gave three counts

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in the first two minutes and then ceased counting. These counts can also be attributed to the sentinel's warming up. W-4,000 began working at + 4-1/2 minutes. Its beginning count was 3 in the first 9-1/2 minutes of operation. The recorder showed one more count for this unit at + 53-1/2 minutes. Therefore, these three units - W-10,000, W-7,000 and W-4,000 registered-negligible radio-activity in their respective areas.

W-1500 was put into operation at +6 minutes and showed 2.97 r/hr for the first minute. From +7 to +10 the ionization was 1.35 r/hr. A graph of r/hr versus time is attached for this unit which shows that the reading fell off smoothly, being less than 0.1 r/hr after 80 minutes.

The sentinel at W-800 failed to operate. Later investigation showed that the concrete counter weight was cracked by the blast and half of it blown from the support; the shelter lid therefore did not rise.

c) North Station. (S/Sgt. Walter J. Breiter) The first sentinel unit, North 10,000 was turned on at about 0535, 17th July, 1945. This unit appeared to operate normally in every respect and gave no count after one minute, so the unit at N-4,000 was tried. The result was the same as above.

N-1500 station began operation with rather slow count, estimated to be slightly less than 3 r/hr. While waiting for the count to settle down it became apparent that the rate of count was accelerating rapidly so a check was made for one minute, giving 7.25 r/hr. This was at 0542. However, by the time this count had been evaluated from the curves, the rate of counting seemed to have approximately doubled, which would mean 14.7 r/hr. The shelter was evacuated before this could be checked.

N-800 station gave some indication of being in operation condition. The plate current meter on the amplifier reached an abnormally high value, fluttering rapidly as it does when the rate of count is much too high for the register to follow. Later tests showed this amplifier to be in good operating condition and inspection showed the 800 yard shelter sufficiently intact for operation. Coils of the pole line on top of the shelter prevented its opening more than three inches, but that is enough to turn on all switches.

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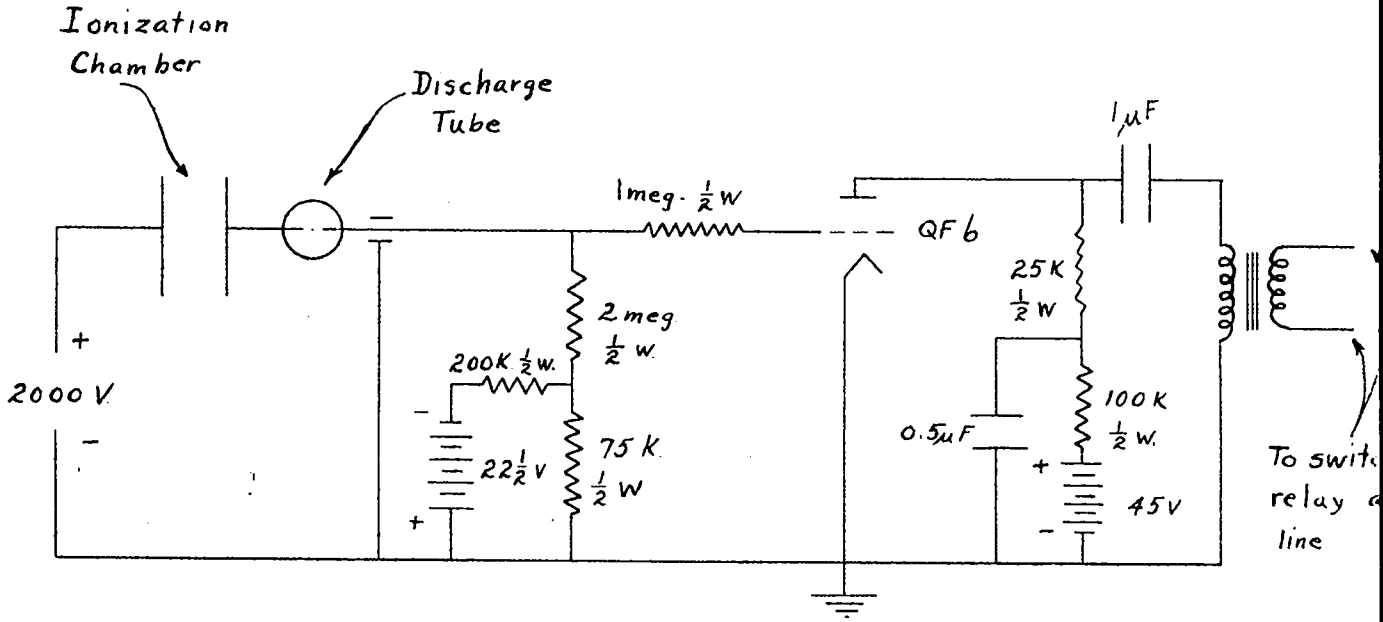


FIG #1

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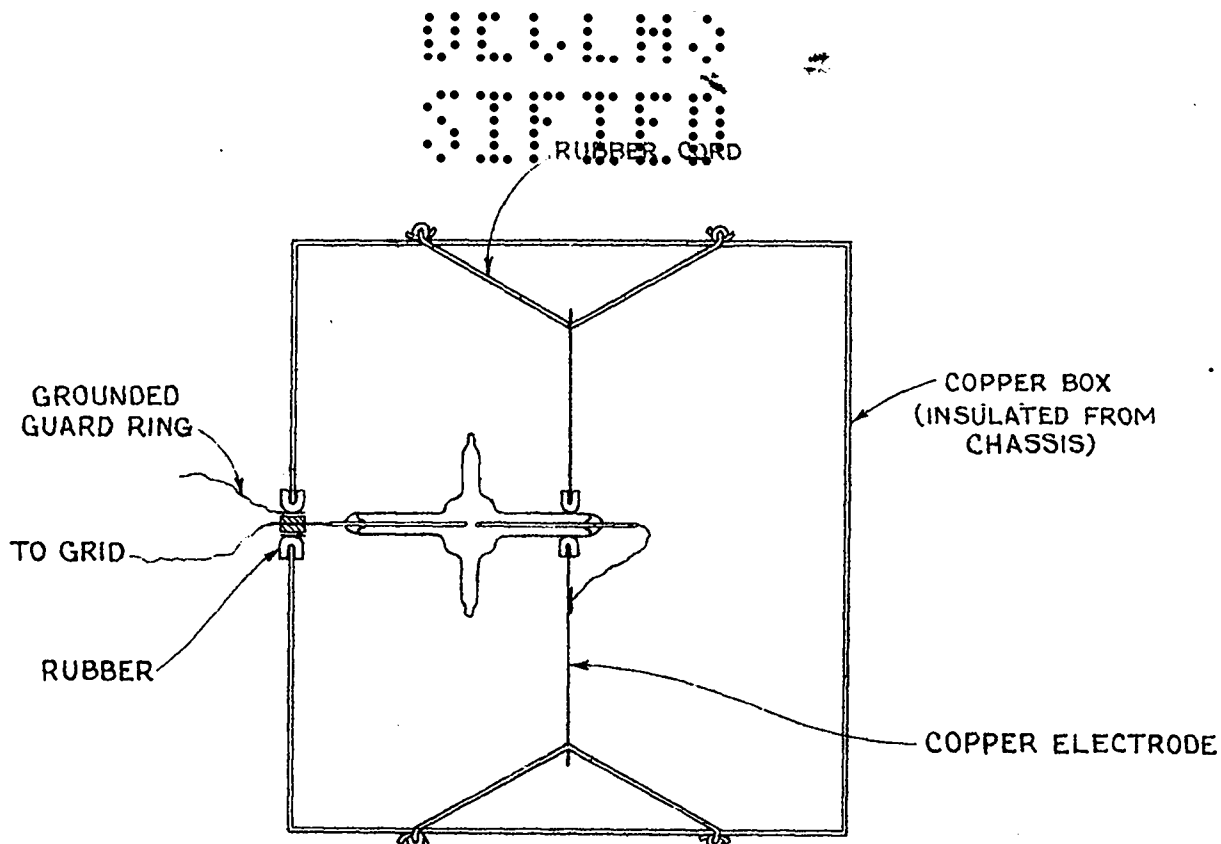


FIG. 2  
IONIZATION CHAMBER

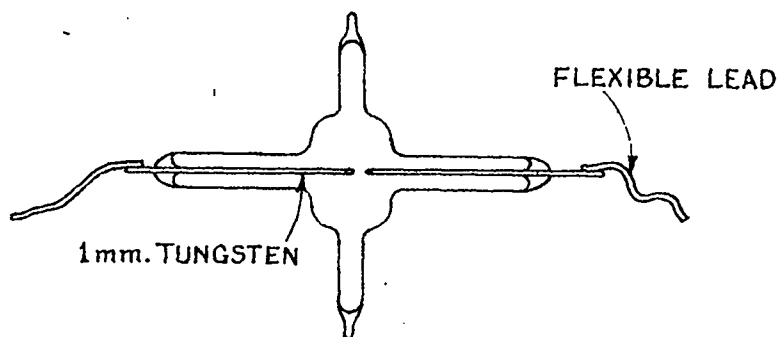


FIG. 3  
DISCHARGE TUBE  
(ACTUAL SIZE: FILLED WITH ARGON AT ABOUT 3mm. PRESSURE)

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01100

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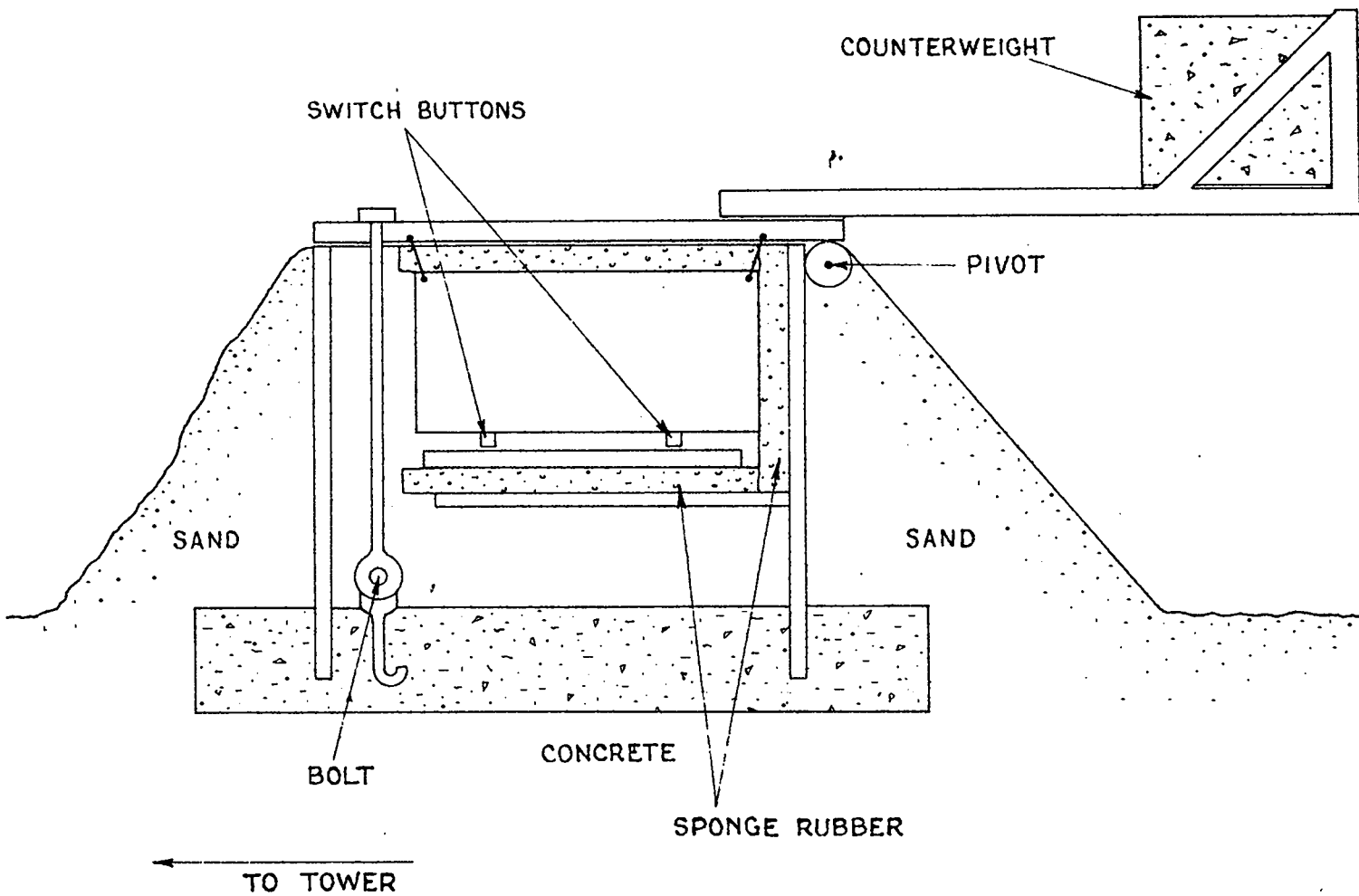
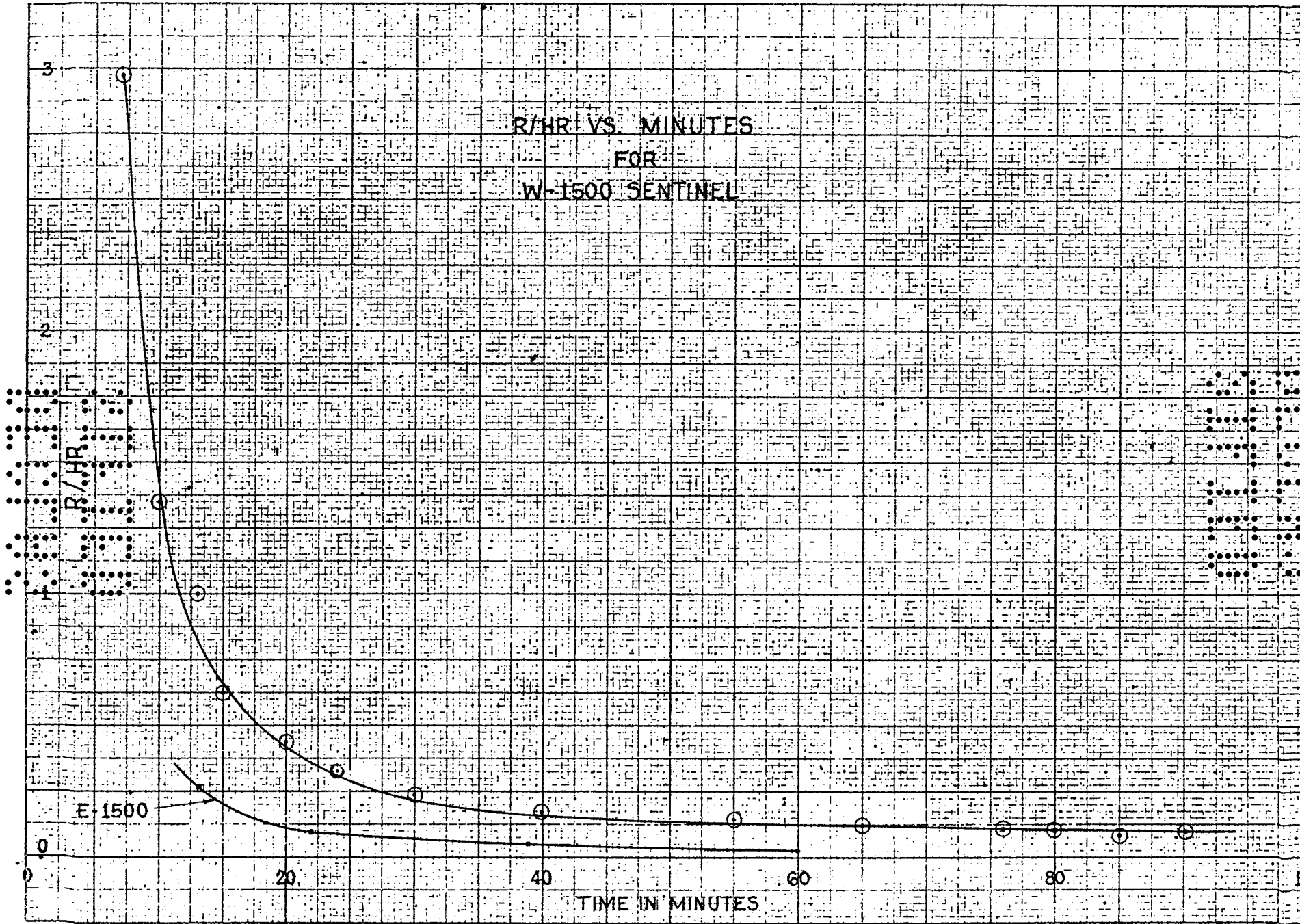


FIG. 4

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R/HR VS. MINUTES  
FOR  
W-1500 SENTINEL



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