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National Aeronautics & Space Administration
Lewis Research Center
21000 Brookpark Road
Cleveland 35, Ohio

Attention: Mr. H. J. Schwartz, Project Manager
Auxiliary Power Generation Office

Subject: Monthly Progress Report - Contract No. NAS 3-2551

Gentlemen:

Enclosed please find subject Progress Report No. 11 covering the work performed during the month of May 1963, as required by the subject contract.

Very truly yours,

TAPCO - A Division of
THOMPSON RAMO WOOLDRIDGE INC.

William J. Leovic
Project Manager
New Product Research

WJL/jmb
Encl. (2) + Reproducible Copy

cc: Mr. R. M. Cohn RPP, NASA-Washington 25, D.C.
Mr. J. J. Fackler, NASA-LEWIS RESEARCH CENTER
Mr. R. S. Godman, " " " "
Dr. B. Lubarsky, " " " "
Mr. N. T. Musial, " " " "
Mr. N. D. Sanders, " " " "
Mr. Wm. Dusenbury, NASA-Manned Spacecraft Center, Houston, Texas
Mr. Wm. M. Rand, Jr., Ionics, Inc., 152 Sixth St., Cambridge, Mass.

OTS PRICE

XEROX $ 1.60 ph

MICROFILM $ 0.80 mf

N64-16320

MONTHLY PROGRESS REPORT

No. 11

for

May - 1963

Submitted by

NEW PRODUCT RESEARCH OF TAPCO

I INTRODUCTION

This document represents the eleventh monthly report covering the work on the experimental program for development of an "Osmotic Still" and improvements in the performance characteristics of the Ionics' Duel Membrane Fuel Cell during the month of May, 1963. This development work is being accomplished under NASA - Lewis Research Center Contract No. NAS 3-2551 by the New Product Research Department of TAPCO, and Ionic's Inc. as a subcontractor to TAPCO.

II OVERALL PROGRESS

A. Tapco Portion of Program

1. The fabrication of all component parts for the 2 KW "Osmotic Still" with the exception of the gaskets has been completed.

2. The construction of the test rig required for performance evaluation of the 2 KW "Osmotic Still" has been completed and instrumentation checkout is now in progress.

3. Calibration of the flow meters has been completed.

B. Ionics Portion of Program

1. The ten-cell battery was assembled, run for more than 100 hours, and delivered to TAPCO. At the design current density of 24 amps/ft^2, a voltage of 7.75 $\pm$ 0.18 was maintained throughout the 100 hour test - compared to a specified minimum of 6.8 volts. Battery performance corresponded to 100 watts at 6.8 volts as compared to a specified minimum of 40.8 watts.

2. A reproducible procedure for "temporarily" improving battery performance was developed. Battery voltage at 24 amps/ft^2 could be raised from 7.75 volts to 8.5 volts. The battery would slowly regress to 7.75 volts over the next 18 hours.

3. Design of the 2 KW battery continued.

4. Further experimentation on a five-cell battery was undertaken to allow more accurate prediction of the rates at which liquid accumulates in the gas streams.

III CURRENT PROBLEMS

A. Tapco Portion of Program

1. There have been no major technical problems during this reporting period, however, procurement of the gasketing material for the 2 KW "Osmotic Still" has been delayed. This delay has prevented

gasket cutting and "Still" assembly. Receipt of this material is expected by mid-June.

B. Ionics Portion of Program

1. Completion of 2 KW Dual Membrane Fuel Cell design.

2. Completion of final report to TAPCO.

IV NEXT MONTH'S EFFORTS

A. Tapco Portion of Program

1. Complete instrumentation checkout of test rig.

2. Complete checkout of test rig construction. (leaks, pump operation, valve operation, etc.)

3. Cut gaskets and assemble 2 KW "Osmotic Still" and install in test rig.

4. Initiate testing of "Still".

B. Ionics Portion of Program

1. Complete 2 KW Fuel Cell Design.

2. Complete Final Report to TAPCO.

V TEST RESULTS

A. Tapco Portion of Program

1. No test data was recorded during this reporting period.

B. Ionics Portion of Program

1. Ten-Cell Battery

The individual components of the 10-cell battery are listed in Table 1. The weights of the various components are also listed. It may be recalled that, as spelled out in the Statement of Work, no attempt was made to minimize weight or volume.

The evaluation run on the ten-cell battery was performed at 24 amps/ft^2 and ambient temperature. Voltages generated by the battery and by each of the cells were recorded at intervals. These voltages are presented in Figure 1. The average battery voltage during the run was approximately 7.75 volts with a maximum of 7.94 volts and a minimum of 7.62 volts. The performance of the cell was considerably better than the requirement which specified 6.8 volts at this current density.

The individual cells produced voltages which ranged from 0.836 to 0.721 volts. Note that the best cell never dropped below 0.81 volts and the best three cells never produced less than 0.795 volts.

Following the evaluation run, it was noticed that considerable improvement in performance occurred when (a) the oxygen supply to the cathodes was cut off, (b) the cell output voltages were then allowed to decline to zero and (c) oxygen feed to the battery was restored. This procedure would increase the battery output voltage at 24 amps/ft^2 from 7.75 volts to 8.5 volts. During the next 18 hours, the battery gradually retreated from this improved condition. Repeating the O_2 deprivation - voltage decline - refeed procedure at any time would again bring the battery performance up to the maximum "improved" level. At present, explanations of the phenomenon are purely conjectural.

A polarization curve was taken while the cell was in the improved condition. This is reproduced in Figure 2. It can be seen that the voltage at 24 ampts/ft^2, 8.5 volts, is considerably higher than any that was produced by this battery previously. At the highest current density, the two cells next to the end plates showed considerably lower voltages than the other cells which was thought to be due to IR-losses in the terminal collector plates. Consequently, two points are plotted at the highest current density (80 amps/ft^2): the lower is the measured voltage, the higher voltage is calculated assuming that the two end cells should produce a voltage equal to the average of the other eight cells.

The two slopes of this polarization curve correspond to specific conductances of 340 and 400 mhos/ft^2. These are quite similar to the conductance of 369 mhos/ft^2 calculated for Battery 3, which also had niobium collector and pusher plates. As an average of these values, a conductivity of 370 mhos/ft^2 will be used in the design of the 2 KW battery.

The polarization curve corrected for terminal losses shown in Figure 3 was used to calculate a power density curve. The peak power for a battery with this polarization curve is 78 watts per square foot for a single cell. This occurs at a current density of 177 amps/ft^2.

In several previous batteries, it had been observed that the gaskets had almost completely blocked the gas inlet and outlet channels. To prevent this, the parts of the gaskets which normally would be over the channels were cut away on the gaskets between collector plates and gas compartments. This resulted in relatively low gas-side pressure drops. These measurements are plotted in Figure 4. The pressure drops ranged from 14 to 24 millimeters of water, which apparently was sufficient for adequate distribution of the gases.

Liquid accumulation on the hydrogen side, Figure 5, was quite regular throughout the run. Values of 5.95 grams of water per hour and 2.34 grams of H_2SO_4 per hour were calculated from the accumulation curves.

On the oxygen side, the picture is more confused. Several breaks occur in the accumulation curves and the slopes vary from 2.06 to 5.08 grams of water per hour and from 0.675 to 1.28 grams of H_2SO_4 per hour. During the run, the battery acid concentration varied from 9.05N to 5.60N. However, the variations do not appear to coincide in such a manner that a reasonable correlation can be established at present.

2. Battery 6

To investigate this problem of liquid accumulation, a five cell stack was assembled for the specific purpose of establishing the dependence of water and acid accumulation rates on current density, electrolytic concentration and cell temperature. Current densities of 12, 24, 40 and 60 amps/ft^2, acid concentrations of about 3N, 6N, 8N and 11N, and cell temperatures of about 30°C and 60°C are being investigated.

These data have not yet been worked up, but they are to appear in the final report.

VI ITEMS DELIVERED

The following items were delivered by TAPCO to NASA-Lewis Research Center on May 10, 1963:

1. The Ionic's Ten Cell Dual Membrane Fuel Cell Battery.

2. Instructions for Filling and Operating Ionic's Ten Cell Dual Membrane Fuel Cell Battery (2 copies)

FINANCIAL REPORT

for

MAY - 1963

(Contract NAS 3-2551)

Submitted by

NEW PRODUCT RESEARCH of TAPCO

(Attachment to Monthly Progress Report No. 11)

FINANCIAL REPORT

for

Contract NAS 3-2551

for

Period Ending May 31, 1963

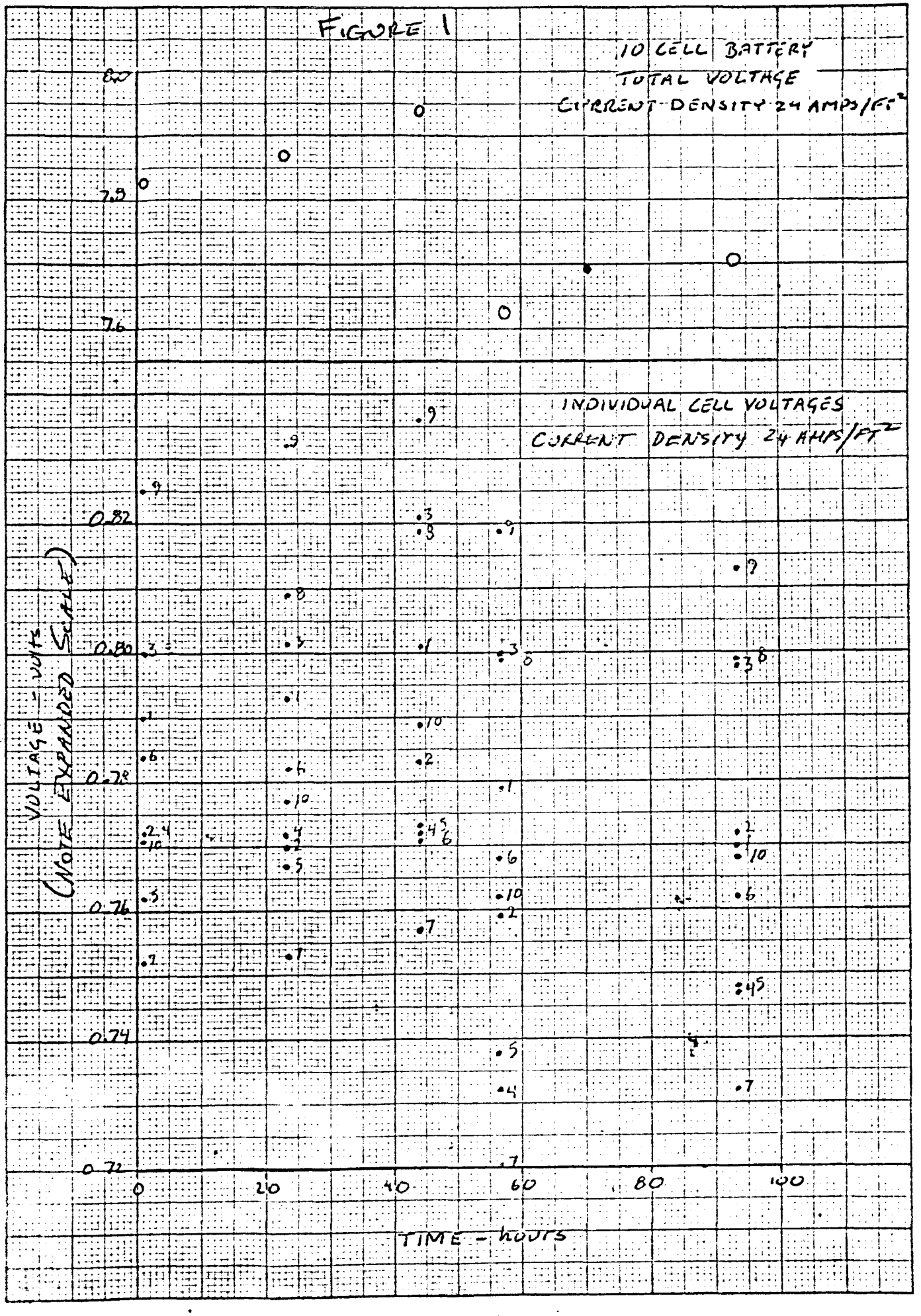
	Current Month	Total To Date
TRW Engineering Hours	267	2,932
TRW Costs and Commitments	$ 4,119	$ 44,073
Subcontractor Costs and Commitments	$ 7,817	$ 161,017
TOTAL	$ 11,936	$ 205,090

TABLE 1

COMPONENTS OF 10-CELL BATTERY

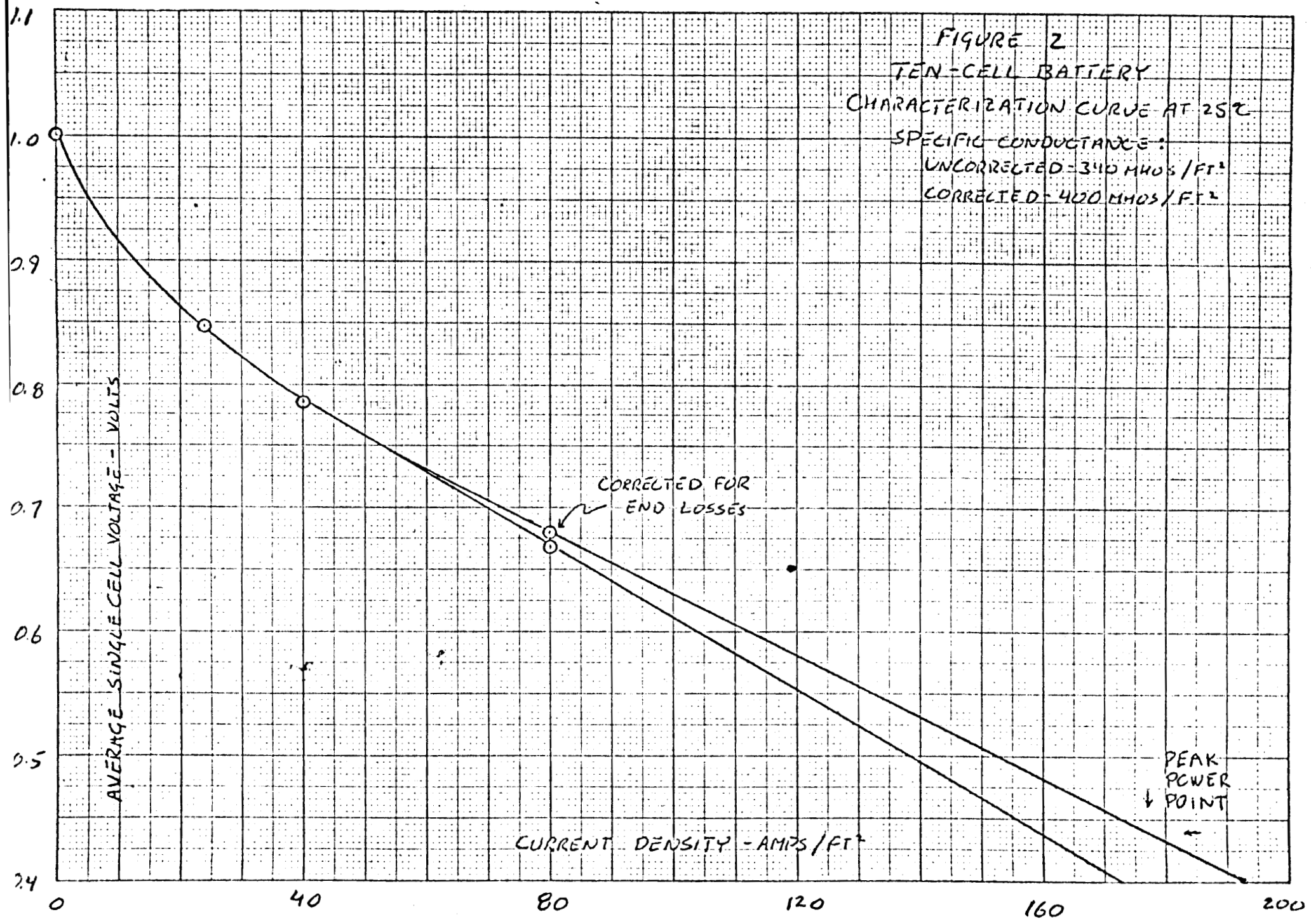
NUMBER	COMPONENT	MATERIAL	WEIGHT, GMS
2	End Plates	3/8" Stainless Steel	
12	Fittings	Swagelock Male Connectors, #400-1-4	
		Gas Inlets: Stainless Steel	13258
		Other Inlets and Outlets: PVC	
		Plugs 1/4" NPT, PVC Plugs	
12	Studs	3/8" National Coarse, Stainless Steel	788
24	Washers	" "	76
24	Nuts	" "	211
2	Insulators	60-Mil Butyl Rubber	200
20	Pusher Plates	10-Mil Niobium	1170
11	Collector Plates	10-Mil Niobium	1328
20	Electrodes	Standard Sintered Pt-Teflon	760
20	Membranes	IONICS CR61AZG	1065
20	Gas Compartments	64-65-Mil Teflon	1866
10	Electrolyte Comp.	118-135-Mil Teflon	2179
20	Trilok Filler	U.S. Rubber #6027-1-1	144
60	Gaskets	8-Mil Dacron Backed Viton A	576
44	Gromments	8-Mil Dacron Backed Viton A	3
	Electrolyte	6N H_2SO_4	1353

FIGURE 1



K+E 80 X 20 TO THE INCH 358-10½ KEUFFEL & ESSER CO. MADE IN U.S.A.

K+E 20 X 20 TO THE INCH KEUFFEL & ESSER CO. 358-10½ MADE IN U.S.A.



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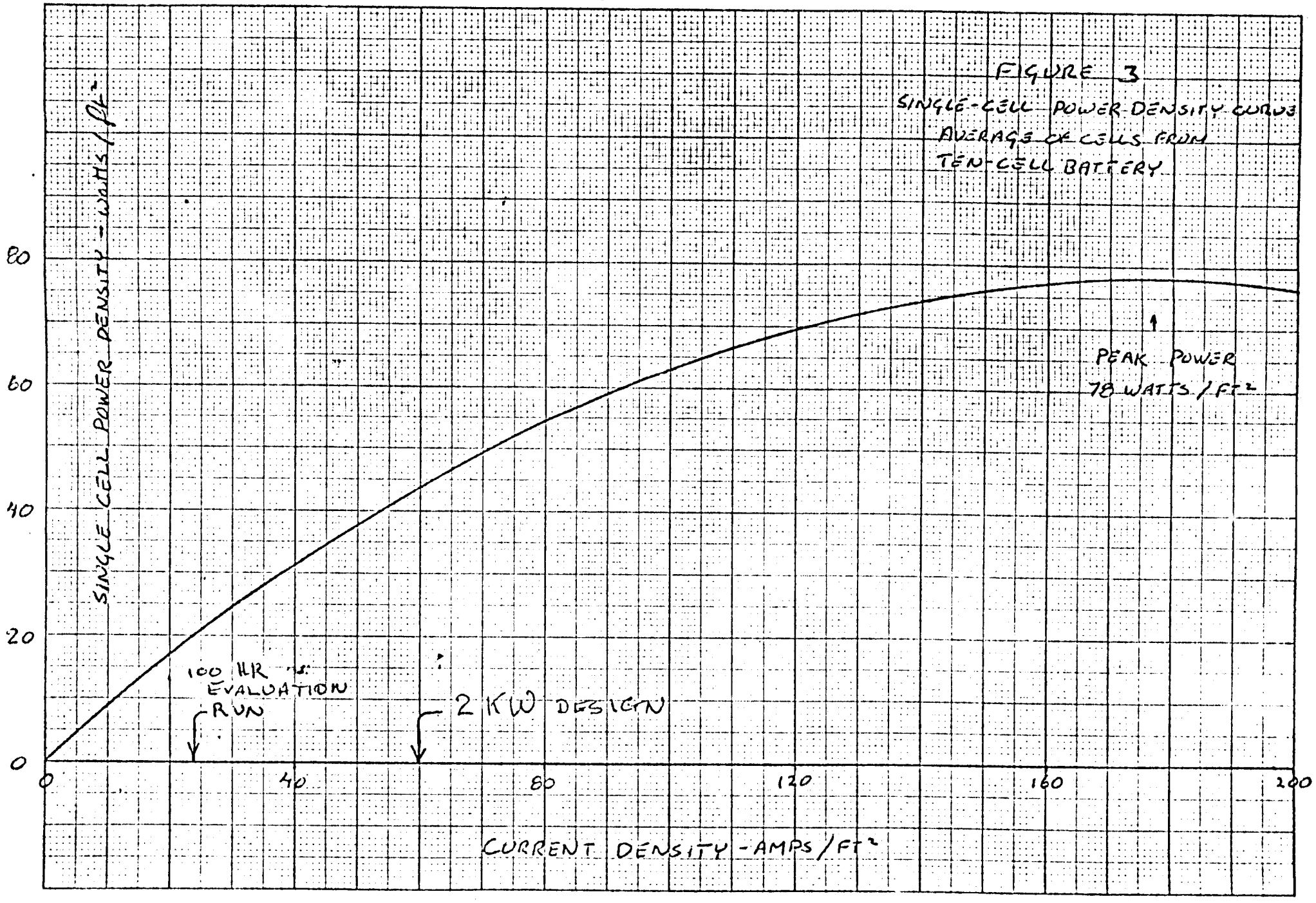
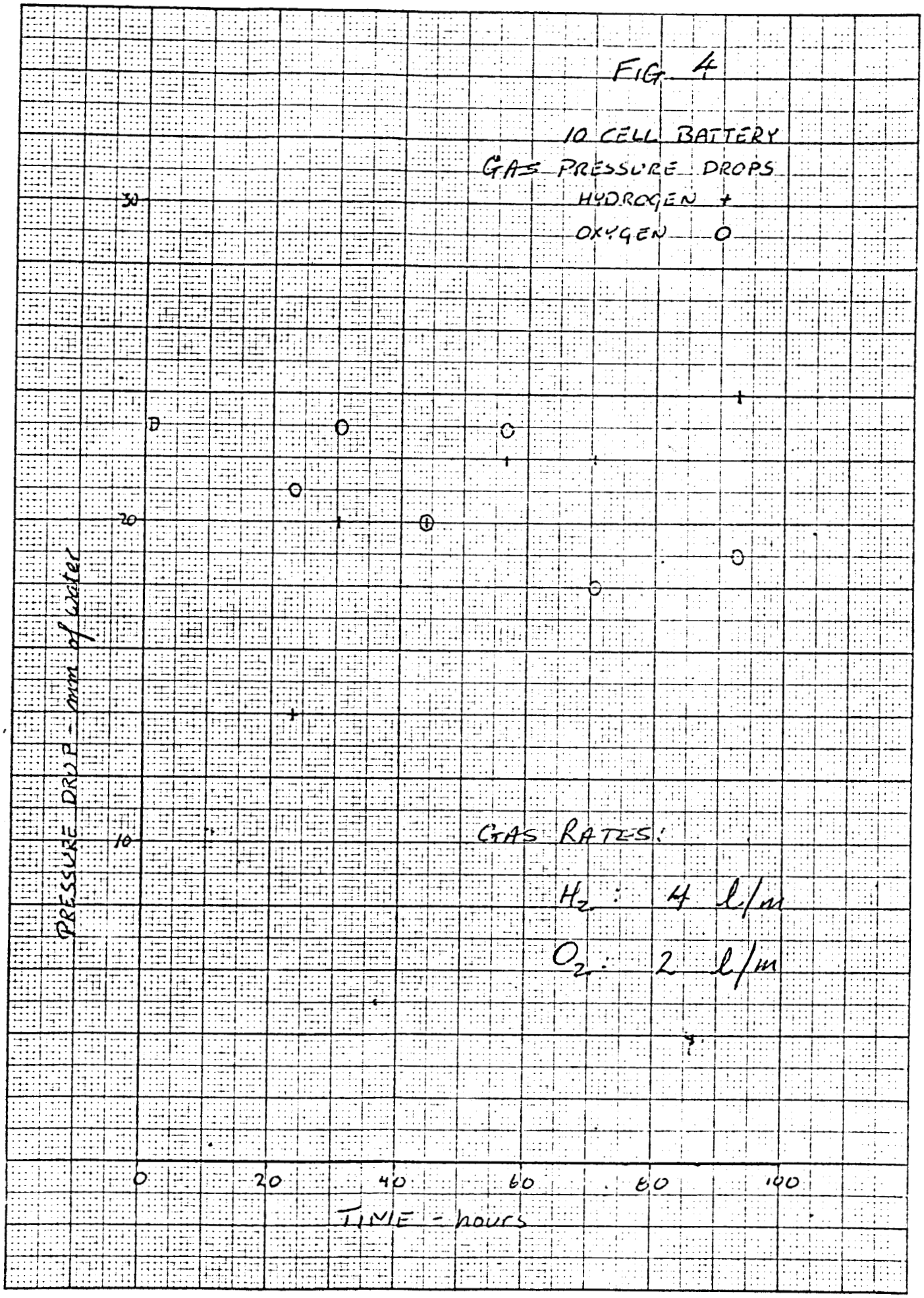
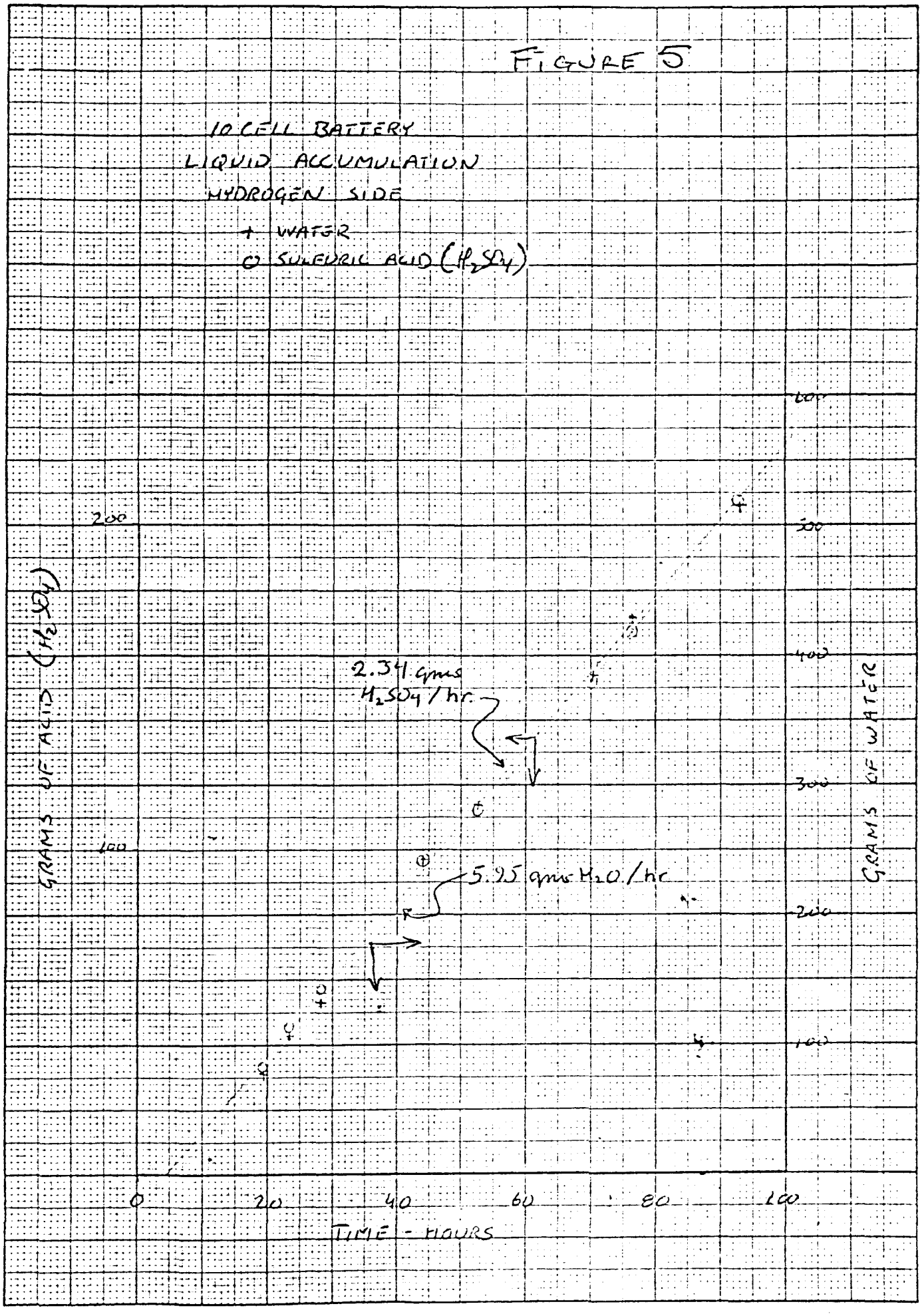




K&E 20 X 20 TO THE INCH KEUFFEL & ESSER CO. 358-10½ MADE IN U.S.A.

FIGURE 5



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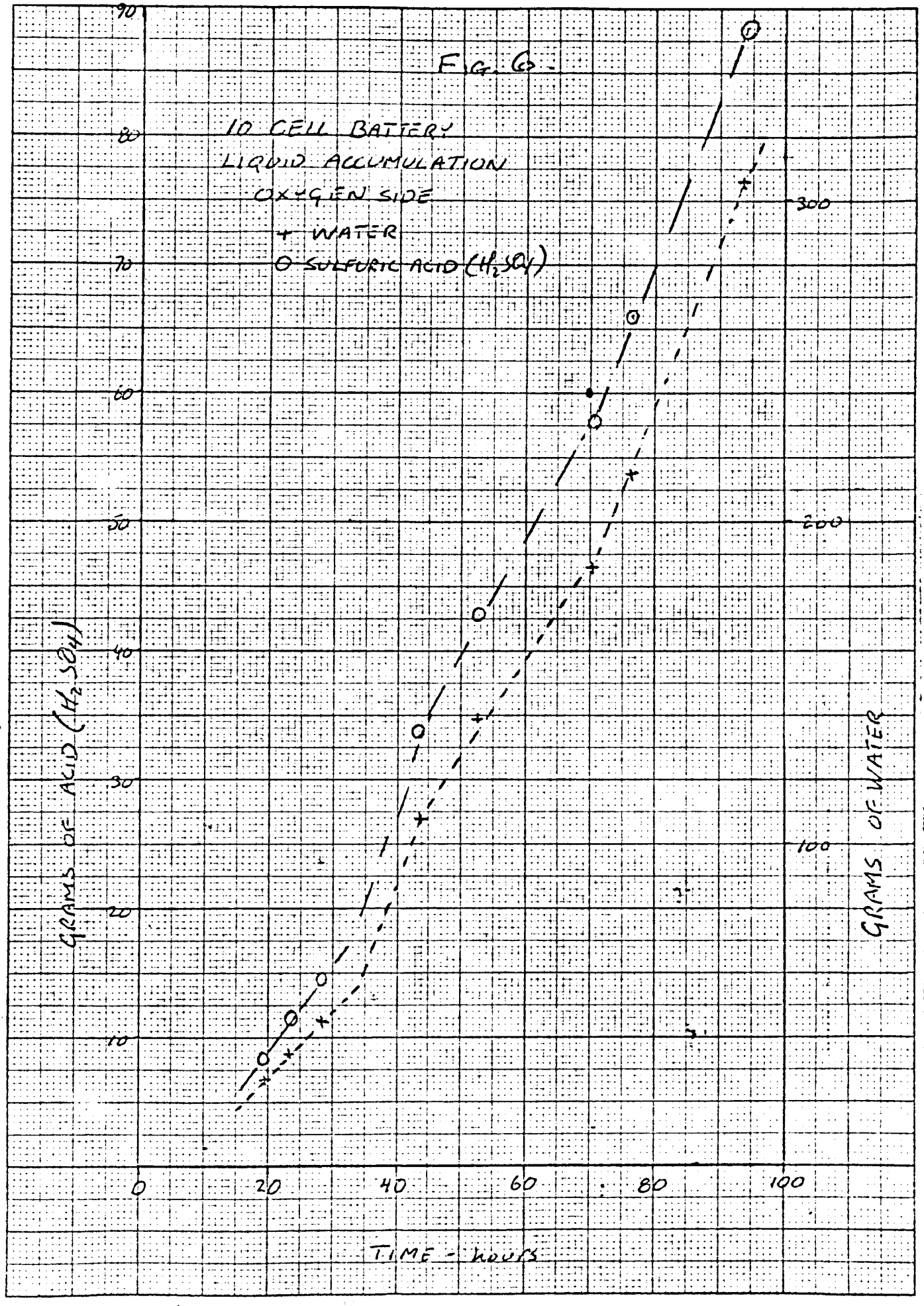

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