Lawrence Berkeley National Laboratory
Recent Work

Title
SCINTILLATION HAND AND FOOT COUNTER

Permalink
https://escholarship.org/uc/item/1kq5j2n4

Author
Goldsworthy, William.

Publication Date
1953-01-27

eScholarship.org Powered by the California Digital Library
University of California

UCRL- 2088
UNCLASSIFIED

UNIVERSITY OF CALIFORNIA — BERKELEY

TWO-WEEK LOAN COPY

This is a Library Circulating Copy
which may be borrowed for two weeks.
For a personal retention copy, call
Tech. Info. Division, Ext. 5545

RADIATION LABORATORY

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

UCRL-2088
Unclassified-Instrumentation
Distribution

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

SCINTILLATION HAND AND FOOT COUNTER

William Goldsworthy

January 27, 1953

Berkeley, California

UCRL-2088
Unclassified-Instrumentation
Distribution

SCINTILLATION HAND AND FOOT COUNTER

William Goldsworthy

Donner Laboratory and Radiation Laboratory
Department of Physics
University of California, Berkeley, California

January 27, 1953

ABSTRACT

The design of a scintillation counter for measuring the radioactive contamination of hands and feet is described. This simple, compact, and reliable unit has many advantages over gas filled proportional counters and Geiger counters for this application.

UCRL-2088
Unclassified-Instrumentation
Distribution

SCINTILLATION HAND AND FOOT COUNTER

William Goldsworthy

Donner Laboratory and Radiation Laboratory
Department of Physics
University of California, Berkeley, California

January 27, 1953

INTRODUCTION

After making extensive studies into the problems of designing an adequate counter for measuring radioactive contamination of hands and feet an entirely new approach to the problem was decided upon.

The following goals were set: The counter had to view a wide area with high uniform sensitivity, be capable of measuring alpha, beta, and gamma contamination of wide energy ranges, be easy to maintain and adjust, be difficult to contaminate and easy to decontaminate, be insensitive to shock and line disturbances, and be usable for long periods without probe replacement. Gas filled proportional and Geiger counters failed to meet all of the above mentioned requirements. Geiger tubes had poor life time characteristics, failed to view a wide area with high sensitivity and are normally useless for counting alpha particles. Gas filled proportional counters were sensitive to shock, sensitive to line noise pick-up, were difficult to maintain as regards to voltage breakdown trouble and window replacement, and did not have uniform sensitivity over their entire window area. Upon examination into the possibilities of using scintillation counters, however, it was found that they would satisfy all requirements for a good usable hand and foot contamination counter.

The resulting hand and foot contamination counter consists of a probe unit, containing photomultiplier tubes, phosphors, light tight window, balance controls, guard screen, photo tube circuitry, and the required mechanical assembly, and a main chassis containing pulse amplifiers, pulse shaper, pulse rectifier, metering circuitry, speaker, and regulated power supplies.

DESCRIPTION OF APPARATUS

Probe Unit

Starting at the input we find the probe unit. (See Figs. 1 and 2.) This unit consists of four 5819 photomultiplier tubes viewing a 25 square inch phosphor consisting of a thin layer of anthracine flake crystals, covered with a thin second layer of silver activated zinc sulfide. The anthracine flakes form the beta and gamma detecting phosphor and the zinc sulfide forms the alpha detecting phosphor. Between this phosphor and the multiplier tubes is an inch thickness of lucite, bonded to the phosphor on one side and to four photomultiplier tubes on the other side, allowing for good light dispersing and good light transfer characteristics between phosphors and photomultiplier tubes. Beneath the phosphor is a light-tight 1/4 mil. aluminum window protected on its underside from contamination and mechanical damage by a guard screen. This entire assembly is mounted in a light tight aluminum box having sockets for the photomultiplier and balancing pots for the photo tubes located in its upper structure.

The probe unit circuitry is somewhat unconventional in that all four photomultiplier tubes are operated from a single dynode supply, high voltage and signal are both conveyed by one single conductor coaxial cable, and photomultiplier tube sensitivity balancing is accomplished by varying the voltage on the third dynode of each photomultiplier tube. There are numerous advantages to the aforementioned circuitry.

Signal and high voltage can be very conveniently conveyed by means of a single conductor coaxial cable since the very high d. c. impedance of the resistor R2 and the dynode supply does not excessively load the signal circuit. The signal path is from dynode No. 10 of each photo tube through capacitor C1 and then down the cable into the main amplifier. The d. c. path is from the main chassis, through the cable and through resistor R2 to the top of the dinode supply. Capacitors C-4 and C-5 form a low impedance signal path to ground, thereby keeping signal voltages off of the dynode supply. Capacitors C-4 and C-5 are series connected to provide the proper voltage rating, while still using compact inexpensive capacitors, since most high voltage condensers are bulky and expensive.

Control of the third dinode voltage to obtain balance of the photomultiplier tubes provided a solution to many problems. It provided a system of balancing with absolutely no interlocking, allowed a single dinode supply to be used for all photomultiplier tubes and eliminated the necessity of insulating the balance potentiometers from ground.

Amplifier

From the output of the probe unit the signal is applied to the input of a two loop inverse feedback amplifier having a gain of 5000. See Fig. 3. This use of inverse feedback was necessary to provide adequate stability. If inverse feedback were not used amplifier gain would vary with line voltage and tube aging, thus producing poor stability.

Both amplifier loops consist of two, two tube inverse feedback loops with inverse feedback being applied from the anodes of V2 and V4 to the cathodes of V1 and V3. Since no blocking capacitor was used between the anode of V2 and the cathode of V1 it was necessary to provide a slightly positive bias on the grid of V1 to compensate for additional current flowing through the feedback resistors R8 and R9, one of which appears in the cathode of V1.

Pulse Shaper

From the output of V4, the amplified pulses are applied to a one shot multivibrator, using tubes V5 and V6, which has been designed to give, even height, even width, output pulses independent of the shape and height of the input pulses. This provision is absolutely necessary for stable operation of the count rate metering circuit. The following arrangement was used with very stable results: a cathode follower having low anode voltage, as a trigger tube (V-5A) driving the grid of V-6A, and another cathode follower, V-5B, having a common cathode connection with V-5A and switching in and taking over the driving operations to tube V-6A after pulse initiation. Tube V-6 in conjunction with tube V-5B forms the one shot multivibrator with cathode follower drive to the grid of V-6A through V-5B. This arrangement provides excellent stability by isolating the input signal from the multivibrator after triggering occurs, thereby removing the possibility of interference by the input pulse.

The multivibrator sensitivity is controlled by adjusting potentiometer R35, which varies the voltage on the cathode of V-6, thereby controlling the grid-cathode bias of V-6A which, in turn, determines the triggering sensitivity.

Rectifier and Compressor

Some sort of meter scale compression was considered desirable so as to measure a fair range of counting rates without the necessity of manual range switching. The scale decided upon was a linear scale from 0 to 100 for the bottom half of the meter scale and a linear scale of from 100 to 1000 for the top half of the meter scale. This scale was chosen because of the simplicity and reproducibility of the accompanying electronic circuitry. Operation of the circuit is as follows: Shaped positive pulses are applied to the anode of V-7A and rectified producing a voltage across resistor R38 proportional to the count rate, with capacitor C17 providing the proper time constant in conjunction with R38. Tube V-7B serves as a coupling tube and is biased to be inoperative for voltages producing less than half-scale meter deflection. For voltages producing greater than half-scale meter deflection, diode V-7B conducts, clamping resistor R39, effectively in parallel with resistor R38, thereby reducing the count rate sensitivity of the pulse rectifier circuit by a factor of ten. This gives the desired compression for the upper half of the meter scale and makes the metering response practically independent of tube characteristics, allowing for replacement of V-7 without recalibration.

Metering Circuit

The metering circuit is quite conventional and consists of a bridge metering circuit with an indicating meter attached in series with the calibration potentiometer R43, between the cathodes of V-8A and V-8B. Potentiometer R43 is for the purpose of compensating for grid current drawn by tube V-8A.

Loud Speaker

In order to provide audible indication of contamination a loud speaker is provided behind the front panel of the main chassis. This speaker is driven by an audio amplifier which, in turn, is driven by the output of the pulse shaper.

Power Supplies

In order to obtain stable operation it was also necessary to provide excellent voltage regulation of both low and high voltage supplies, both of these supplies having complete electronic regulators.

OPERATION

Through many months of operations these scintillation hand and foot counters have proved to be very satisfactory, with a minimum of maintenance. The contamination problem is practically eliminated by the use of easily replaceable screen guards and the use of overhead sensitive windows. Excellent stability, sensitivity, and uniform efficiency to a wide range of alpha, beta, and gamma emitters are obtained. Due to the arrangement of the metering circuit, fast metering response is attained, making for quick contamination determination and reducing the reluctance of some personnel to using hand and foot contamination meters. The apparatus is also immune to microphonic troubles and to line voltage disturbances present in many types of contamination meters.

Figure 4 shows the front panel view of the scintillation hand and foot counter main chassis. It will be noted from the photograph that the front panel contains only one meter, a speaker, a push button, and a pilot lamp. Since any controls placed upon the front panel may be tampered with, it was decided to place only controls and devices upon the front panel necessary to determine the contamination level of hands or feet. These devices consists of a speaker giving audible indication, a meter giving visual indication, a pilot lamp showing that the unit is in operation and a zero set button for periodic

checking of the meter zero by the Health Chemistry Monitor. This indicating meter shown in the photograph has not had its calibrated scale attached.

Figure 5 shows the assembled and blown up views of the scintillation probe unit. This unit can be used in an inverted position as a foot counter when used with a different mounting frame. The mounting frame shown in the probe unit photograph is used only for hand counter use.

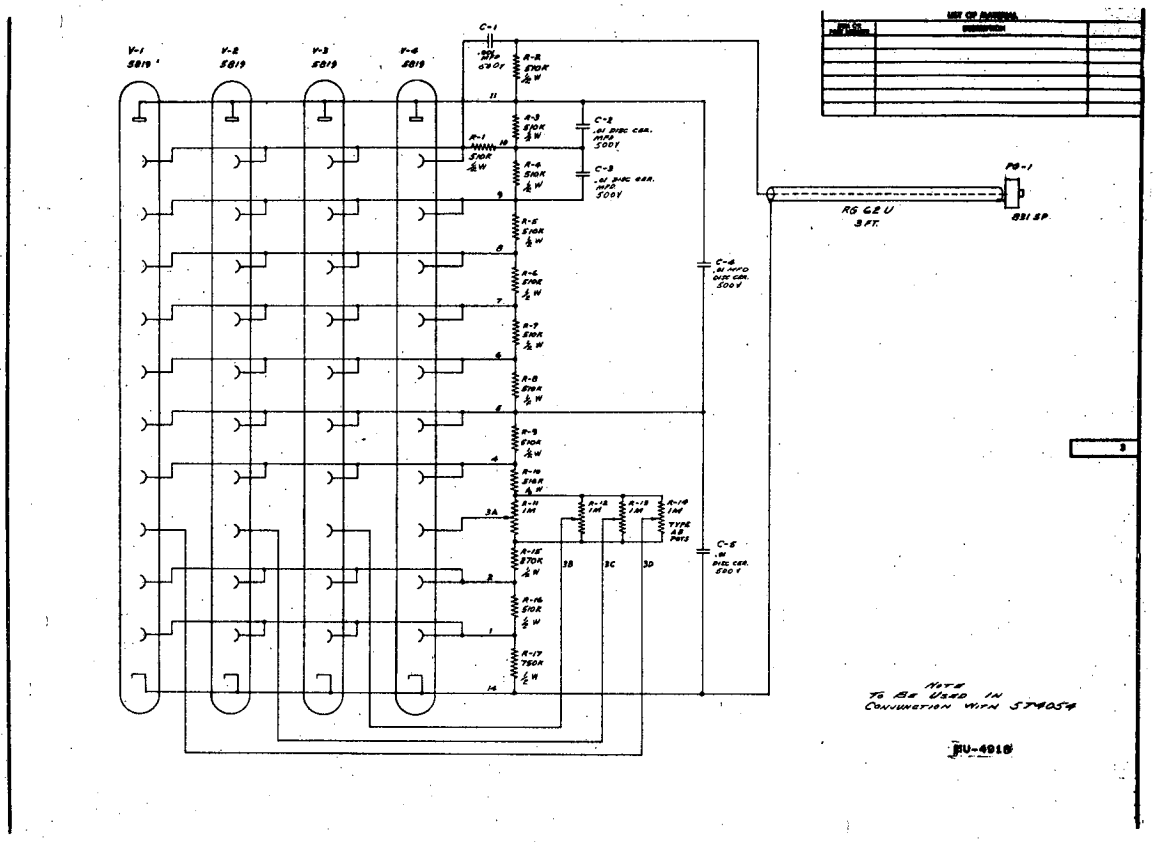


Fig. 1 Scintillation Hand Counter Probe Unit Schematic

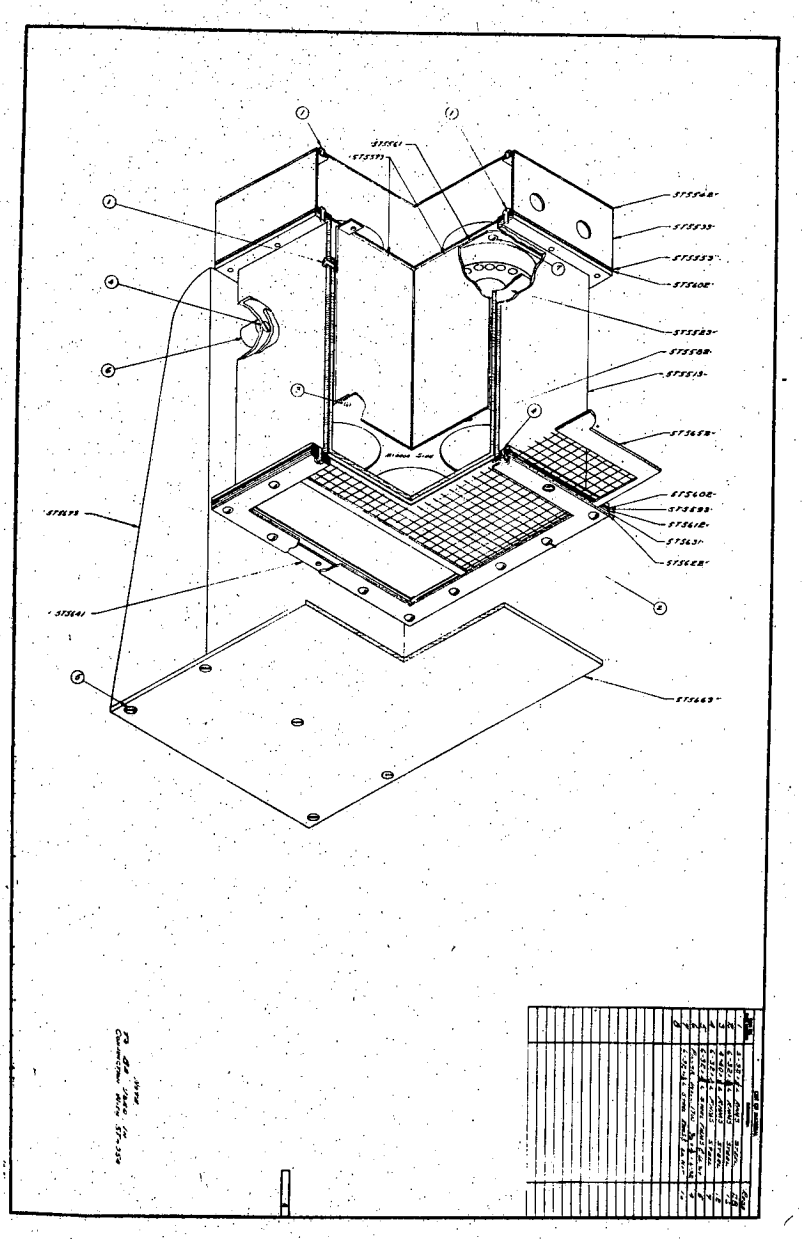


Fig. 2 Scintillation Hand Counter Probe Unit Assembly

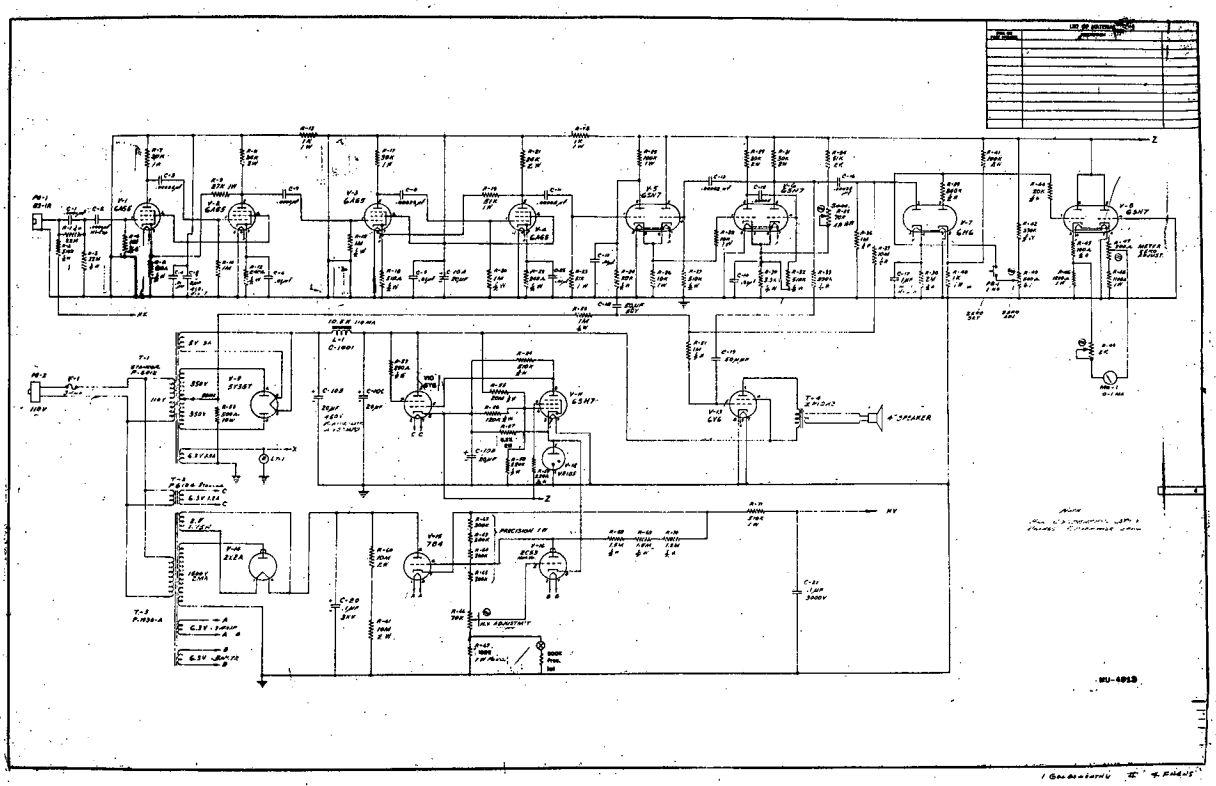


Fig. 3 Scintillation Hand Counter Schematic

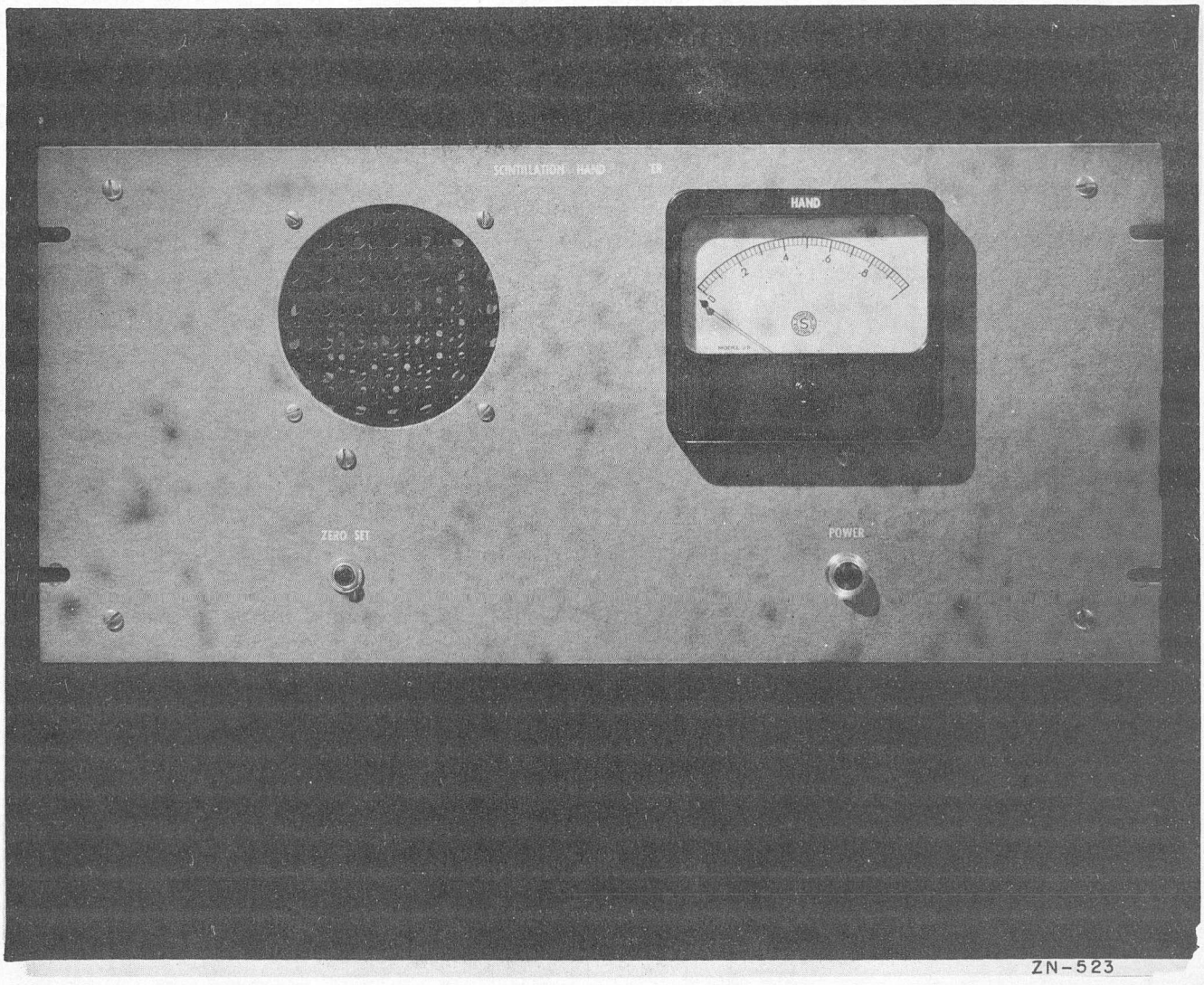


Fig. 4 View of Scintillation Hand and Foot Counter Main Chassis, Showing Simplicity of the Front Panel.

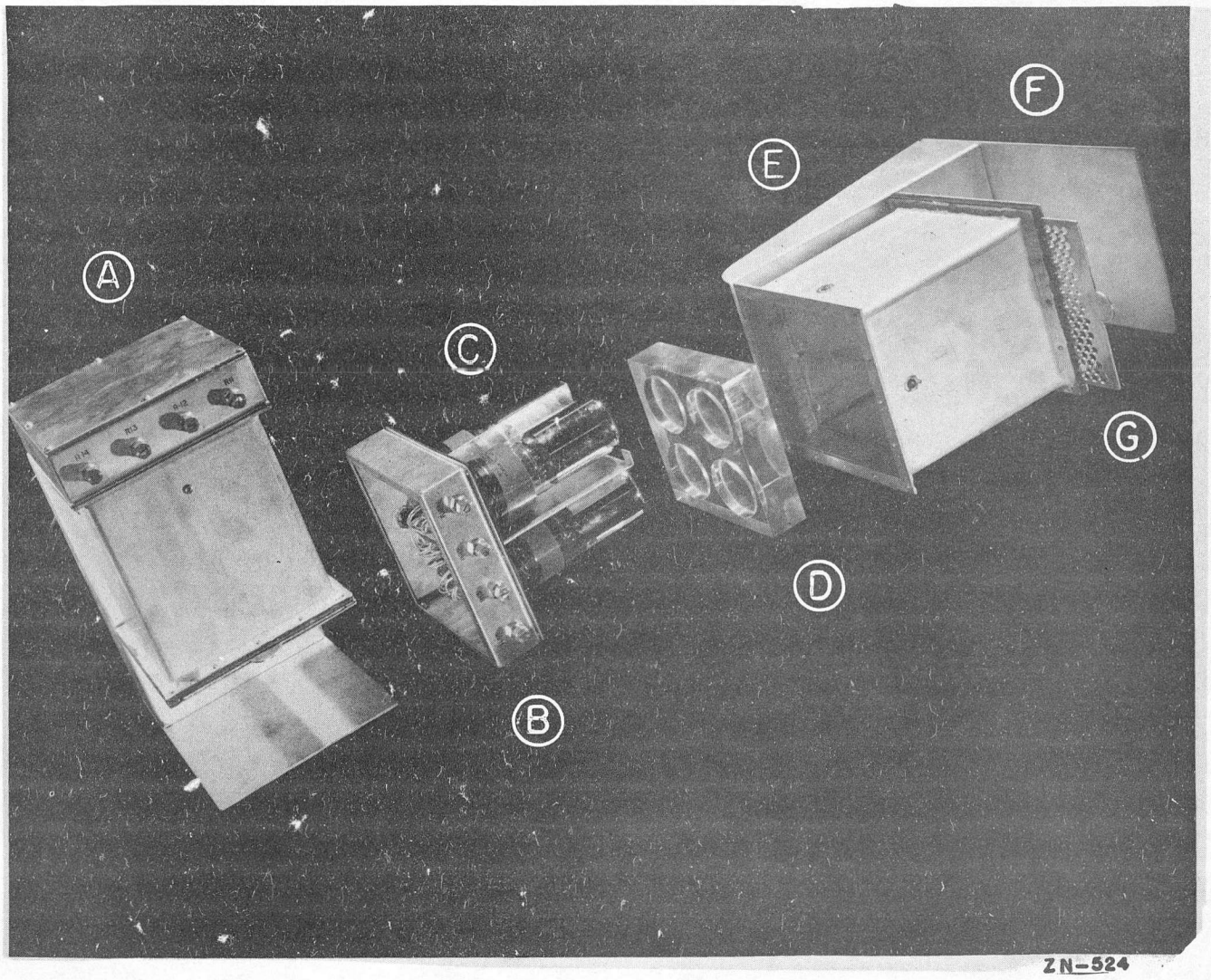


Fig. 5 View of Probe Unit Assembled for Use as a Hand Contamination Probe.

(a) Assembled Counter
(b) Sockets and Balancing Potentiometers
(c) Four Photomultiplier Tubes
(d) Phosphor on Lucite Block and Lucite Block
(e) Light Tight Aluminum Box and 1/4 mil Aluminum Light Tight Window
(f) Hand Counter Mounting Frame
(g) Guard Screen