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MEASUREMENT OF THE RESIDENCE TIME OF SLURRIES IN AN AERATOR TANK, USING RADIOACTIVE TRACERS

by

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E. C. Gibson* and G. G. Eichholz**

ABSTRACT

Radioactive silver was used as a tracer to investigate the flow characteristics and the effective residence times of a slurry in a laboratory tank used for aeration in pilot plant flotation operations. It was found that short-circuiting occurred with the air inlet in its original position, and satisfactory mixing was established by relocating the inlet pipe. The interpretation of retention time data is discussed briefly. Measurements of this type can be carried out during normal operation of the plant and at negligible cost.

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INTRODUCTION

In the course of pilot plant operations on a copper ore in the mill of the Mineral Dressing and Process Metallurgy Division of the Mines Branch, it became apparent, from rapid changes in pulp density and poor flotation results, that aeration in the aerator tank did not take place with the calculated contact time. To establish this fact and to test any remedial steps taken, it was decided to use a radioactive tracer. This permitted uninterrupted operation of the pilot plant while the test was in progress, and produced the required results within a few hours.

The isotope chosen was silver -110, both because it was known to adhere readily to all mineral particles under the conditions of the flotation run [1], and because it was readily available at the time.

Two test runs were undertaken to establish initial conditions, and two more were made later to check on mixing conditions with the air cut off and with a different air inlet location.

EXPERIMENTAL DETAILS

The general procedure was similar to that described by Turgeon[2]. A solution containing radioactive silver nitrate was added to a small quantity of slurry. At a given moment this activated slurry was poured into the intake pipe to the aerator tank under test and 100 ml samples were then taken at the outlet pipe at regular intervals. The samples were contained in 250 ml Pyrex beakers and were counted, in a fixed geometry, by means of a scintillation counter.

Each test was carried out with an amount of radioactivity of about 0.1 millicurie of Ag-110.

The aerator tank tested was a Denver air lift mixer tank of 42.5 cu ft capacity. Figure 1 shows its initial arrangement. The plant was run at a feed rate of 500 lb per hour.

The first experiment was carried out to establish whether or not serious short-circuiting took place in the tank between intake and outlet. The results obtained are shown in Figure 3 and it is evident that a considerable fraction of the activity passed through the tank very rapidly.

For more quantitative information a second test was run with more frequent sampling during the first 12 minutes. The results of this run are shown in Figure 4, in which the upper curve contains the information on the first few minutes, while the lower line contains later results from which the steady-state contact time can be derived. Again, there is a short-lived, sharp peak at the beginning, followed by a long steady fall. Note the small peak at 6-7 minutes, followed by another one, less well defined, at 12 minutes.

As it was suspected that the short-circuiting was mainly due to the fact that the downward flow of the incoming pulp was opposed by the upward movement of compressed air, it was decided to repeat the run with the air shut off. The results obtained are shown in Figure 5, which indicates plainly the absence of the initial peak.

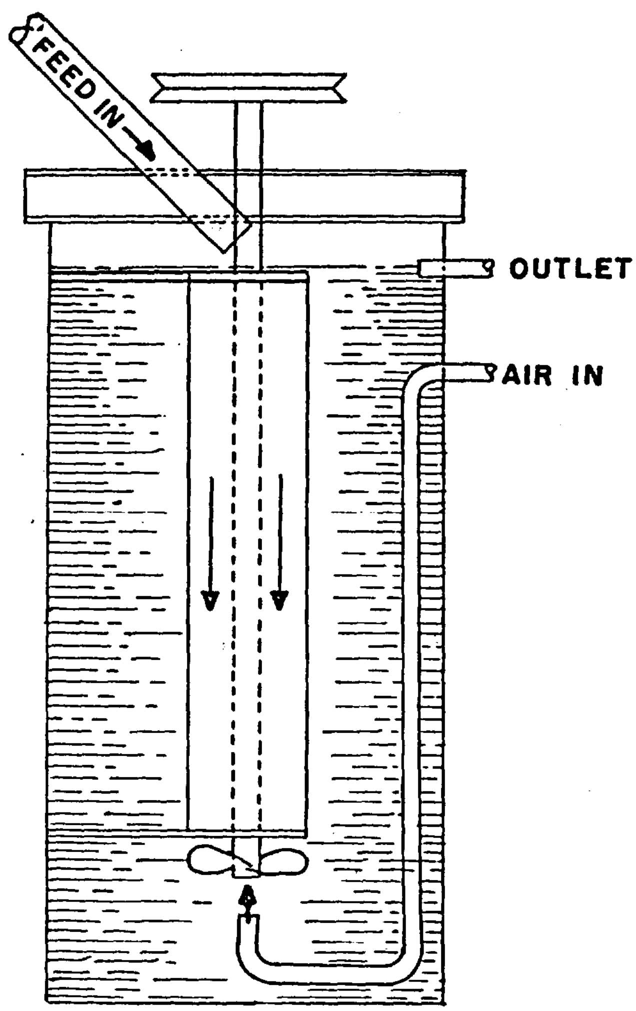

FIG. 1 – AERATOR TANK, INITIAL CONDITION.

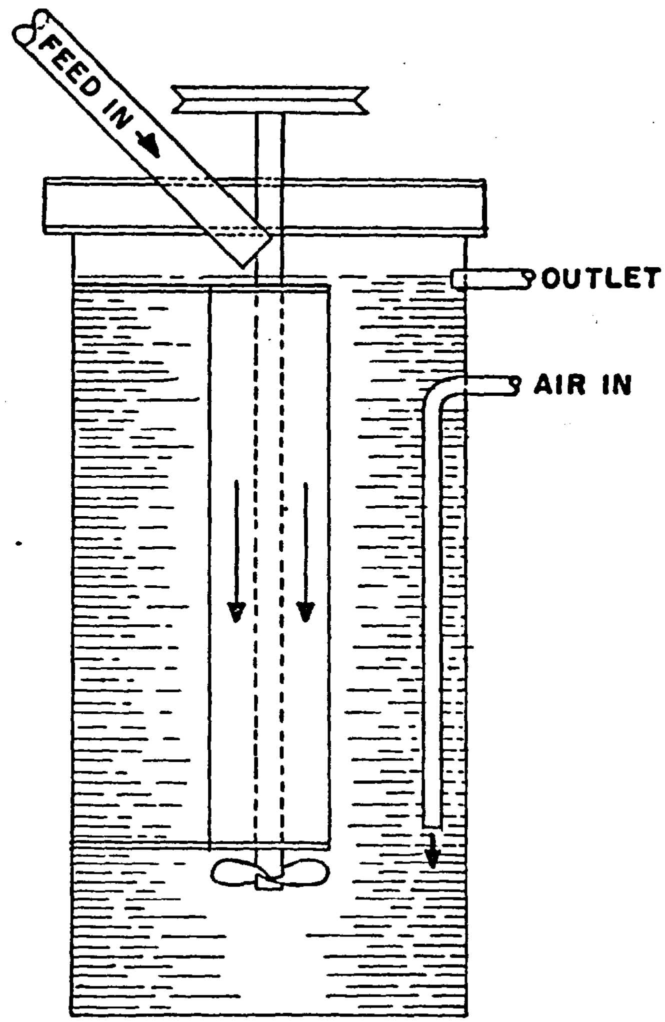

FIG. 2 – AERATOR TANK, MODIFIED CONDITION.

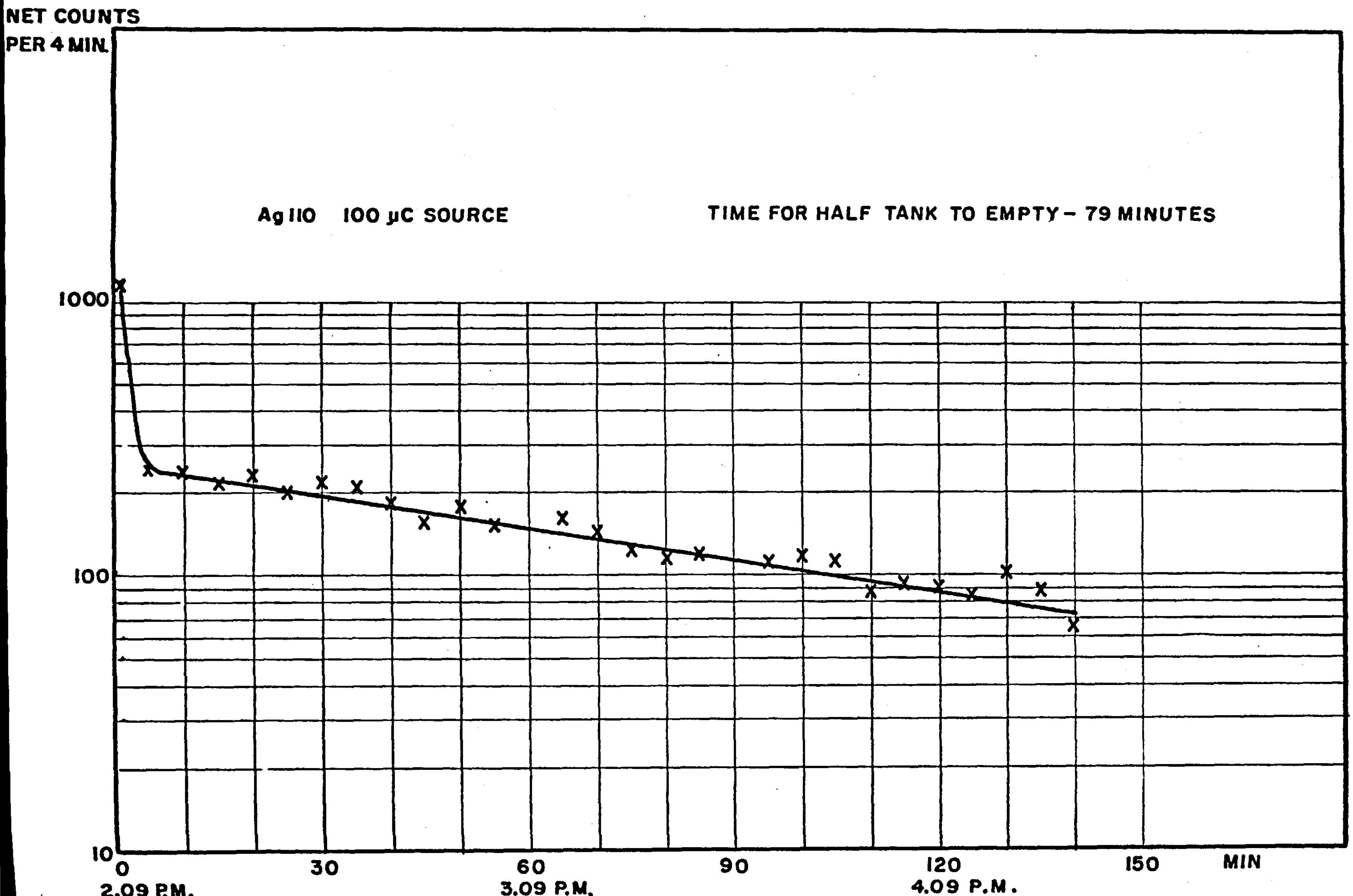

FIG. 3 — TRACER TEST ON AERATOR - M.D.P.M. MILL.

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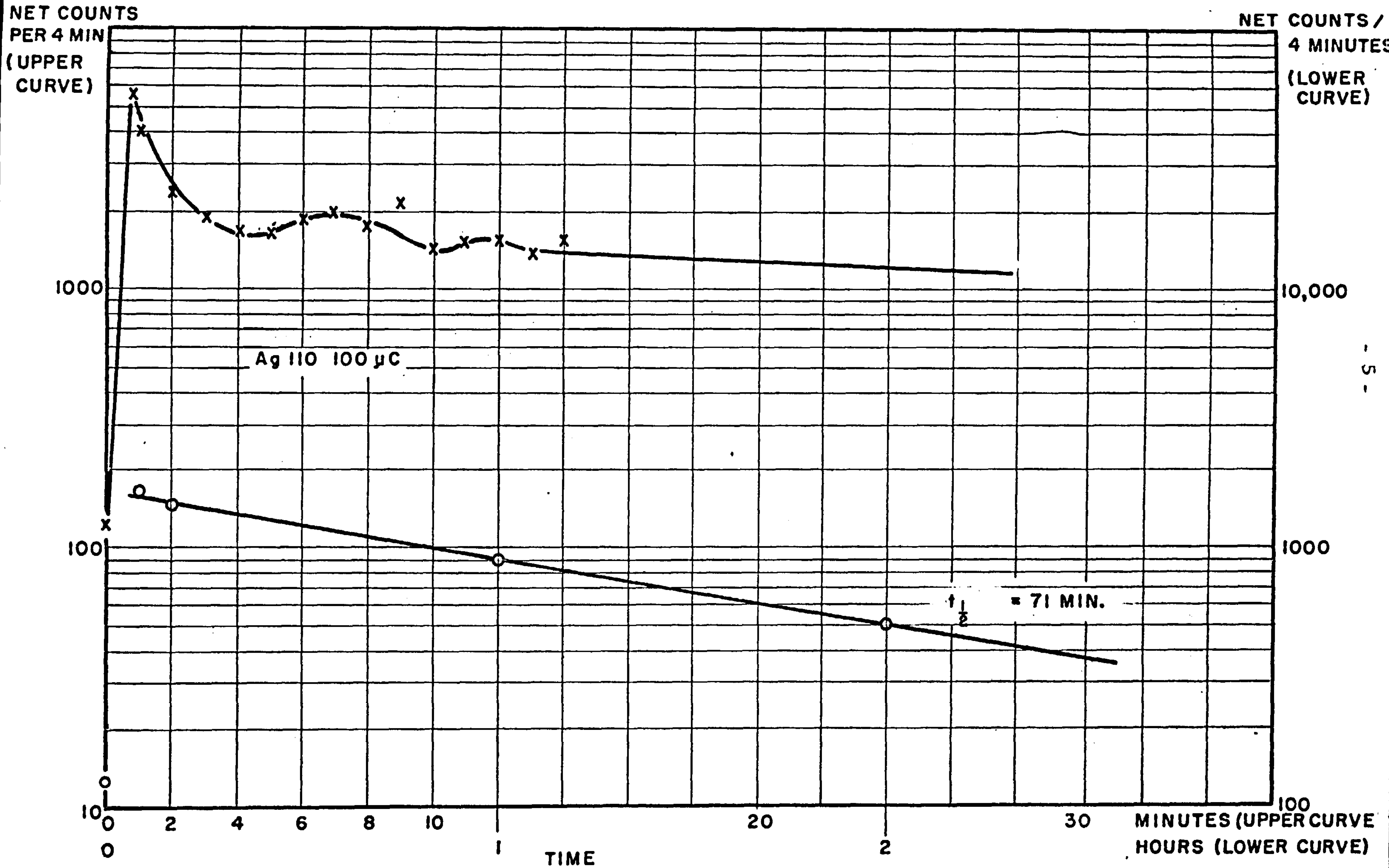

FIG. 4 - TEST 2, AIR ON, REPEAT RUN.

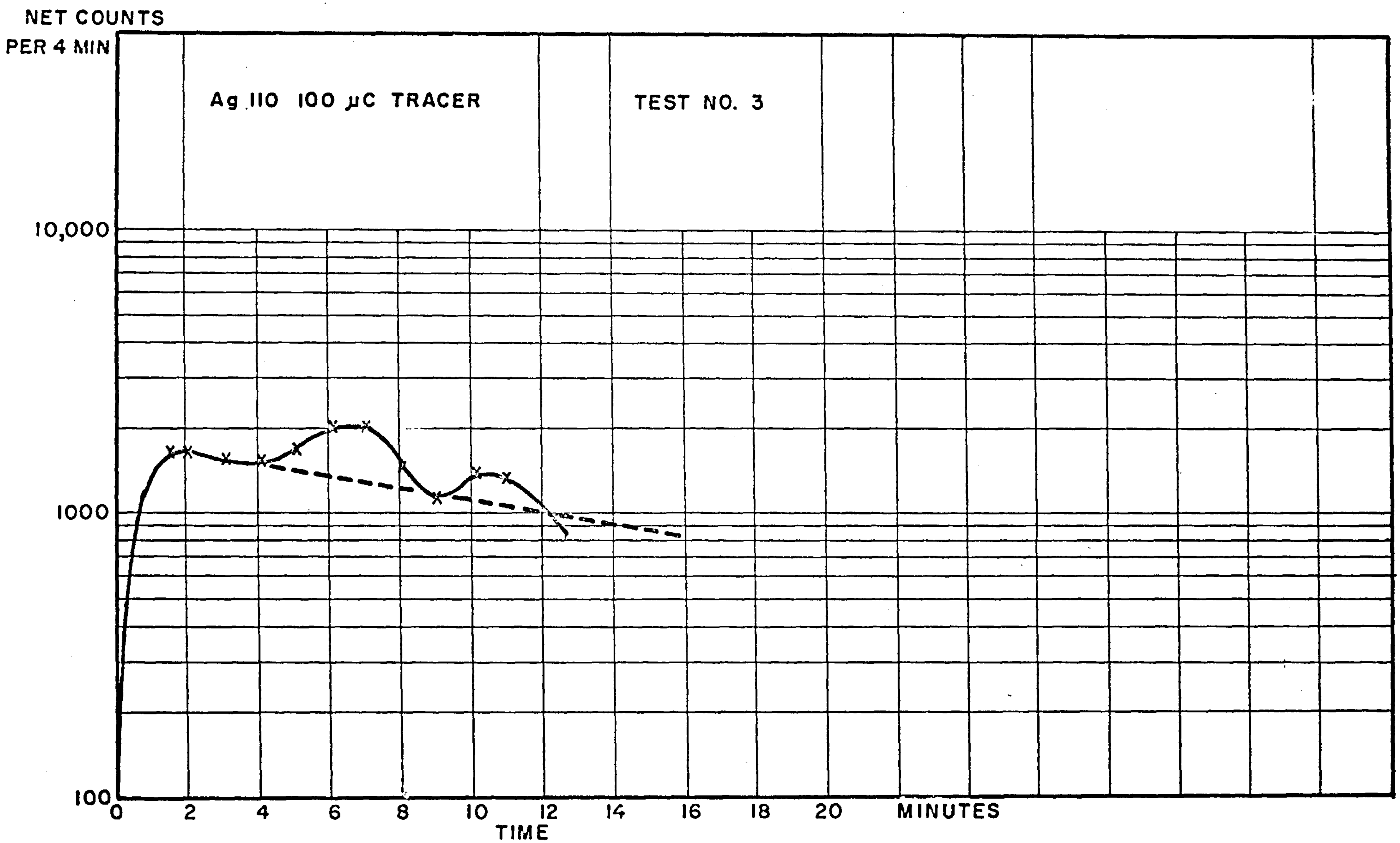

FIG.5 - TEST 3, FEED MAINTAINED, AIR SHUT OFF.

In view of this fact, the air pipe was moved to one side of the tank as shown in Figure 2. After that, another tracer test was carried out, with the results shown in Figure 6. Now there was no short-circuiting, but just the expected build-up and slow decay of activity in the pulp samples.

DISCUSSION

The tests have indicated in a quick and simple fashion the removal of the short-circuiting condition that was present in the tank initially. From a comparison of the count rate at the initial peak, in Figure 4, with that obtained by projecting the straight line part of the graph back to 1 minute, one can estimate roughly the extent of this short-circuit loss. This gives a ratio of 3.8:1; that is to say, about 74% of the pulp was short-circuiting.

The "nominal" retention time for such a tank is usually calculated from the ratio of volume to flow rate. For a feed rate of 500 lb/hr, a pulp density in the aerator of 25% solids, and a tank capacity of 42.5 cubic feet, the nominal retention time is calculated as 98 minutes. This is not a very satisfactory approach to retention time calculations as it presupposes a uniform, unique flow path. A more satisfactory method of calculating "effective" retention times has been pointed out previously [3], and utilizes the slope of the activity plots. From the time, $T_{1/2}$, which elapses for a decrease of activity to one half of its earlier value, an average effective retention time can be calculated. This time, $T_c = 1.44\, T_{1/2}$, represents the average residence time of the marked

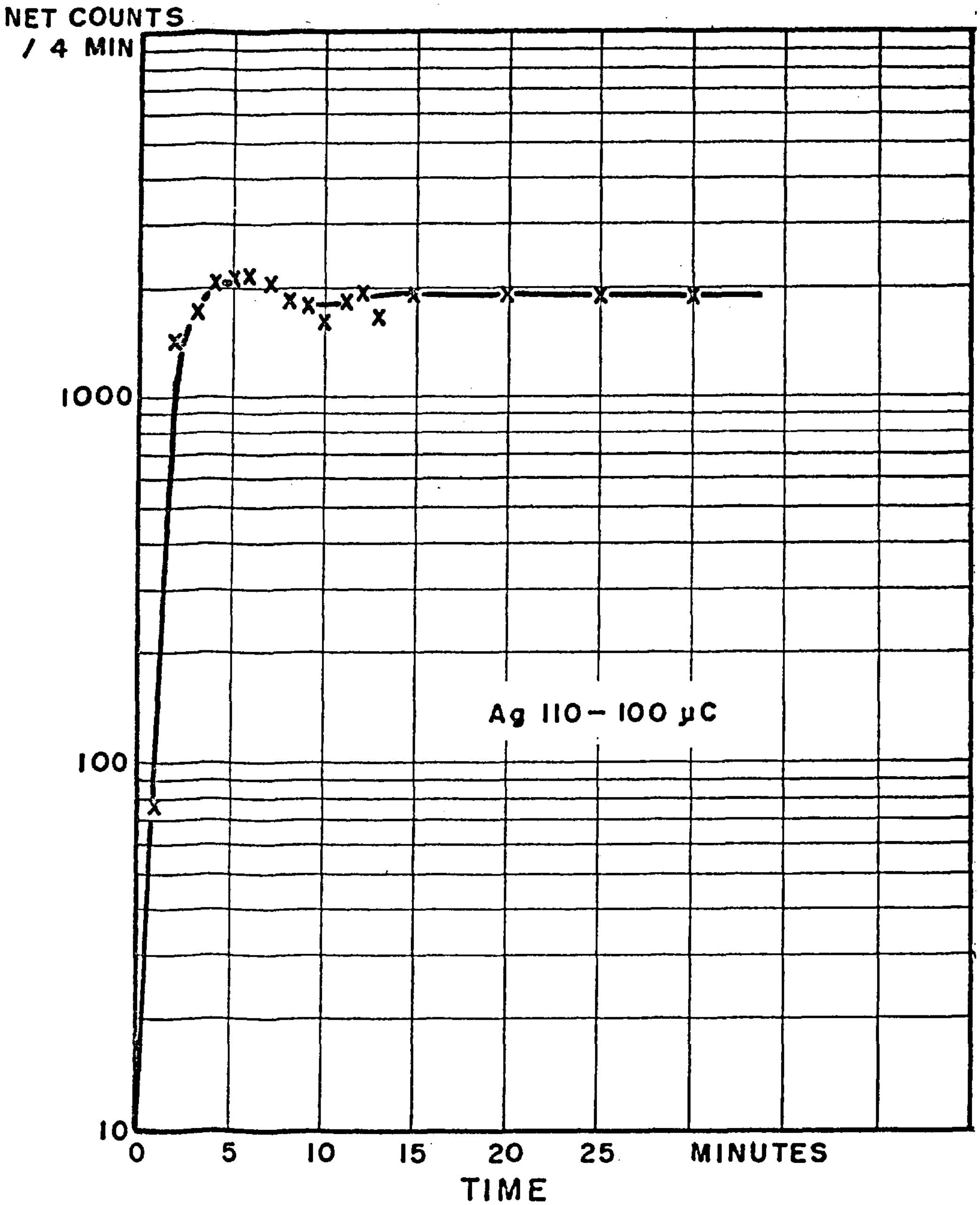

FIG. 6 - PILOT RUN, TEST 4.

particles in the system under test. In the present test work, Tests 1 and 2 gave a mean value for $T_{1/2}$ of 75 minutes, so that the effective contact time for those particles which did not follow the short-circuit path was 108 minutes, not very different from the nominal value. In contrast, the short-circuit residence time was about 1.3 minutes.

Another noteworthy feature of the test plots are the secondary peaks occurring at 7 and 11 minutes after the start of each test. Occurring always in the same position, they can hardly be discounted as statistical vagaries and presumably represent a single vertical loop circuit in the tank with a path time of 5-6 minutes.

It appears, therefore, that the tank had a more complicated flow pattern initially than had been suspected, namely: (a) a short circuit path of about 1.3 min duration, which was removed by the relocation of the air inlet pipe; (b) the steady vortex path, leading to a spiral motion of the particles upward along the wall of the tank, and downward through the centre pipe, with an average residence time of 108 minutes; and (c) a single loop duration of 5-6 minutes, so that an average particle travels up and down about 18-25 times during its stay in the tank.

It is evident, from these results, that considerable design information may be gathered from tests of this type. Each test took 2 to 3 hours for completion and was carried out without interruption of the flotation test work. The cost of the radioactive material used was 40 cents per test.

ACKNOWLEDGMENTS

We wish to acknowledge with thanks the assistance of Messrs. H. Hughes, C. A. Josling and J. V. Krzyzewski in carrying out this work.

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