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2 FIG.

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DECONTAMINATION OF RESIDUAL WATER-BOILER OFF-GAS

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SAFE DISPOSAL OF RADIOACTIVE GAS FROM THE WATER BOILER

This project has been authorized to develop a method of reducing the volume of contaminated gas from the water boiler to a small quantity. Originally the procedure to be followed was to study methods of collecting the fission products from the gas stream, reducing the total quantity of gas, storage of gas for decay, or returning contaminated gas to the reactor.

At this time the water boiler is operated about six hours each day at a maximum power of 36 KW. Approximately 100 ml. of air per minute are forced into the system to keep the radioactive gas flushed from the pressure gage lines. The uranyl nitrate solution in natural water is radiolytically decomposed and the resulting gases with the gaseous fission products are mixed with the gas above the liquid in the sphere. This gas is circulated through a platinum on alumina catalyst to combine the hydrogen and oxygen. The water formed is condensed and added to the solution in the reactor. Nitrogen and more oxygen than is needed to burn the hydrogen are also released from the solution. For each 1000 KWH of operation, 185 ml. of 15.8 N HNO_3 must be added to replace that decomposed. It is necessary to vent this gas and the flushing air through a long pipe to the 150 ft. high stack on top of the canyon wall. In the stack the radioactive gas is diluted with a great quantity of air and released. Since the volume of radioactive gas was reduced two years ago, when the catalyst system was placed in operation, there have been no serious complaints of the activity released. However, this gas is still too active to be released in the proximity of a town.

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The radioactivity results mostly from the iodine and bromine decay chains which yield xenon and krypton and finally solids. The half lives of these vary from seconds to a few years. Particularly bad is the iodine which will accumulate in the body. Because of this, the limit of eight day I^{131} permissible in breathable air has been established to be only 3×10^{-9} millicuries per liter. The maximum limit for the other gases is 2×10^{-6} millicuries per liter.

EXPERIMENTAL: Several analyses have been made of the composition of the gas resulting from the decomposition of the nitric acid and uranyl nitrate solution. To do this the air in the system was replaced by argon. Then after the reactor had operated three hours at 31.7 KW, the composition was determined. There were found 0.1% H_2, 52.2% O_2, 23.8% N_2, and 24.0% A. The ratio of oxygen to nitrogen formed was found to be only 2.2 compared to 2.5 expected from

$$2\ HNO_3 \xrightarrow{Pt} H_2O + N_2 + 2.5\ O_2$$

This was probably due to a small air leak. Any air leaking into the system would lower this oxygen to nitrogen ratio. Also the quantity of nitrogen needed to be added to gas to give it the final observed composition was calculated to be 45 ml. per minute and only 24.3 ml. per minute could have been formed from the nitric acid known to be consumed.

No oxides of nitrogen have been found. In volumetric microanalysis methods these would be removed by freezing along with moisture. This moisture content was less than one per cent which is expected from the temperature of the sample when taken. Also a ferrous sulfate test made on 500 ml. of the gas

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was negative. As low as 0.002 per cent of nitric oxide could have been detected.

In another experiment, the decay rate of the gas mixture has been followed. A one liter sample was removed after the reactor had operated four hours at 35 KW. The activity of the gas was measured through one meter of air and one millimeter of pyrex. The effects of various shields were also observed. This information is shown graphically in figure 1. At one, two, and four days the gas was transferred to clean, glass wool filled bulbs so that the activity of the secondary solid decay products could be followed. The activity of these bulbs is shown in figure 2. It was observed that the half life of the mixture was about one-fourth of the time that the gas had been out of the reactor. This information will be of value in the design of any system of decay tanks.

Also by observing the periods of operation and the activity fluctuations at each end of the long vent pipe to the stack, it has been found that there is not much mixing as the gas flows through the two-inch i.d. pipe.

In a fourth series of experiments, it has been found that activated charcoal will remove the radioactive isotopes from the gas. A 1700 gram sample decontaminated the gas stream for six hours. Its useful life was found to be a function of the total gas flow instead of the power of the reactor. Therefore, it must be deactivated by the moisture carried by the gas. The gas flow is about 100 ml. per minute (flushing air) at zero power and about 200 ml. per minute when the reactor is operating at 36 KW.

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FUTURE: Pilot studies should be made to establish the respective advantages of the decay tank system and the regenerative charcoal method.

At this time the apparent advantage of the decay tanks would be the fact that they would require almost no maintenance. However, it would have the disadvantages of being very large if a long decay period is desired, and the gases would eventually be released to the atmosphere. One hundred and eighty liters of storage space would be necessary for each day of decay.

A charcoal trap system would probably be smaller than a decay tank system, but would require regenerating once each month. It can be estimated at this time that a trap containing less than 100 kilograms of charcoal would be adequate to decontaminate the gas for a month. Another trap could be used for a second month while the active isotopes caught in the first decayed enough to be concentrated in a small tube to be buried.

Harold M. Busey

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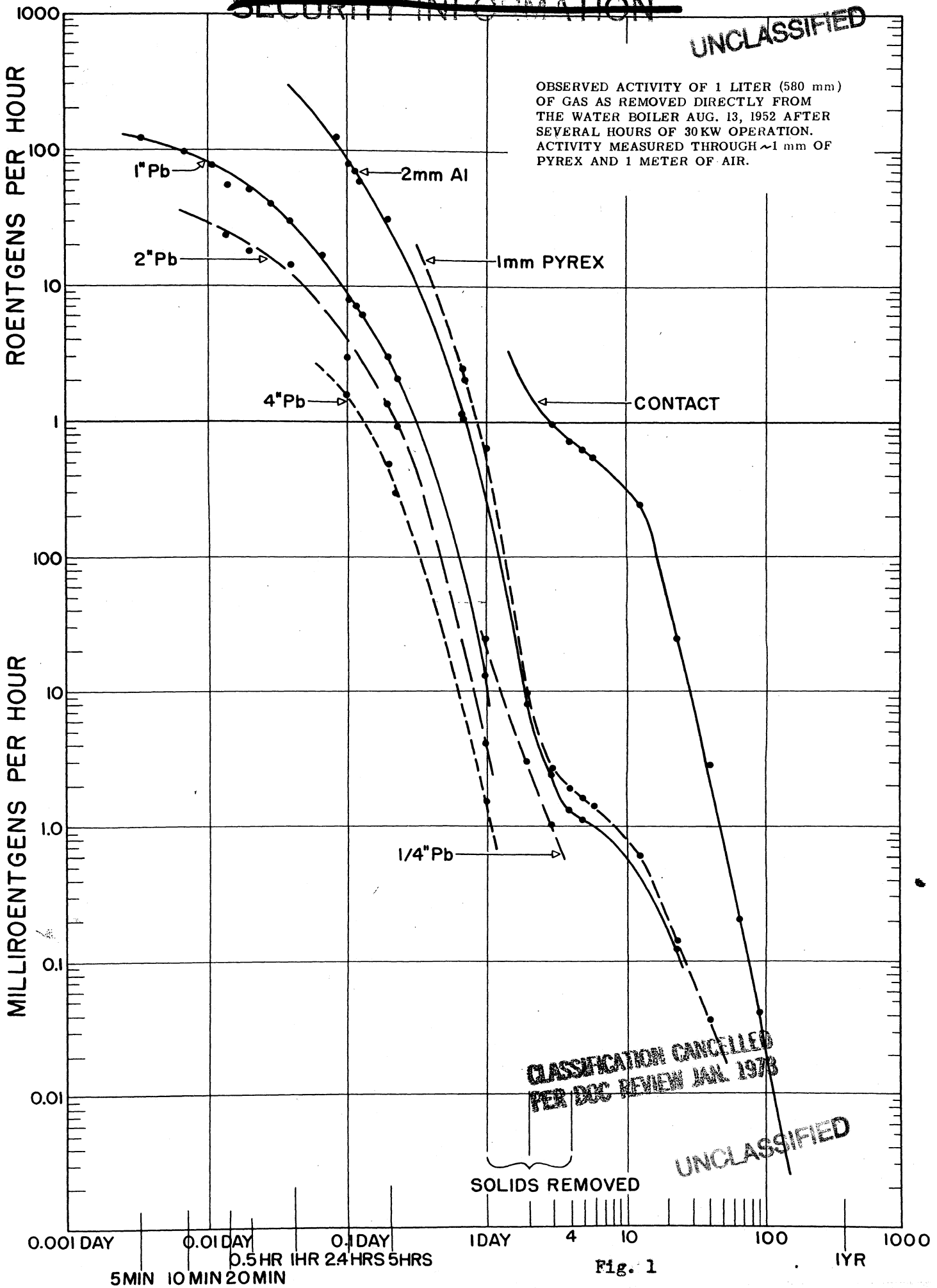

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Fig. 1

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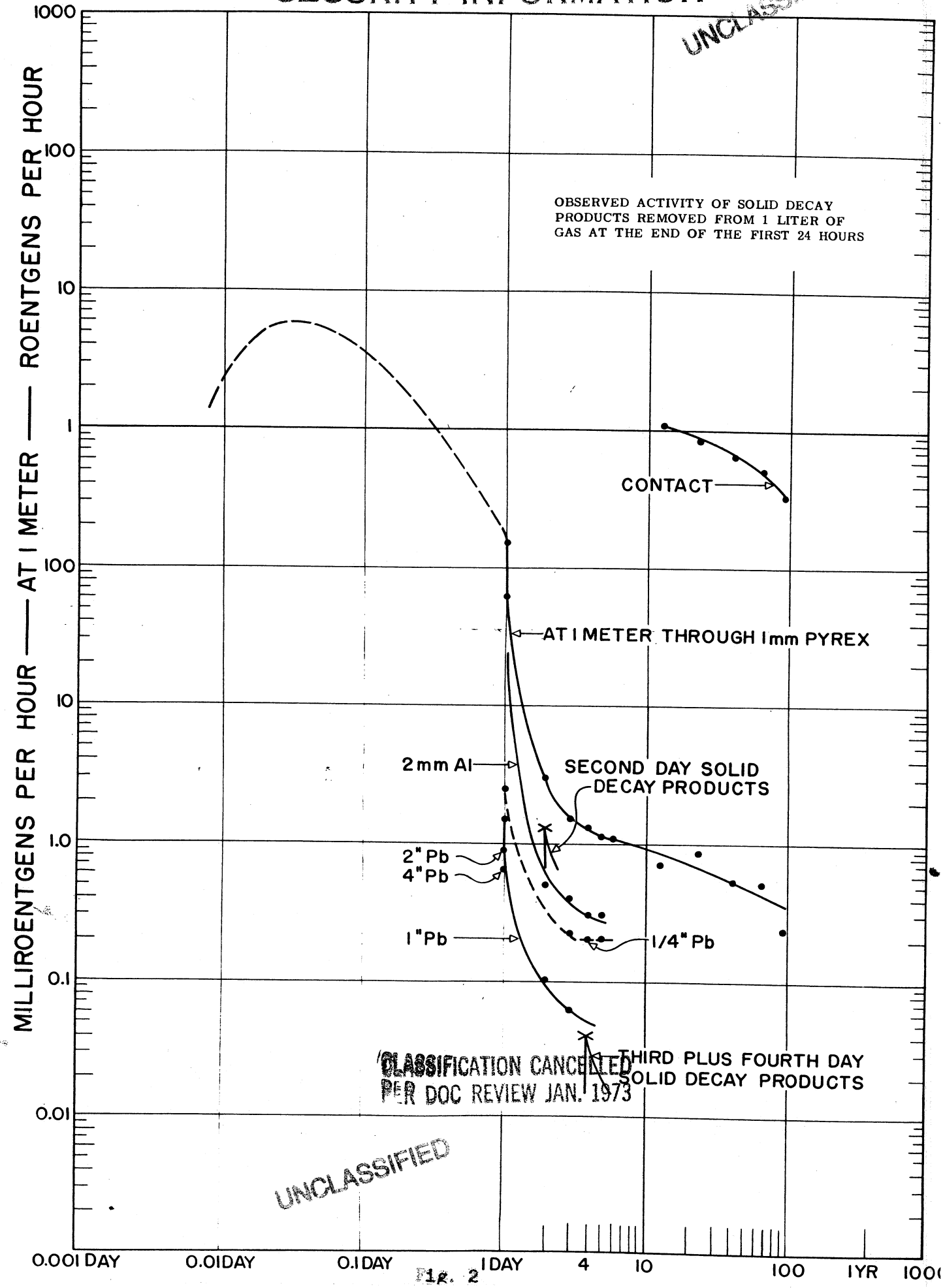

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Fig. 2