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PRELIMINARY PLAN FOR ENVIRONMENTAL MONITORING AT SLAC

The Health Physics group at Stanford Linear Accelerator Center will maintain a program of environmental surveillance in the vicinity of the two-mile accelerator. It will consist of a variety of measurements performed both on and off site for the following purposes:

1. The detection and prevention of radiation exposure or radioactive contamination beyond allowable limits.
2. Accumulation of data and records adequate for the legal protection of SLAC and the AEC.

In addition, the principle will be followed that all unnecessary radiation exposure is "bad" and whenever practical the data will be used to further reduce exposures. This environmental monitoring program is already in operation in part in order to provide data on the radiation environment before accelerator operation.

Direct Radiation From the Accelerator

A series of Peripheral Monitors is planned which will measure neutrons and γ-ray levels near the site boundary. There will be eight stations at the sites shown in Fig. 1. Each station consists of a G-M counter and a moderated BF_3 counter with their associated scalers, high voltage supply, timers, etc. The accumulated counts are stored on a Sodeco register and printed out once each hour. An underground 120 V 60 cps line has been layed to five of the sites. The other three sites are close to power outlets. A circuit diagram of a peripheral monitoring station is shown in Fig. 2. A completed station is shown in Fig. 3 with a wooden dog house for weather protection and a fence to keep the cattle away. The door raises up to provide a roof during maintenance in rainy weather. The power drain is 35 watts.

Two of the stations are in operation now, one of which has been operating for nearly a year. Typical G-M counter rates are 55 cpm with a variation of about $\pm$ 10%. The moderated BF_3 counter typically records about 10 cpm and varies by about $\pm$ 10%. Once a week a technician visits these stations, collects the tape records and provides any necessary service.

In addition, a group of 15 locations have been selected for monthly measurements. Ten of these are on site as shown in Fig. 1; the other five are in the nearest inhabited areas, namely Stanford Hills, Sharon Heights, Woodside, Stanford Weekend Acres and near the Stanford radiotelescope. For measurements at these locations a panel truck (Metro Mite) has been fitted as a mobile laboratory as shown in Fig. 4. We have provided 120 V 60 cps power by means of a truck battery and an inverter (Terado "Continental"). This inverter does not provide a true sinusoidal wave form but it has proven adequate for operating all devices which do not incorporate Sola type regulators. A shock mounted relay rack has been built into the truck to carry the equipment. It is planned to measure both neutron fluxes with a moderated BF_3 counter and γ-ray spectra with a NaI crystal and multi-channel analyzer. Our first round of measurements were made before we had a multi-channel analyzer and only integral γ-ray counts were measured.

The above measurements will be supplemented with a high pressure ionization chamber with a self contained electrometer. This device is built around a skin divers air tank and is closely patterned after an instrument developed by Spiers et al.[1] (see Fig. 5). It operates at about 45 atmospheres of nitrogen and is capable of measuring 1 μrad (microrad) with a standard deviation of about $\pm$ 3%. Since background levels are typically 10 μrad per hour, this means that a measuring time of 6 to 10 minutes will give very good results. During measurement at some of the on site locations, the detectors will be taken out of the truck (weather permitting). The off site measurements will all be done with the detectors inside the truck in order to be as inconspicuous as possible.

Radioactive Air

The important sources of radioactive air are from venting the BSY, End Station B target room, and the Accelerator Housing. In addition there will be a certain amount of tritium produced in the beam dumps which will be vented as hydrogen gas.

The venting problem has been treated by DeStaebler[2,3,4] who concludes that there should not be a serious hazard. Similar conclusions were reached by a consulting firm which was asked to do a study on the subject.[5] The major radioactive constituents are N^{13}, O^{15}, H^3, C^{11}, Ar^{41}, Be^7, Cl^{39} and Cl^{38} in decreasing order of saturation concentration. Tritium will probably be much lower than this because of its long half life. A two hour waiting period will allow all of these to decay to below tolerance levels except Be^7 and H^3. Tritium should not be a problem unless venting is less than once a year.

Initially the air will be monitored whenever venting begins. There will be four monitors at the BSY vents, one at the B target room vent, and eight along the Klystron Gallery. We will have two units reserved for special tests. Since it is so difficult to predict frequency of venting and the behaviour of single atoms of materials like Be^7 created in air, the first period of operation will be used to accumulate data to enable us to assess the real problem. The monitors will start automatically whenever the associated venting fan starts and run for fifteen minutes. In the early operation it seems likely that venting will be desired after running periods of a few hours rather than a few days. Under these conditions a waiting period of 30 minutes will reduce the activity by about an order of magnitude and seems like a reasonable minimum.

The air monitors consist of a tank of 8.5 liters volume with a single thin walled G-M counter inside. The tank is surrounded by three inches of lead to reduce background. The G-M counter pulses will be counted by a Tracerlab MM-6B Log Ratemeter or equivalent. Recording is accomplished by a Rustrak recorder on the count rate meter output. Using Kr^{85} as a calibrating gas, the sensitivity of the air monitors is 5 $\mu\mu$Ci/cc. The sensitivity for C^{11}, N^{13}, O^{15}, Cl^{38} and Ar^{41} should be better due to the higher β-ray energies of these isotopes.

Monitoring for H^3 and Be^7 presents special problems. Be^7 decays by pure electron capture with a 0.477 MeV γ-ray emitted about 12% of the time. The sensitivity of our air monitor will therefore be very low for this isotope, probably about a factor of 10^{-3} times that for Kr^{85} or 5×10^{-3} $\mu\mu$Ci/cc. The method for measuring Be^7 will depend upon what we discover about its behavior. If we find that it remains suspended in air it may be filtrable and can be measured by pulling known volumes of air through a filter paper and measuring the activity with a γ-ray spectrometer. If it is not filtrable it may be possible to collect cylinders of compressed air and again measure the activity with a γ-ray spectrometer. A third possibility is that the Be^7 will plate out on various surfaces in the BSY. Professor Taube of the Stanford Chemistry department said that he believes the beryllium atoms will rapidly form BeO which is very reactive. The BeO would then react with dust particles, walls, metals, etc. and where it went would depend mostly on relative surface areas available.

Tritium will not be counted in the air monitors because of the low β-ray energy (18 KeV). Special monitors will have to be used in this case and again the question is complicated by uncertainty in the chemistry of isolated atoms. The H^3 can appear as tritiated hydrogen gas (HT) or tritiated water (HTO). Until the nature of the tritium is known, monitoring methods must be used which allows for both possibilities. Initially, we will use both collection of water samples from the air for liquid scintillation counting and the use of ion chambers to measure activity of dried air.

There is also the problem of radioactive dust in the air. It is anticipated that this will be a minor problem, but measurements will be made using filter papers.

A final problem concerns toxic gases produced in the air, mostly ozone, oxides of nitrogen and nitric acid.[6,7] We have built and calibrated a chemiluminescent ozone detector for the purpose of monitoring air. A concentration of 0.02 ppm is easily detectable as compared with the tolerance level of 0.1 ppm. Methods of measuring the oxides of nitrogen and nitric acid concentrations have not yet been prepared.

Radioactive Water

Among the many sources of radioactive water at SLAC, we are concerned here only with those which can get into the public water supply. The radioactive cooling water loops are designed so that a leak to the outside will drain into sumps. A leak into the clean loop of the heat exchanger would be detected by an in line water monitor and the pumps turned off before the contaminated water reaches the cooling tower. Due to the geology of the site, the problem is essentially one of avoiding contamination of San Francisquito Creek. There are two ways this could happen, by introduction or production of radioactive water to the water table followed by underground flow, or similarly by surface and sub-drain drainage. Again, all estimates show that these are not serious hazards and the main purpose is to provide sufficient monitoring to confirm these estimates. The monitoring needs to be such that if the estimates are wrong, it will be discovered early enough to allow further preventive measures.

The two problems are quite different. The water from surface and sub-drains flow rapidly and could reach San Francisquito Creek in a very short time, (an hour or less) but is near the accelerator for only a short time. Underground water flow is very slow in this area and would normally take years to reach the creek but is also near the accelerator for a long time. We must, however, watch out for the possibility of construction work having provided a fast flow path.

All normal surface water, i.e. run-off water from rain, has been heavily shielded from radiation and cannot be radioactive. It is only necessary to guard against the possibility of massive spills to protect against surface drainage problems. The sub-drain system could conceivably show some activation, at least in the area of the BSY and end stations. The sub-drains have four outfall points, all on the south side of the accelerator. It is too early to know what the flow rate from these points will be when construction is finished. The three outfalls along the accelerator were dry during the summer and it is probable that the flow from the one in the BSY area was from cement curing water. During the current rainy season, outfall flows have been of the order of a gallon a minute.

It is necessary to satisfy the Water Pollution Control Board on the safety of this water. In our case it is the Santa Clara County Board which has responsibility. We are proposing essentially the following system: During the first year of operation, we will be operating well below our final megawatt day/year capabilities. During this time, we will make very careful monitoring measurements of all water. If we detect any radioactivity which would be a hazard if extrapolated to full power, we would still have the dry season of 1967 to apply corrective measures. Our monitoring program assumes acceptance of this proposal.

At the two potentially most active sub-drain outfalls (positron source and BSY) we will have a small sump of perhaps 50 gallons capacity protected from surface water dilution. These will provide a collection point for water samples and sediment samples (if any). Water and sediment samples would be taken from these two points every two weeks. Samples would be measured in a commercial laboratory for gross beta and tritium. Spectral measurements would be made in house with a γ-ray spectrometer. This schedule would be maintained for at least the first two years. At that time if the problem appeared minimal, we would consider less frequent sampling.

The presence of radioactive ground water can be monitored only through the use of wells. For this purpose there exists a network of 20 peripheral wells (Fig. 1). Samples have been taken from these during the last 18 months to establish background conditions. Four more wells are needed at points A, B, C and D as suggested in Ref. 8. These wells can serve another purpose in that it would be possible to lower the local water table if needed. The wells would be sampled on the following schedule the first two years.

1. Wells A, B, C and D once a month.
2. Peripheral wells once every two months.

In addition samples would be taken from San Francisquito Creek upstream and downstream of the project on a monthly basis. Any operating wells in the San Francisquito basin downstream of SLAC would also be sampled, including those used by Stanford University. As before, samples would be sent to a commercial laboratory for gross beta and tritium measurements and γ-ray spectra would be measured in house.

Finally, there exist three environmental plots for sampling[9] (there were five, but one was partially cut away in constructing the research area and one was covered up)(Fig. 1). Vegetation samples will be taken from these on a semi-annual basis and compared with similar samples from a distant location. Gamma ray spectra will be measured in house and gross beta will be measured in the ashed samples at a commercial laboratory.

REFERENCES

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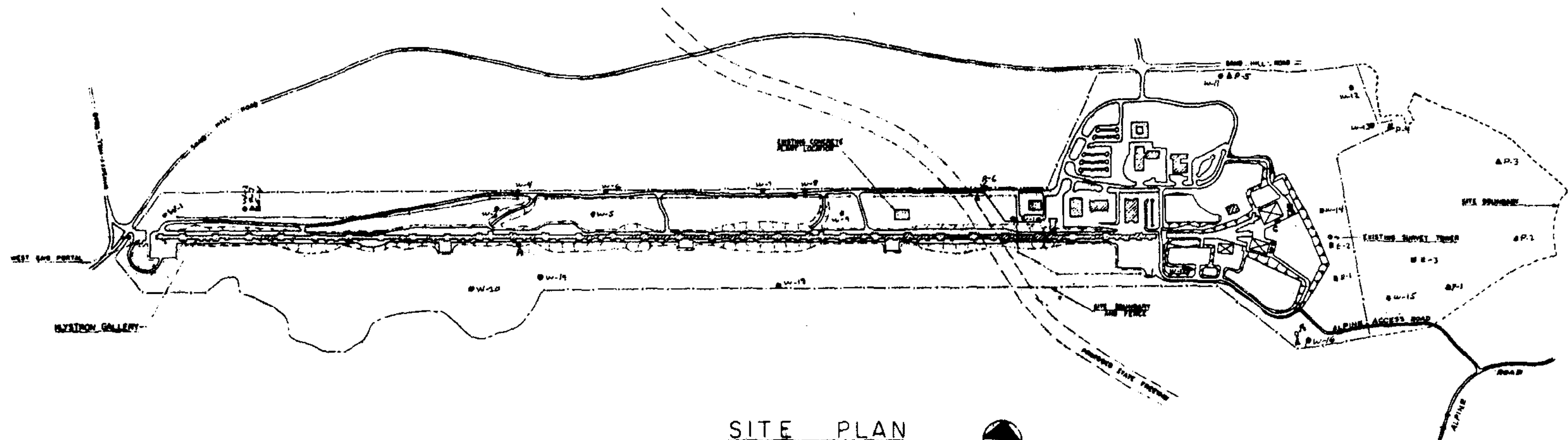
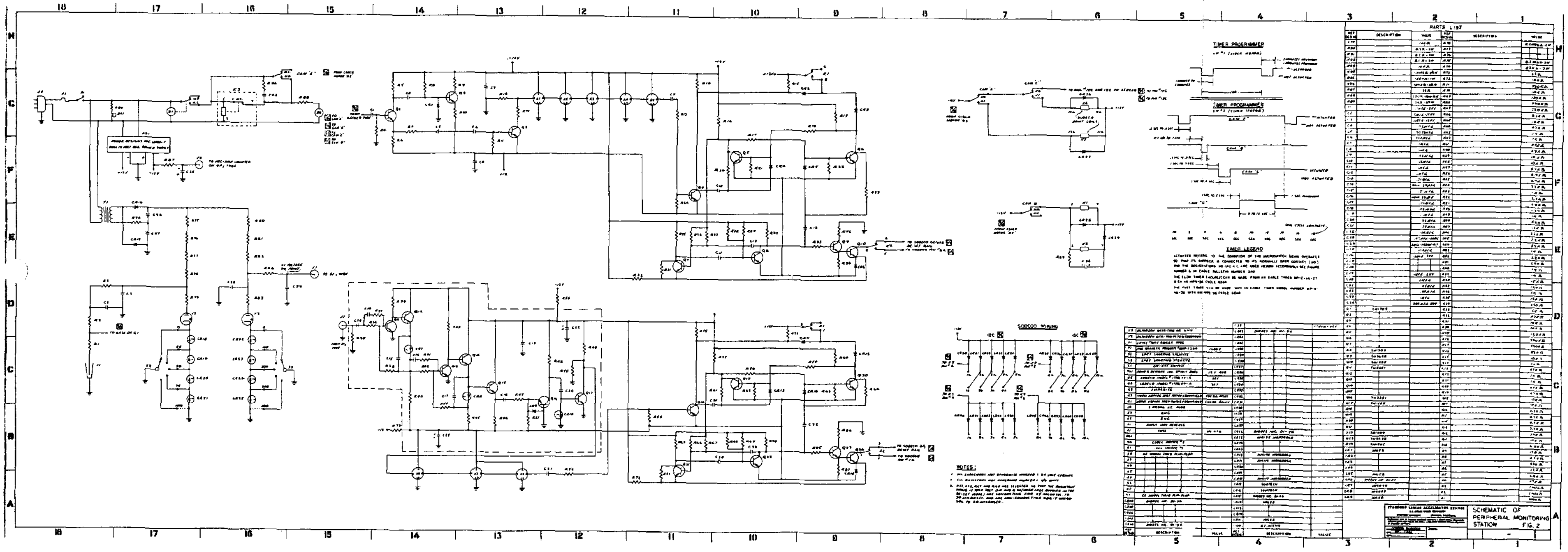
LIST OF FIGURES



SITE PLAN

LEGEND

EXISTING BUILDINGS
EXISTING ROADS
EXISTING SLOPES
WATER WELLS
ENVIRONMENTAL PLOTS
PERIPHERAL STATIONS



SCHEMATIC OF PERIPHERAL MONITORING STATION FIG. 2

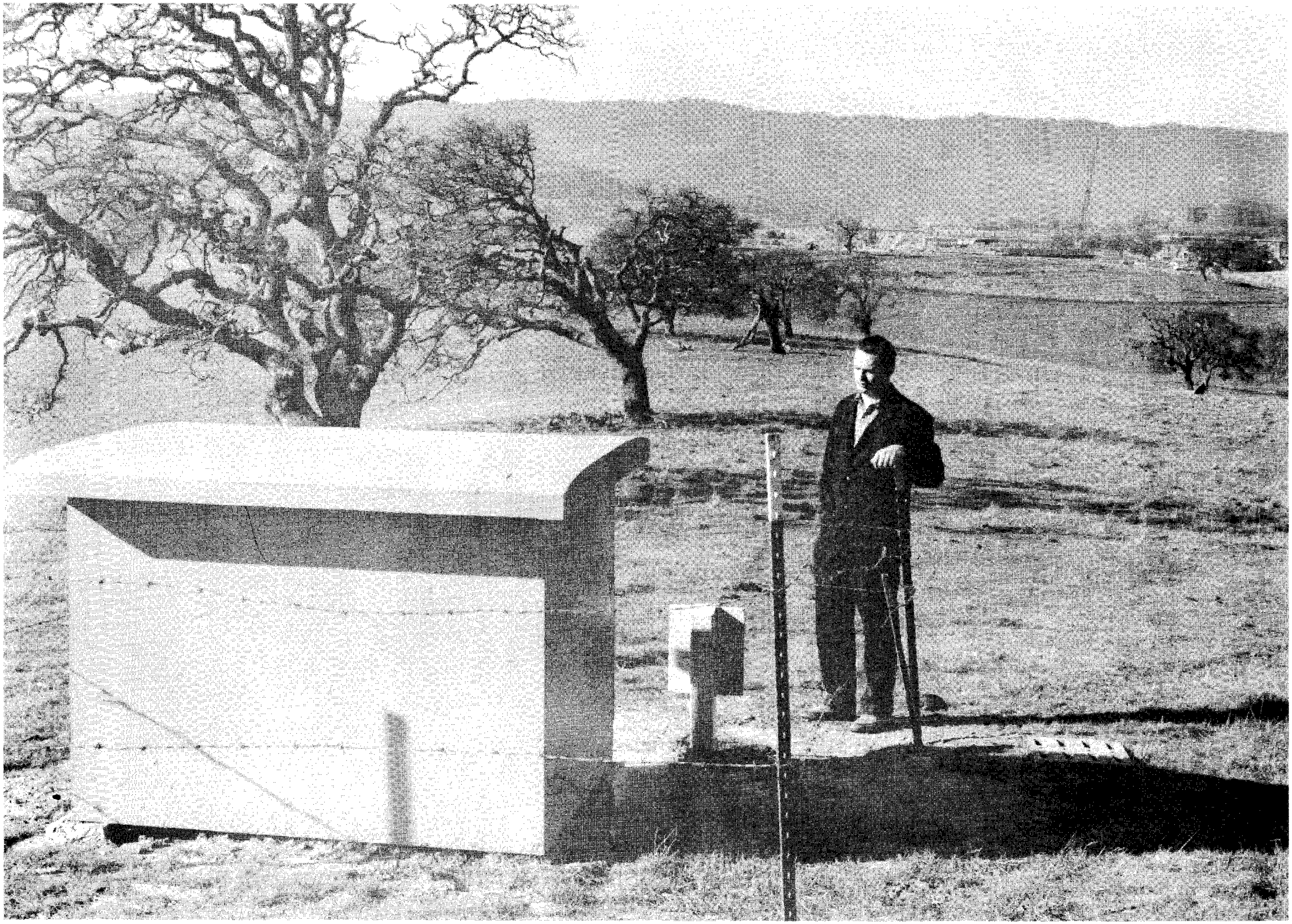


Figure 3

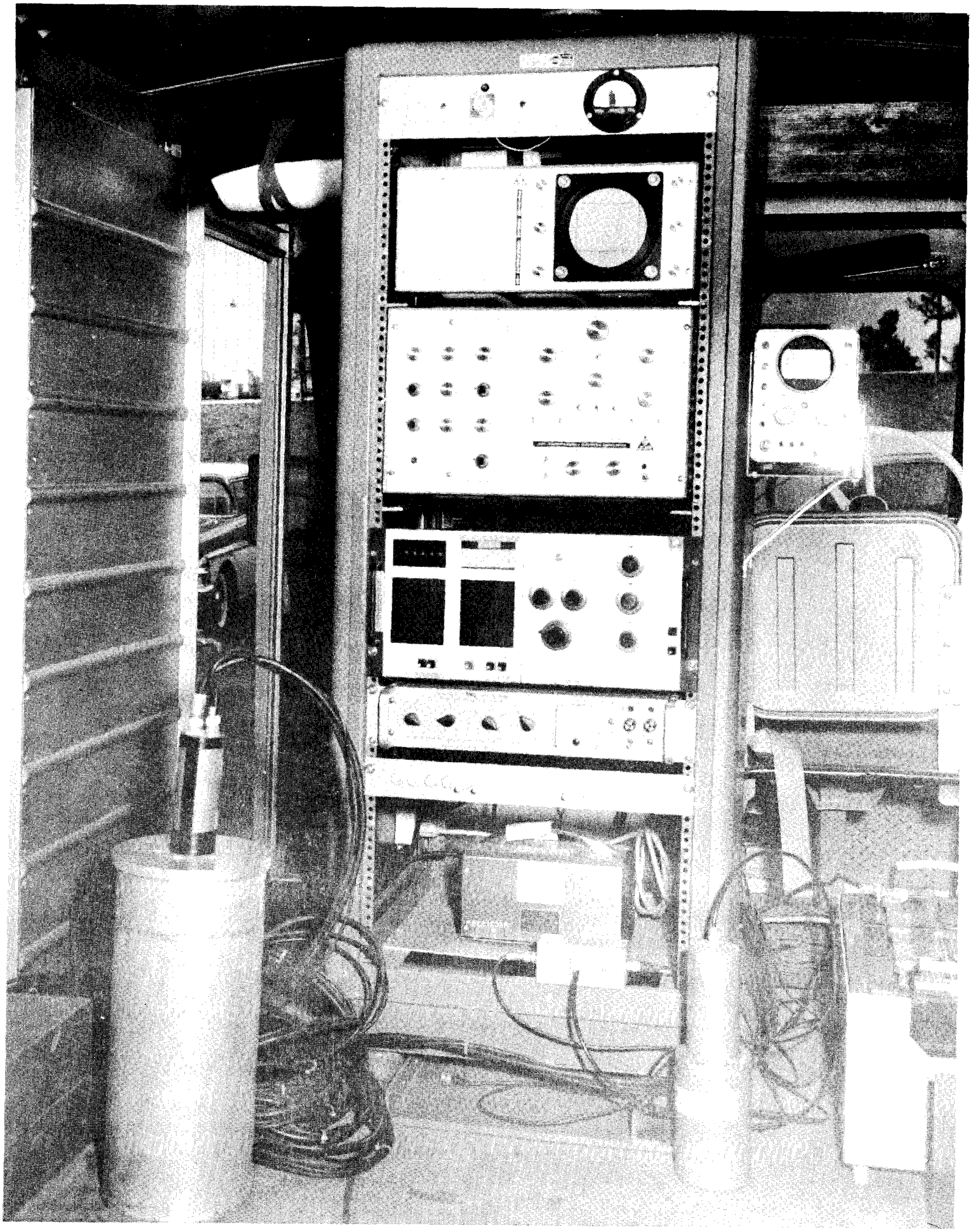


Figure 4

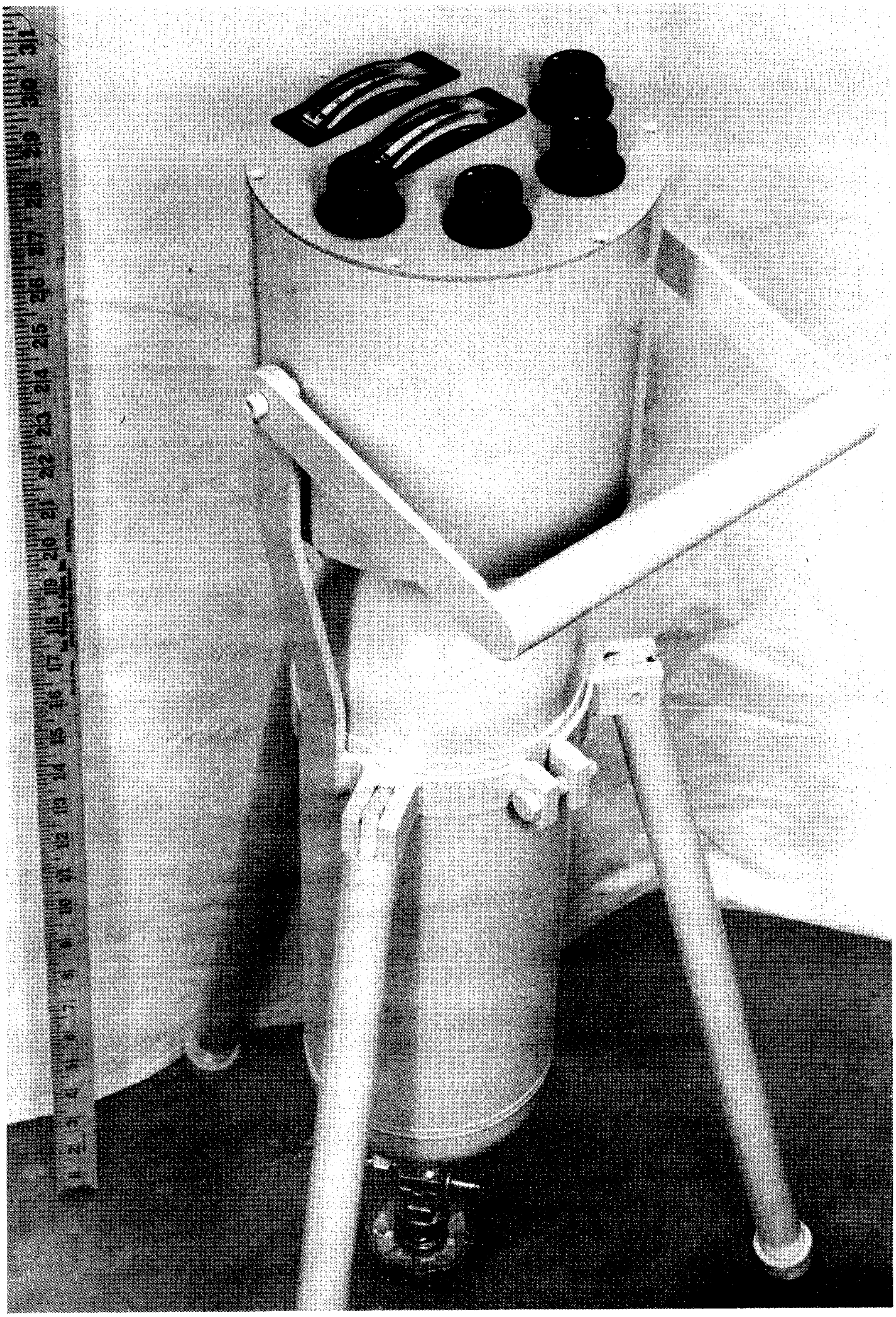


Figure 5