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DEVELOPMENT OF THE DESIGN CONCEPTS FOR A MEDIUM-SCALE WIND TUNNEL MAGNETIC SUSPENSION SYSTEM

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TABLE OF CONTENTS

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I. INTRODUCTION

The potential utility of magnetic suspension techniques for large scale aerodynamic testing has been established on the basis of two successful developments, viz., (i) a prototype superconductor magnetic suspension system[1], and (ii) a pilot cryogenic wind tunnel facility[2].

In the first development, the University of Virginia research group designed, built, and tested an all-superconductor prototype magnetic suspension system for the principal purpose of establishing the feasibility of utilizing superconductor technology in the highly coupled, dynamic operating mode which is characteristic of a wind tunnel suspension and balance device. Furthermore, scaling predictions based on small-scale experiments form the basis for estimates about power dissipation and other operating characteristics of larger facilities.

In the process of performing preliminary design calculations for an intermediate-size facility to be operated in conjunction with NASA LRC's transonic pilot facility, it became apparent that typical support coils for such an intermediate-size facility could be tested using the cryogenic equipment and power amplifiers of the University of Virginia's prototype magnetic suspension facility[3]. It is hardly necessary to argue in favor of verifying scaling predictions on at least one test coil before finalizing the design of a complete coil assembly for the intermediate-size facility. The obvious advantages of such an approach, together with the efficiency of utilizing existing equipment and operational knowhow, prompted the writing of and the subsequent funding of a research proposal. This final report documents the efforts and results of this research.

1.1 Typical Intermediate Size Support Coil

From calculations reported in Reference (1), an intermediate-size coil configuration geometrically similar to the prototype coil configuration will consist of gradient coils specified as follows:

mean radius	16 cm
cross-sectional area	13 cm^2
# ampere turns	10^5 (on the basis of peak current)

Assuming the most favorable coil fabrication conditions, including availability of a highly twisted multifilamentary superconductor wire, predicted liquid helium boil-off for 3.3 Hz sine-wave excitation at peak current is about 8 ℓ/hr.

Preliminary calculations of a 5-D coil configuration utilizing four support magnets arranged in V, reveal that the above gradient coil may be considered typical for this (different) configuration also.

The University of Virginia prototype facility has a physical space available, for placing a test coil in the appropriate cryogenic environment, as shown in Figure 1.

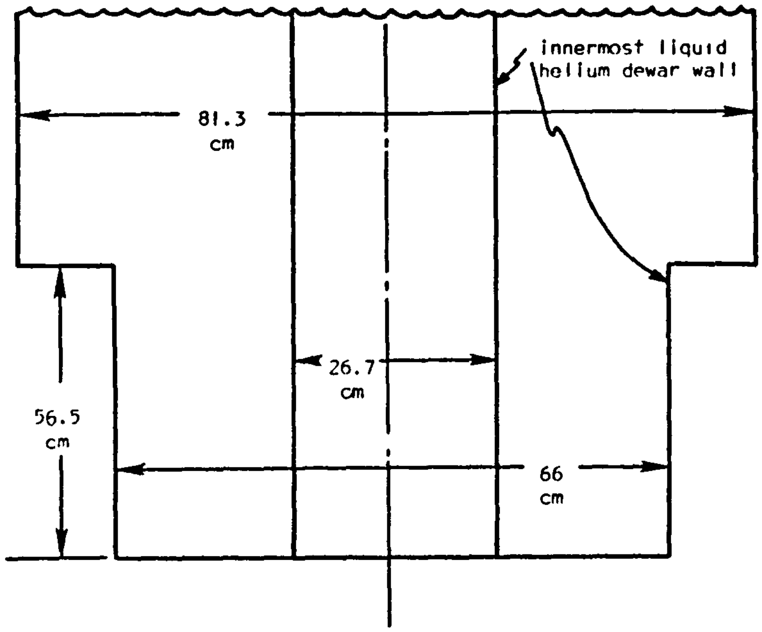


Figure 1. Coil Testing Space Available in Cryogenic Dewar

Another important consideration is the overall capability of the power supply. This is given in terms of maximum current and maximum voltage as functions of coil inductance in Figures 2 and 3. Note that frequency of coil excitation is used as the parameter in both plots. Operating conditions for a prototype facility gradient coil pair are clearly marked in the plots. On the basis of the above considerations, two representative test coils were initially selected for the proposed research program. The dimensions and predicted operating characteristics of these two coils are given in Table I.

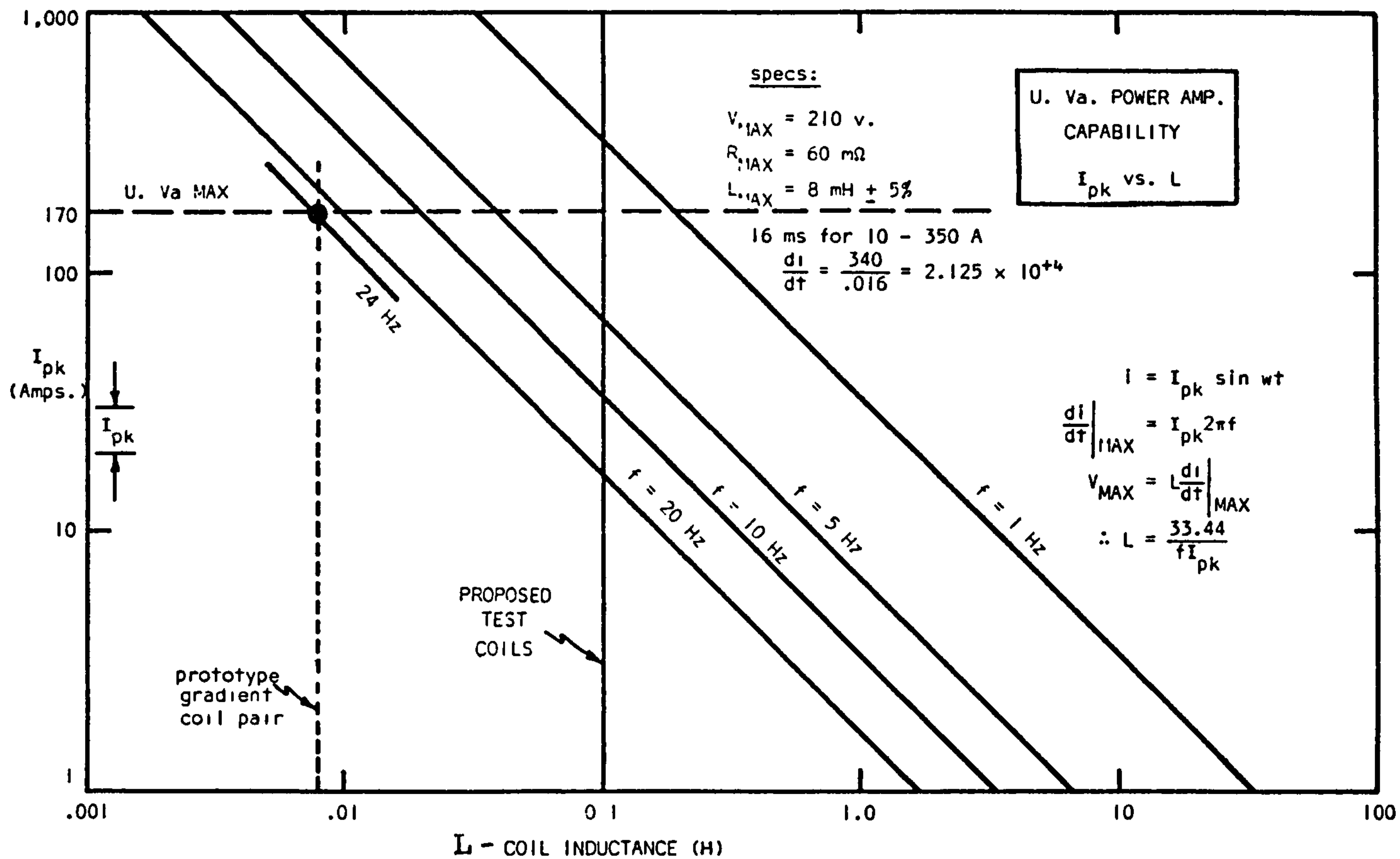


Figure 2. University of Virginia Power Amplifier Capability

(Peak Current vs Coil Inductance)

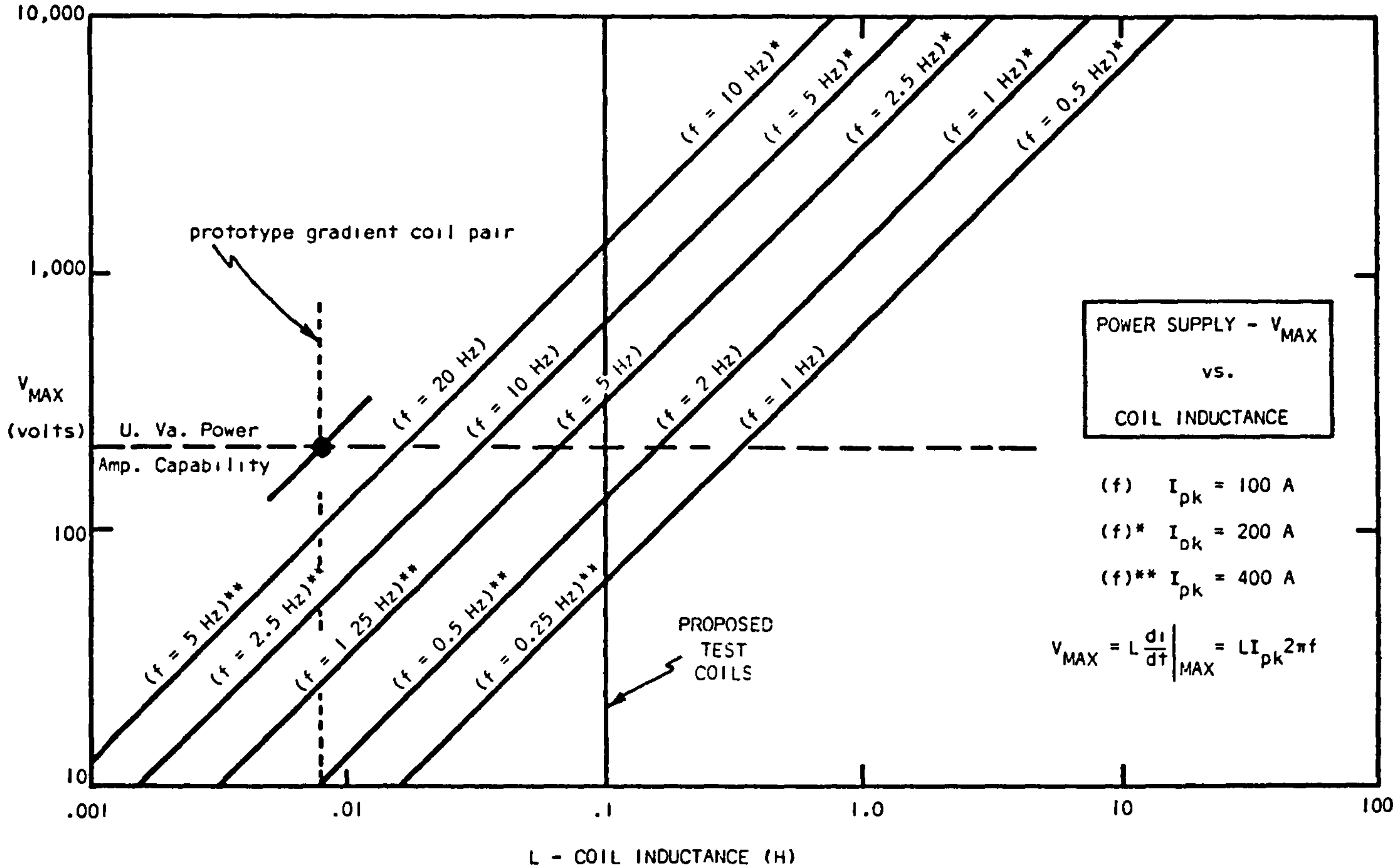
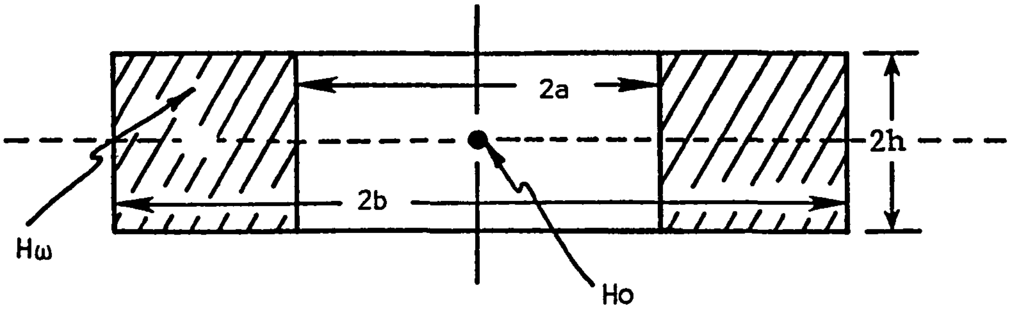


Figure 3. University of Virginia Power Amplifier Capability

(Max Voltage vs Coil Inductance)

TABLE I

Proposed Test Coil Characteristics



Characteristics	Coil 1	Coil 2	Units
inner radius a	0.15	0.15	m
outer radius b	0.19	0.19	m
length h	0.02	0.02	m
α = b/a	1.27	1.27	-
β = h/a	0.133	0.133	-
Hω/Ho	1.75	1.75	-
# turns N	400	400	-
peak current I	200	200	Ampere
inductance L	0.102	0.102	Henry
central field Ho	17.8	17.8	10^4 A/m
winding field Hω	32.9	32.9	10^4 A/m
max. excitation frequency f	2	4	Hertz
wire twist rate	1	3	twist/cm
a.c. loss rate Q	150	50	KW/m^2/Hz
power dissipation q	45	30	Watt
liquid He boil-off	50	32	l/hr

Predictions on power dissipation and corresponding He boil-off rates were based on theoretically calculated a.c. losses for multifilamentary superconductors of the type utilized in the small-scale experiments reported in Reference (4) by Pierce and Zapata. These theoretical losses and supporting experimental results obtained by the University of Virginia group are plotted in Figure 4. It is important to note that a conductor twist rate of about one twist per centimeter was assumed in the calculations and used in these experiments. Since twist rate is reported to have a

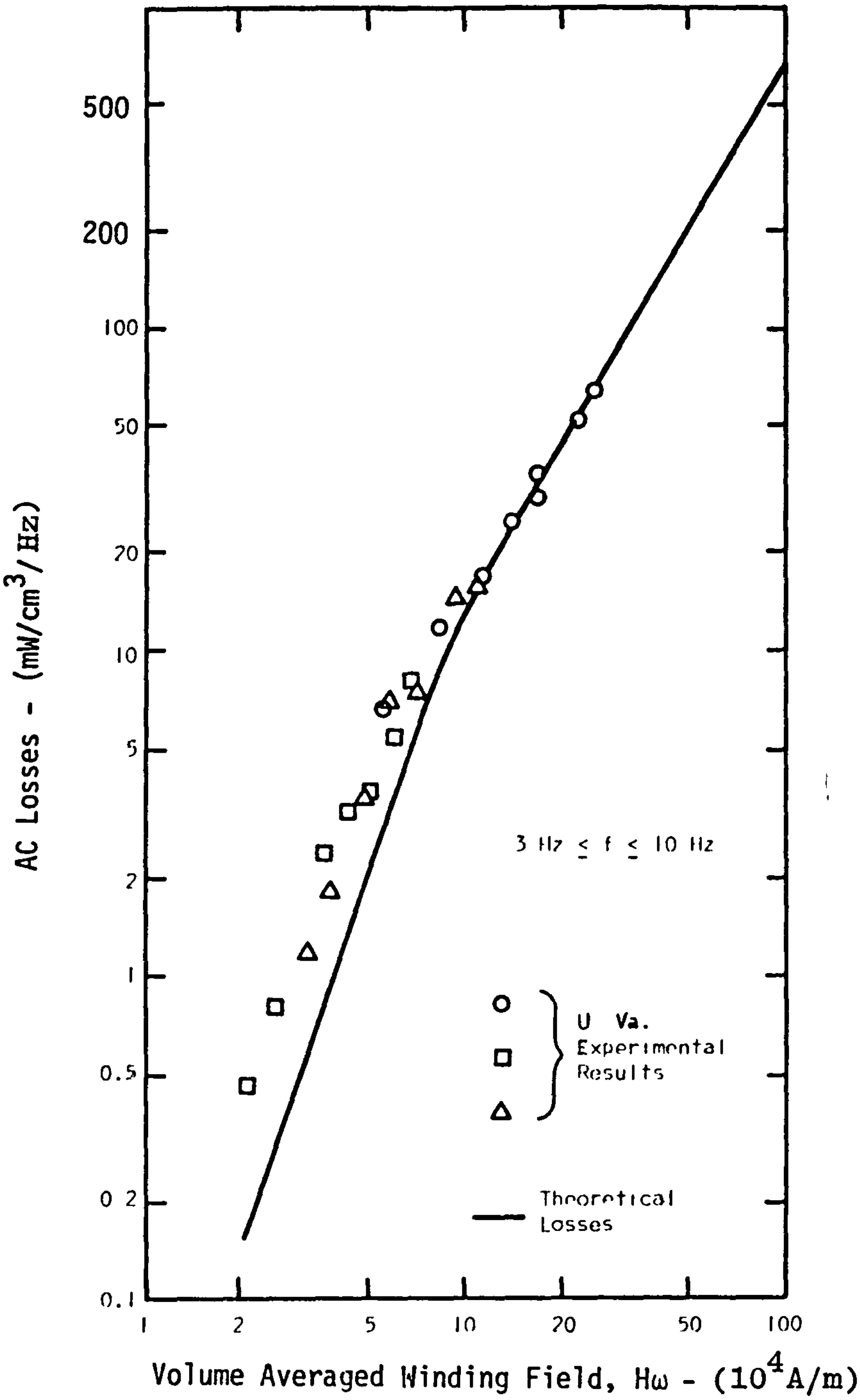


Figure 4. AC Losses Versus Hω for Coils of Different Winding Densities[4]

significant influence on a.c. losses, the second test coil was to be built with the super-conductor wire twisted at a rate three times that of the (standard) conductor used in the first coil. However, due to the severe time delay in the delivery of the test coil necessary to perform the scaling experiment and to personnel and funding constraints, only one coil was tested.

II. EXPERIMENTAL SET-UP

2.1 Coil Design and Fabrication

Two of the specific areas of concern are (i) adequate helium ventilation of the inner turns and (ii) special winding techniques required to implement the low-winding density concept. Taking the above considerations into account in discussions with personnel at the Superconductor Magnet Laboratory of the University of Wisconsin, along with the size and power supply constraints, the resulting design of the first test coil was chosen as shown in Figure 5. Also shown in this figure, for comparison, are the proposed coil parameters.

2.1.1 Magnetic Fields - Ho and Hω

From Ampere's law, it is easily deduced that the magnetic field on the axis of a circular loop at the center of the loop is,

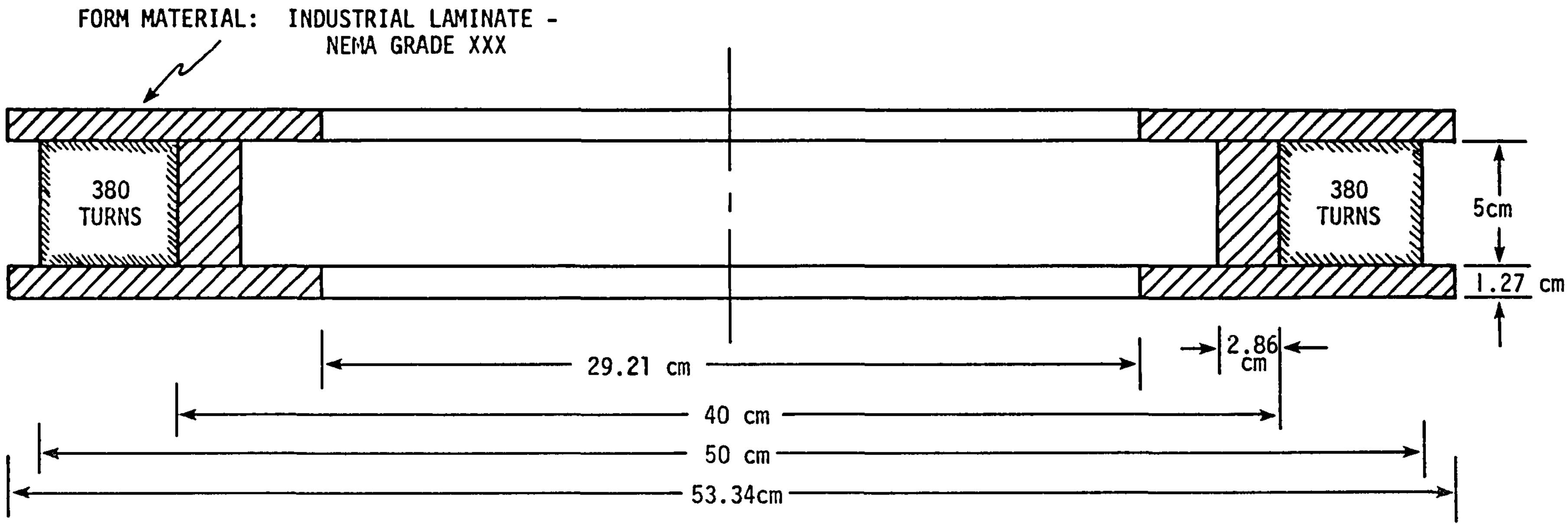
$$Ho = \frac{I}{2r} ,$$

where I is the total or peak current in amperes flowing in the loop and r is the loop radius in meters. For the test coil,

$$Ho = \frac{N\ Ipk}{2r} .$$

With N = 380 turns and the mean radius = .225m,

$$Ho = 844\ Ipk \quad (A/m) .$$



CHARACTERISTICS	Units	PROPOSED COIL	ACTUAL TEST COIL
Inner radius - a	(m)	0.15	0.20
Outer radius - b	(m)	0.19	0.25
Length - h	(m)	0.02	0.025
$\alpha = b/a$	-	1.27	1.25
$\beta = h/a$	-	0.133	0.125
$H\omega/Ho$	-	1.75	1.85
# Turns - N	-	400	380
Peak current	(Amps)	200	200
Central Field - Ho	(10^4A/m)	17.8	16.9
Winding Field - $H\omega$	(10^4A/m)	32.9	31.2
Wire twist rate	(twist/cm)	1	~ 1

VSF SUPERCON WIRE

1 cable = 5 wires & nylon strand

1 wire = 400 strands

1 strand ≈ 7μ dia.

Copper: Superconductor ratio = 1:1

Cable dia.~.023 cm with Formvar insulation

380 Turns = 20 turns/layer x 19 layers

Total cable length = 537 m

Total supercond. volume = 20.7 cm^3

Total cable resistance (T_{Rm}) = 121.3 Ω

Figure 5. —— TEST COIL PARAMETERS and CROSS SECTION

From the empirical relation in reference (4) for the ratio of the volume-averaged winding field, H_ω, to the central field, Ho, it is seen that for the test coil,

$$\frac{H_\omega}{H_o} \simeq 1.85$$

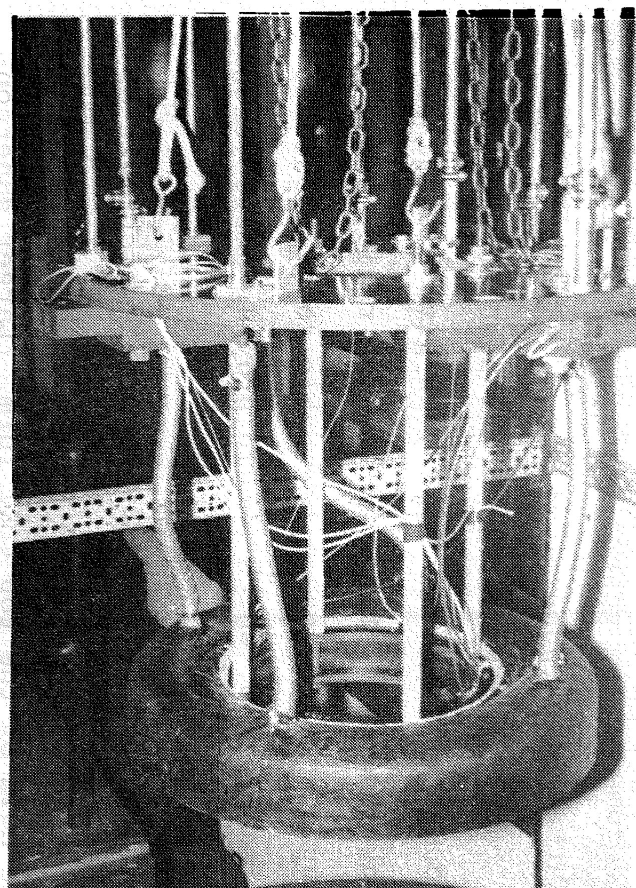
or, by substituting for Ho,

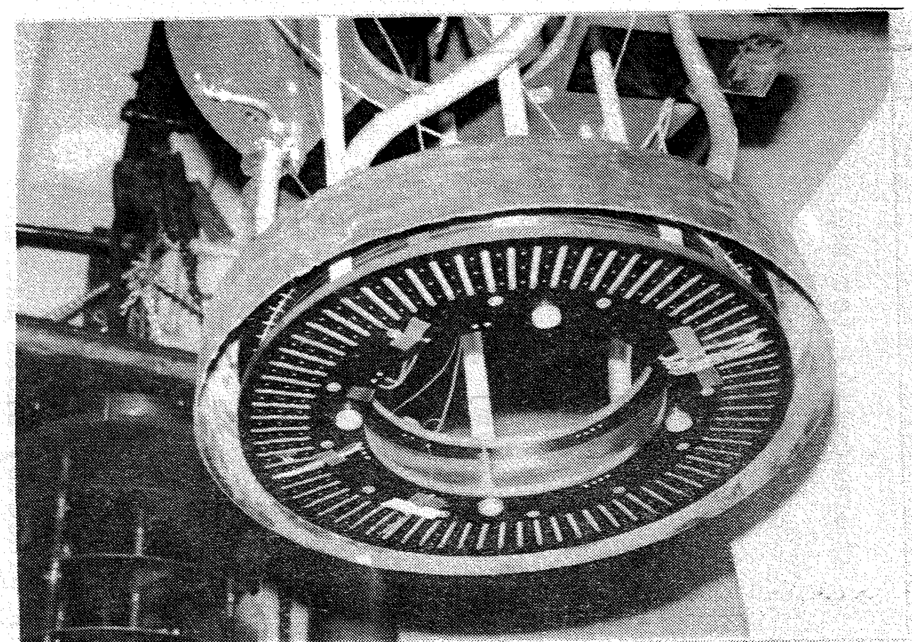
$$H_\omega \simeq 0.156 \times 10^4 \ I_{pk} \quad (A/m) \ .$$

2.1.2 Test Coil Construction Features

The coil was fabricated at the Superconductor Magnet Laboratory of the University of Wisconsin. Helium ventilation was a primary concern, and ~ 2.5 mm thick mycarta spacers with slight grooves for the cable in the 6 mm wide face were used between the superconducting cable layers every 5° around the coil. The spacers were kept in place by slots machined into the coil form every 5° and by the tension of the cable. These slots and some of the general construction features can be seen in the photographs of Figure 6. The spacing between adjacent turns on a given layer was also about 2.5 mm. Thus, the 20 turns per layer and 19 layers give a total of 380 turns of the superconducting cable. The ratio of the open area between turns to the area of the cable total cross section is approximately 160, which should provide ample ventilation of the liquid helium.

The ends of the 5 superconducting wires, which make up the cable, were soldered onto lugs which were then mounted near the inside hole of the top coil form. Larger superconducting wires were then attached to these lugs to bring in the





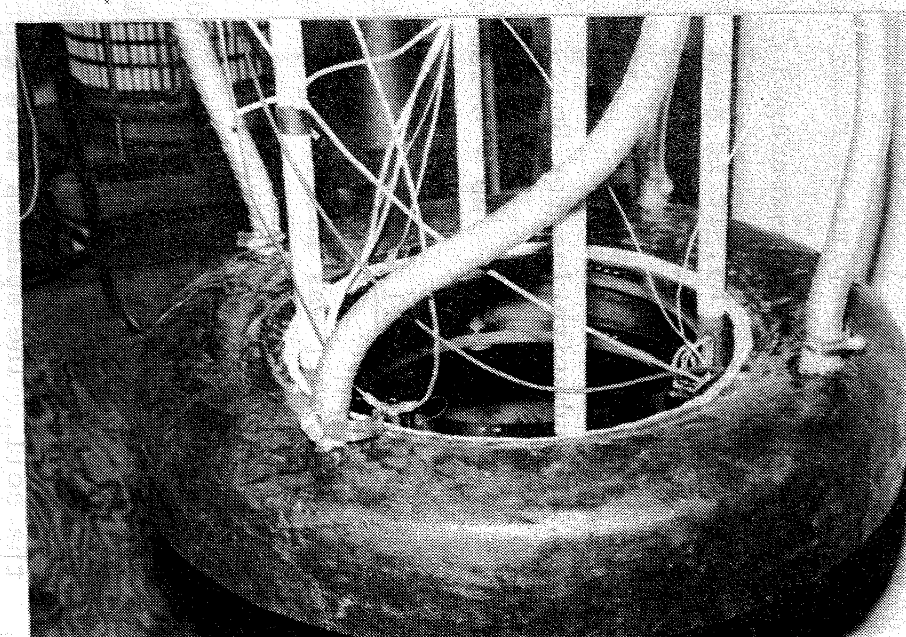


Figure 6. Photographs of Test Coil, Hood, and Support Rig.

test currents.

The coil had 5 stainless steel bands, 0.64 cm wide x 0.013 cm thick, "snuggly" tightened around its circumference and spot welded, to hold the spacers and cable in firm support.

A nichrome resistance wire for calibration of the helium "boil-off" was mounted on ceramic stand-offs around the outer edge of the top coil form. Several liquid-level sensing resistors were mounted near the inner radius of both the top and bottom coil forms. Some of these details are shown in Figures 6 and 7.

A hood to contain the "boil-off" gas was fabricated from a fibre-glass epoxy. The outer edge was just below the level of the bottom coil form and the inner edge was sealed and screwed to the top coil form. A gas capture system resulted and the "boil-off" flowed upward to an external flowmeter through 4 vent outlets (total area ≈ 4.1 cm^2) (see Figures 6 and 7). All of the electrical connections for the various functions were made on the top coil form, outside of the gas-capture hood. The superconducting cable and calibrating resistor leads were run under the bottom coil form and up through small holes at the inner edges of the forms, to assure that the only gas collected by the hood system would be from either a calibration or the desired AC losses in the coil.

2.2 Instrumentation

A block diagram of the overall measurement system is shown in Figure 8. There are three methods of supplying

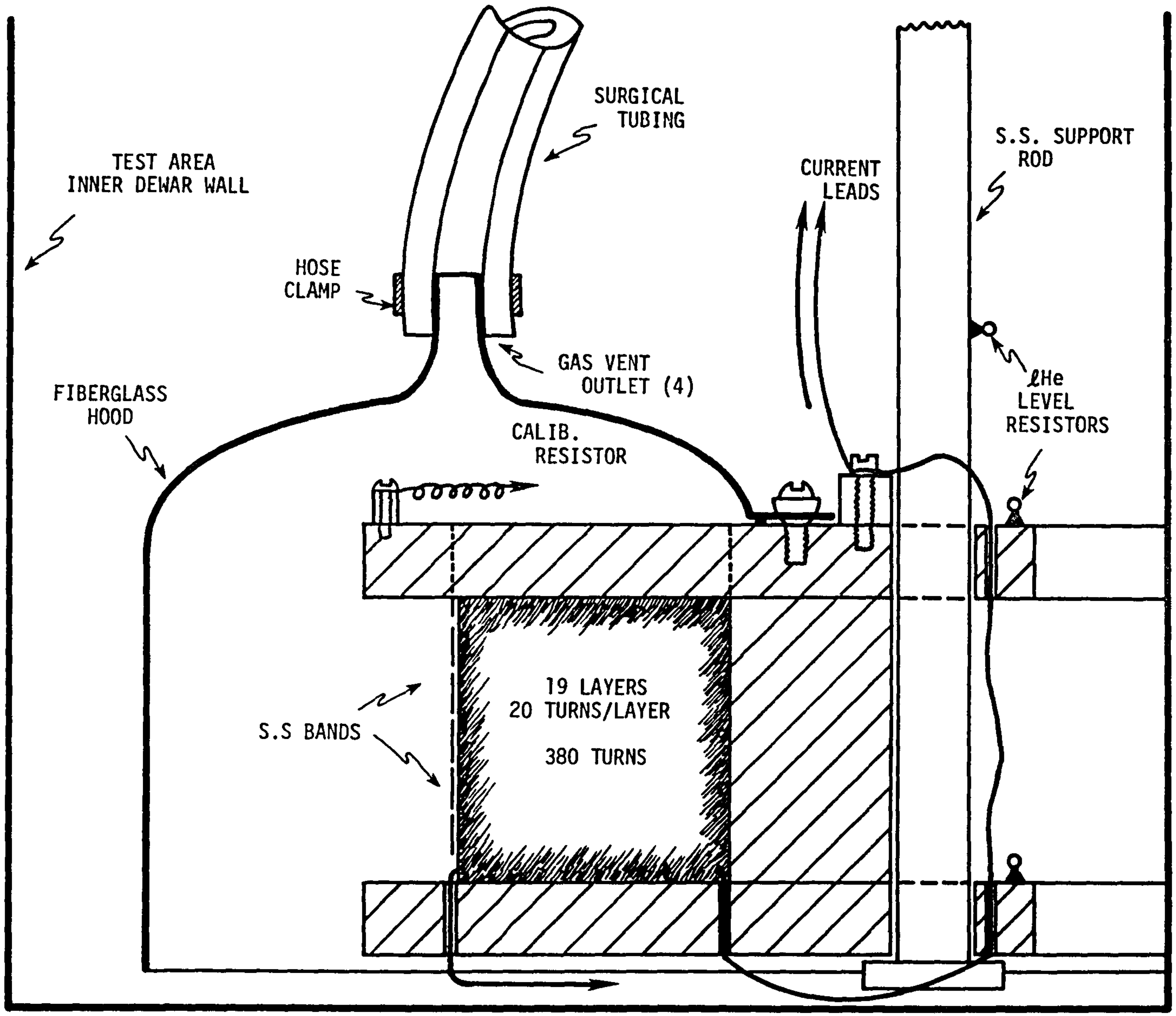


Figure 7. Sketch of Test Coil and Hood Cross Section

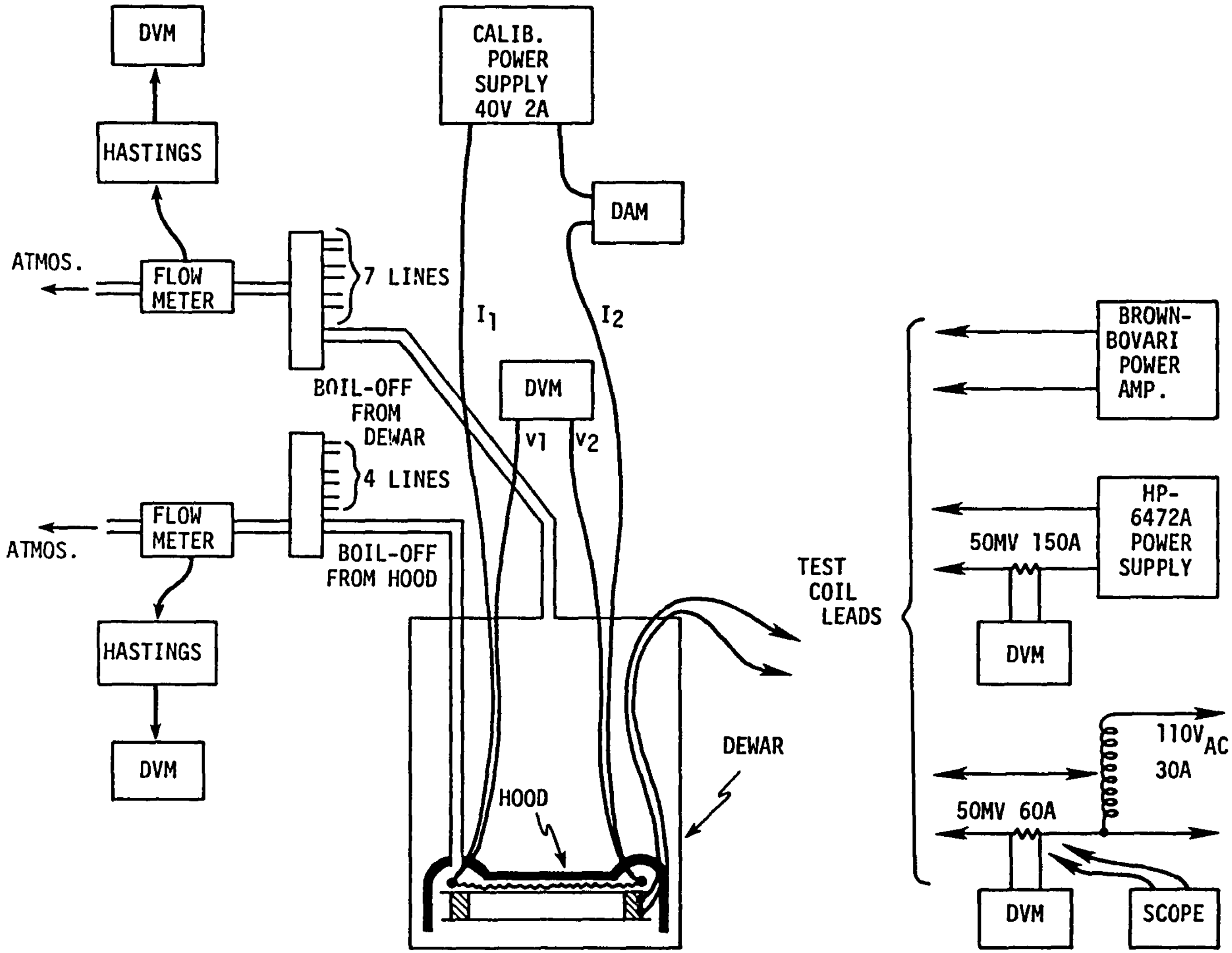


Figure 8. Block Diagram of Measurement System - Run 23

current to the test coil: (1) One of the three programmable Brown-Bovari power amplifiers designed for the gradient coils of the magnetic suspension balance. These can each supply, at 210 Volts max, a varying current from 10 to 350 Amps in 16 msec, (2) A Hewlett-Packard Model 6472A DC Power Supply which is somewhat programmable at frequencies up to about 5 Hz. The maximum DC current is 150 Amps at 63 Volts, (3) A simple high-current variac connected to 60 Hz line voltage.

Losses were measured by the well-known calorimetric method in which helium gas, evolved from the liquid helium coolant by the heat of the AC losses, is collected by a gas trap or hood and measured by a gas flowmeter.

Helium gas from the four lines from the collection hood goes to a manifold and then to a Hastings Mass Flow Transducer, type H-3M and a Hastings Mass Flowmeter, Model AHL-106. Similarly, the "boil-off" gas from the remainder of the dewar, other than that collected by the hood, goes through eight lines to a manifold and then to a second Hastings Mass Flow Transducer and Flowmeter.

The calibration voltage is measured by a 4-wire technique to eliminate errors in lead-loss. The digital voltmeters were all checked for accuracy against a secondary standard before the experiment was conducted.

III. COIL TEST - RUN 23

After the coil and hood were properly attached to the mounting plate and all the connections were checked and double-checked, the rig was carefully lowered into the cryogenic dewar. Then after sealing, insulating, and connecting leads and gas vent hoses to the top of the dewar, the coil and associated apparatus was ready for cool-down and testing.

The precooling of the coil was begun two days prior to the test day and about 800 liters of liquid nitrogen was used in this cool-down period. Approximately 175 liters of liquid helium was required in the transfer process. By 1:00 PM on the test day, 22 June 1978, the system had thermally settled down and there was about 41 cm. of liquid He in the dewar. The coil and hood would be covered by 18 to 20 cm of liquid He and thus testing could still be safely carried out down to about the 23 cm level. The typical background boil-off flow rate for the dewar corresponded to an input power of ~1.80 W and for the hood background flow, it was ~0.34 W.

3.1 Calibration

The first procedure, after the system is thermally "quiet", is to run a calibration curve of the flowmeter output voltage versus the power input to the calibrating resistor. This was done and the straight curve shown in Figure 9 was obtained (1:15-3:25 PM). However, later at 10:30 PM, after various tests were performed on the test coil, another calibration curve was run and this one, as shown in Figure 9, indicated a saturation effect above about 2 watts input.

This nonlinear effect will be discussed later.

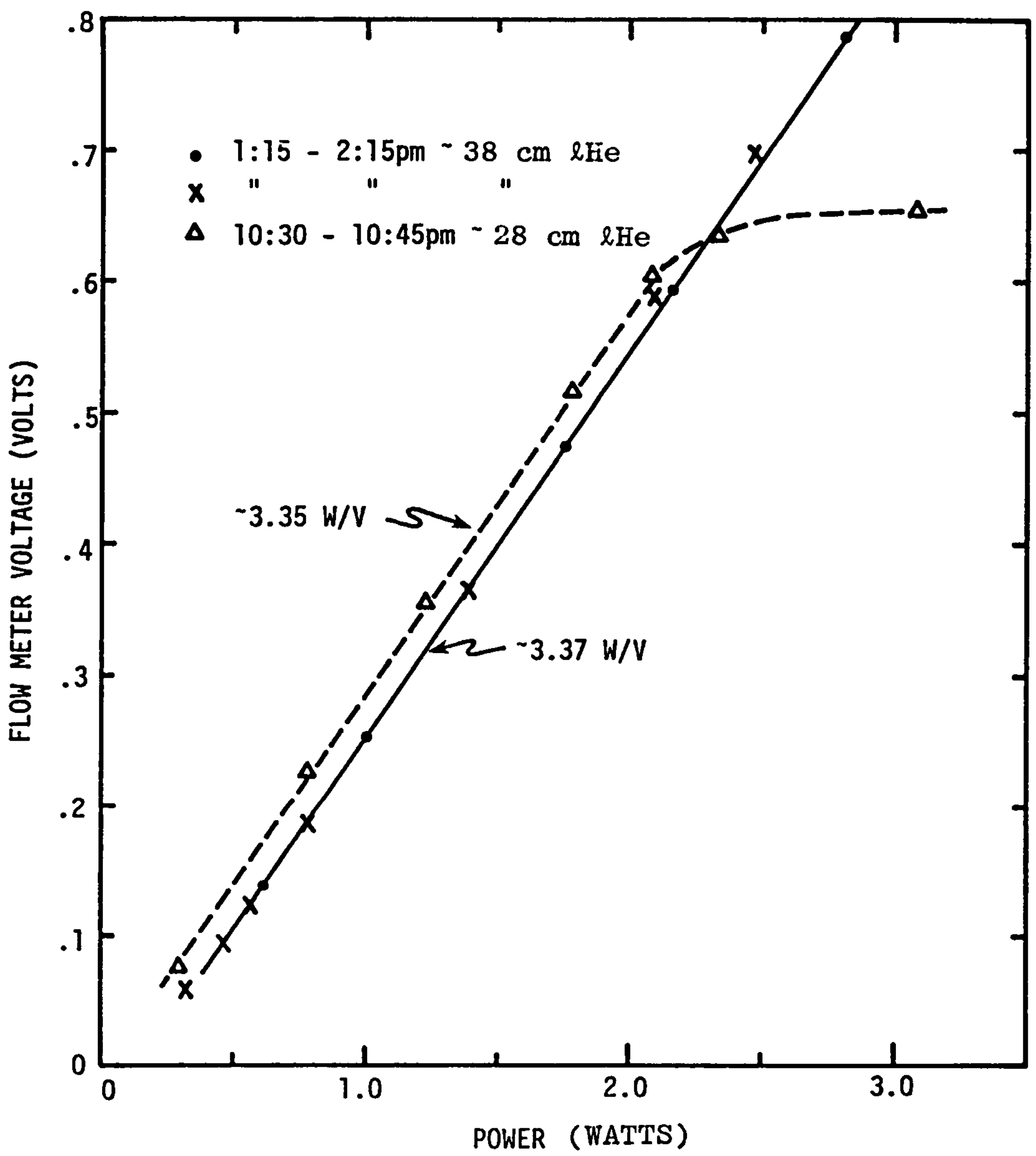


Figure 9. Calibration - Run 23

3.2 Coil Test Using HP-6472A DC Power Supply

A slowly increasing DC current of 0 to 100 Amps was put through the test coil over a 15-minute period. As expected, no change in the "boil-off" was noted. Next, this power supply was programmed with a signal generator to produce at 0.1 Hz, a maximum peak to peak current of 18 to 76 Amps. This represents a peak current of 29 Amps or $H\omega = 4.5 \times 10^4$ A/m, and if the minimum detectable voltage from the flowmeter is 0.002 Volts, then with a calibration factor of 3.36 W/v, the minimum detectable AC loss would be about 3.2 $mW/cm^3/Hz$. This value is very near to an expected value, as seen in Figure 10. However, no AC loss was observed.

At 1.0 Hz, the maximum peak to peak current obtainable was 32 to 41 Amps, or a peak current of 4.5 Amps. Again, no observable AC loss was noted, but the minimum detectable value of AC loss is greater than the value expected for this peak current.

3.3 Coil Test Using Brown-Bovari Power Amplifiers

Two of these power amplifiers were independently connected to the test coil and programmed at 1.6 Hz to produce a peak to peak current of 10 to 30 Amps. A 10 Amps "idle" current is the minimum obtainable from this type of power amplifier. Over a 15-minute period, the "boil-off" gas would not stabilize, but continually increased. Even in an "idle" condition of supposedly 10 Amps DC, the flowmeter

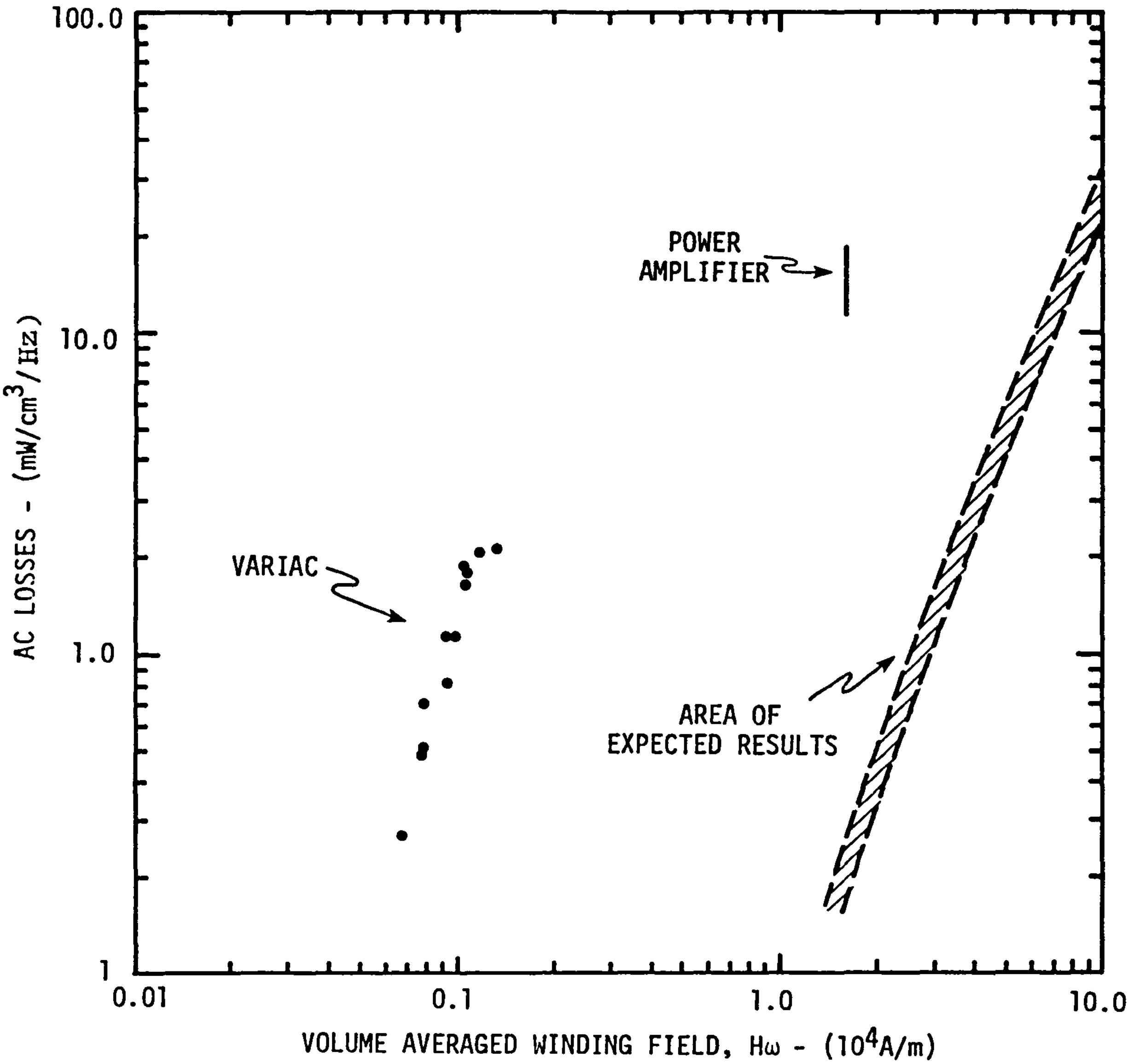


Figure 10. Measured AC Losses Versus Hω - Run 23

output was extremely erratic and would not settle to a constant value. Behavior with both power amplifiers was similar.

It was noted that the current waveform showed approximate jumps of 10 Amps of a spike-type nature, regardless of the current magnitude. This behavior is inherent in this fast response commutating type of power amplifier. Thus, it would be impossible to perform any kind of meaningful AC losses experiment with these power amplifiers.

3.4 Coil Test Using a Variac and 60 Hz Power

A series of tests were run using a variac as the power source to generate the currents through the superconducting coil. It was obvious that for the higher currents, the flowmeter indication showed some kind of saturation effect. The flow rate would only increase a slight amount for a substantial current change. Then, when the coil current was reduced to zero, the gas flow did not drop to the expected value, but rather it remained high for a period of time before it would drop to near zero in a "normal" manner. For lower coil current values, the behavior was as expected.

The reduced data is shown plotted in Figure 10. Although the slope of the general trend is as predicted, there are two major problems noted with this data.

(1) The measured AC losses appear to be much greater than expected from the previous UVa work[4], that is, if the scaling laws are as predicted. It is seen that the losses observed were expected to arise from currents or winding fields, H_ω, some 25 times of that actually experienced.

(2) The data reflects some sort of saturation effect of the AC losses, as mentioned above. Indeed, one of the last tests made in Run 23 was to redo the calibration curve. It is noted, in Figure 9, that a bending or saturation effect is present in the curve run at ~10:30 PM. This effect was not observed during the first calibration run for the same wattage input.

3.5 Other Observations Noted

An interesting phenomena was observed during the periods when the helium gas flow from the hood was in a "saturation" state, shortly after the current to the coil had been cut off. It was noted that by placing one's hand or other object over the exit port of the flowmeter for several seconds and then removing it, the gas flow in the line would begin to flutter or oscillate at a low frequency of ~1 Hz. There was an audible sound and the needle on the flowmeter would fluctuate. This would continue for several seconds, before ceasing and the flow would return to its normal value with no current in the coil.

3.6 Discussion of Run 23 Results

As mentioned above, there are two major concerns with the results of Run 23, namely, the unexpected large AC losses for a given current and a limiting boil-off gas saturation effect. These will be discussed separately.

3.6.1 Magnitude of AC Losses

The larger than expected losses, while using the power amplifiers as a current source, could be readily explained as due to the spike type of commutating effect inherent in these power amplifiers. The higher frequency currents making up the spike would probably account for the much greater than expected losses.

However, the unexpected results from the variac test are not so easily explained. During the following days after the run, all of the DVM's were checked. The variac and current shunt were connected to a dummy resistance load and currents were double checked with several other shunts and meters, etc. The two flowmeters were connected in series, to at least see if their readings agreed. Various hose and electrical connections were checked and double checked, but no faulty equipment or procedure was identified.

It was suggested * and derived, in a simplified calculation, that perhaps the five stainless steel bands and the test coil could be acting as a coaxial transformer. The secondary voltage induced in the bands would create current and hence a power or I^2R loss due to the resistance of the bands. This power loss would then create an undesired helium gas "boil-off" or false AC loss indication. Assuming ideal conditions and resistivity of stainless steel at $4°k \approx 3 \times 10^{-7}$ Ω-m, then the power dissipated in the bands would be,

$$P_{band} \approx 0.05 \ I^2_{pk\ coil} \quad \text{(Watts)}.$$

Since the maximum measured current for the test with the variac was slightly less than 1 Amp, it would appear that this effect did not contribute greatly to the measured AC losses. For example, with a 1 Amp peak coil current, the power in the bands would calculate to ~0.05 watts and with a calibration factor of 3.36 W/V, it would produce ~15 mV at the flowmeter. The measured flowmeter reading for this current was 779 mV, so the power produced in the bands would supposedly contribute only about 2% of the total "boil-off" gas.

*By Colin Britcher, University of Southampton, October 1978.

On the other hand, one wonders if, perhaps in reality, the current in the coil was actually much greater than the measured value. This would have to be due to some faulty condition on the day of the test, such as a sneak circuit or ground which was shunting current by the measuring devices. This possibility was not investigated immediately after the test.

3.6.2 Boil-Off Gas Saturation Effect

This saturation effect was noted during both the coil testing and the last calibration for helium gas boil-off corresponding to more than 2 watts of power dissipation. With the calibration runs, the effect commences at a lower power as the level of the liquid helium in the dewar decreases. When in this saturation state, it seems as though the gas flow may be limited by the hose area and the hood is storing gas the way a capacitor stores charge. As pressure in the hood increases, the flow would increase, but still be limited by the resistance of the hose. When the source of power is removed, the flow continues near its previous rate, until the stored-up gas is eliminated.

A telephone call, to Dr. Jesse Hord of the National Bureau of Standards in Boulder, Colorado, indicated that this problem might be a gaseous film boiling phenomenon, causing a heat transfer problem and resulting in a vapor blanking effect. He also suggested trying to keep the pressure in the larger dewar equal to the hood pressure. The density of liquid helium is very low, such that one psi corresponds to about

18 feet of liquid helium and unequal pressures of the dewar and hood could cause unwanted boil-off as the level of helium varies in the dewar and the internal hood vent hoses.

3.6.3 Recommendation

It was decided that the end of a mostly successful long-term relationship with NASA-LRC should not end with questionable results such as Run 23 produced. Thus, one more run was planned with 2 changes in the set-up. (1) Remove the s.s. bands around the test coil. (2) Enlarge the hood vent lines from the dewar to the flowmeter. Also, a careful inspection of the system during disassembly was planned.

Shortly after Run 23 was completed, there was an extensive study conducted on the characteristics and modifications to be made on the super-sonic wind tunnel which passes through the center of the dewar. This effort prevented the immediate implementation of the planned modifications to the superconducting test coil and as a result, Run 24 did not take place until September 1978.

IV. COIL TEST - RUN 24

4.1 Modifications

After the coil and mounting assembly were removed from the helium dewar and during the disassembly of the test coil, a very careful inspection was made to look for any irregularities in the connections, hoses, etc. However, no problem areas were noted.

The 5 s.s. bands were removed from the coil circumference. The superconducting cable itself and the spacing were checked. Then, a layer of masking tape was put around the coil circumference. Next, three widths of one layer of a nylon 1.9cm wide tape was wrapped around the coil. Then, four green nylon bands (each ~12 mm wide), used for packing and shipping large boxes, were tightly wrapped around and secured with a small 3.2 cm long s.s. buckle, and last, three more widths of the nylon tape were added.

This was the only change made to the coil system inside the dewar. The test coil, gas collection hood, and all the electrical connections and hose connections were carefully reassembled and reinserted into the dewar. The dewar lid was then attached and sealed and all external connections made.

There were several modifications and additions made externally to the system. First, the manifold, between the flowmeter and the 4 boil-off gas lines from the hood, was increased in size from ~1.9cm diameter by 20 cm long to a manifold ~ 5 cm in diameter by 20 cm long. The 4 hood gas lines from the top of the dewar to the manifold were made shorter by about 3 m, so that they each were now only ~ 1.2 m long. A single large 2.5 cm diameter hose then connected to the flowmeter. All of these changes were made in an attempt to increase the hose conductance or decrease its resistance to the gas flow. A thermocouple was mounted in the inlet region of the hood flowmeter to check for possible erroneous readings due to temperature effects. Second, a pressure measuring capability was installed. A Validyne differential pressure gage with a 34 kPa (5 psi) full scale range was connected between the two manifolds. A valving arrangement also made it possible to measure either pressure individually. It was hoped that the pressure measurements would lead to a better understanding of the gas flow behavior. This new instrumentation arrangement is shown in Figure 11.

4.2 Calibration

After liquid helium had been transferred into the dewar and the system had thermally settled down, a calibration test was made of the flowmeter output voltage versus the power input to the calibrating resistor. The first curve was linear at the higher power levels, but four hours later, the curve again showed a saturation effect, as seen in Figure 12.

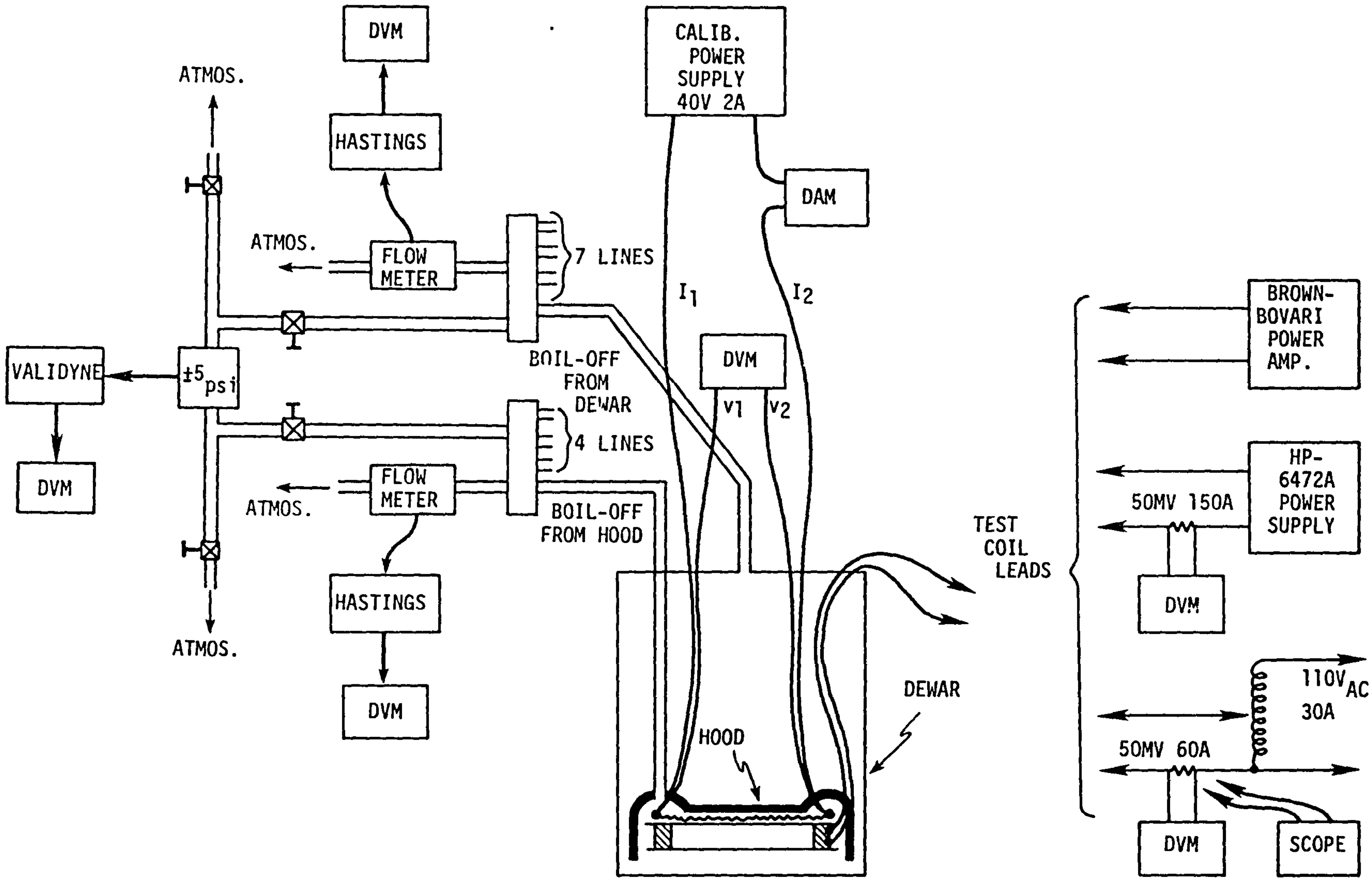


Figure 11. Block Diagram of Measurement System - Run 24

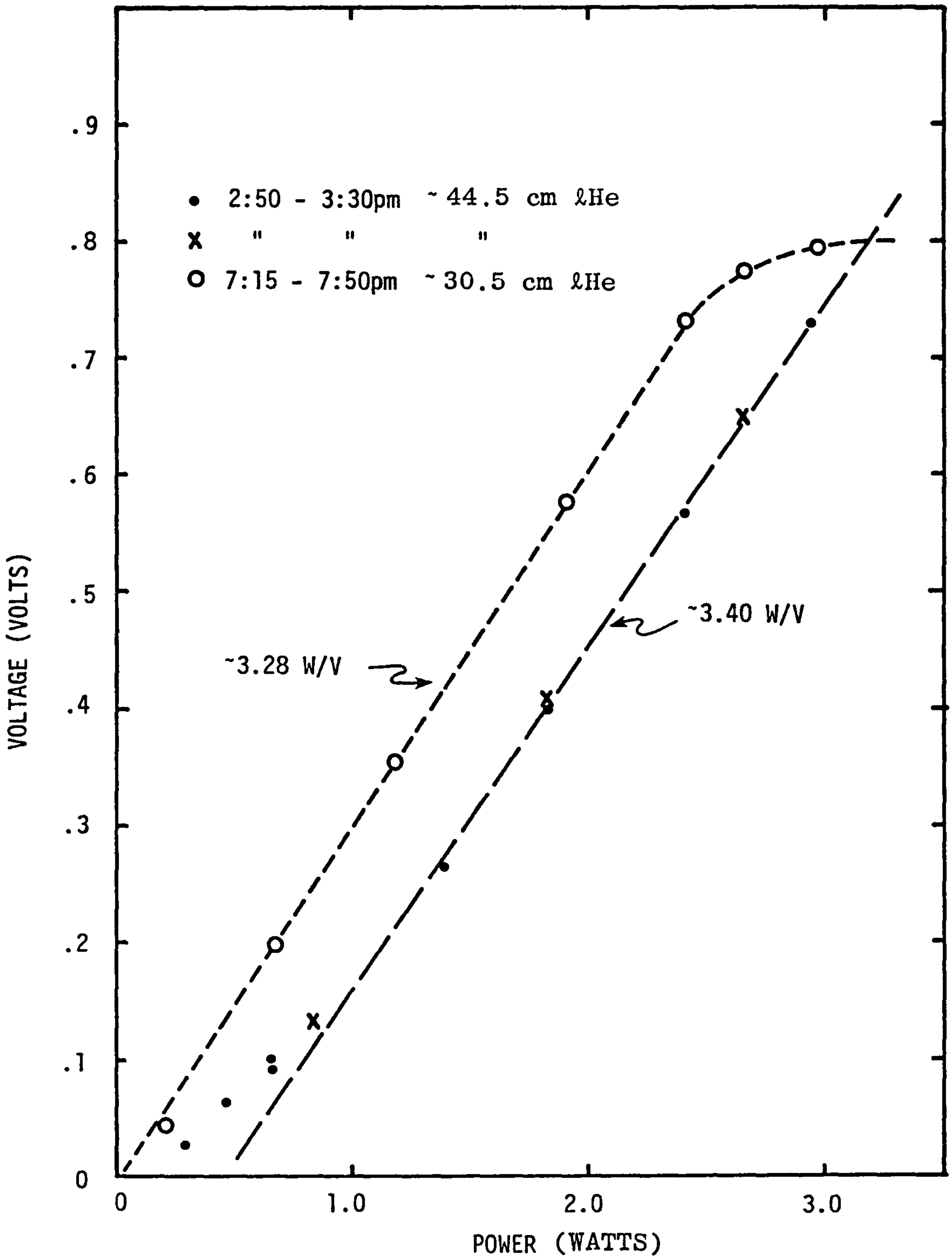


Figure 12. Calibration - Run 24

4.3 Coil Test Using HP-6472A DC Power Supply

Over a 15-minute period, a slowly increasing current of 0 to 95 Amps was passed through the test coil and then slowly decreased to 0. As before, no increase in the boil-off gas rate was observed.

4.4 Coil Test Using a Variac and 60 Hz Power

The AC losses versus the volume averaged winding field for Run 24 is given in Figure 13. Note that for the lower values of $H\omega$, the points do indeed fall approximately within the range of expected values. However, for values of $H\omega$ greater than ~5×10^4 A/m, the trend of the points indicates that again some saturation effect is limiting the AC losses measurement. The effect was also noted in the calibration plot, so apparently, the modifications to the system, after Run 23, did not alter the cause of this saturation phenomena.

Measurements of the various pressures indicated that the manifold pressure in the hood line varied from 55 Pa with a "quiet" system to ~ 372 Pa in a saturated condition. The dewar manifold pressure varied from ~ 117 Pa to ~ 152 Pa .

The thermocouple on the flowmeter inlet for the hood gas indicated that the helium gas was near room temperature most of the time, and dropped to ~278 K during a saturation type of behavior or loss. This temperature should not affect the flowmeter calibration, according to the instruction manual.

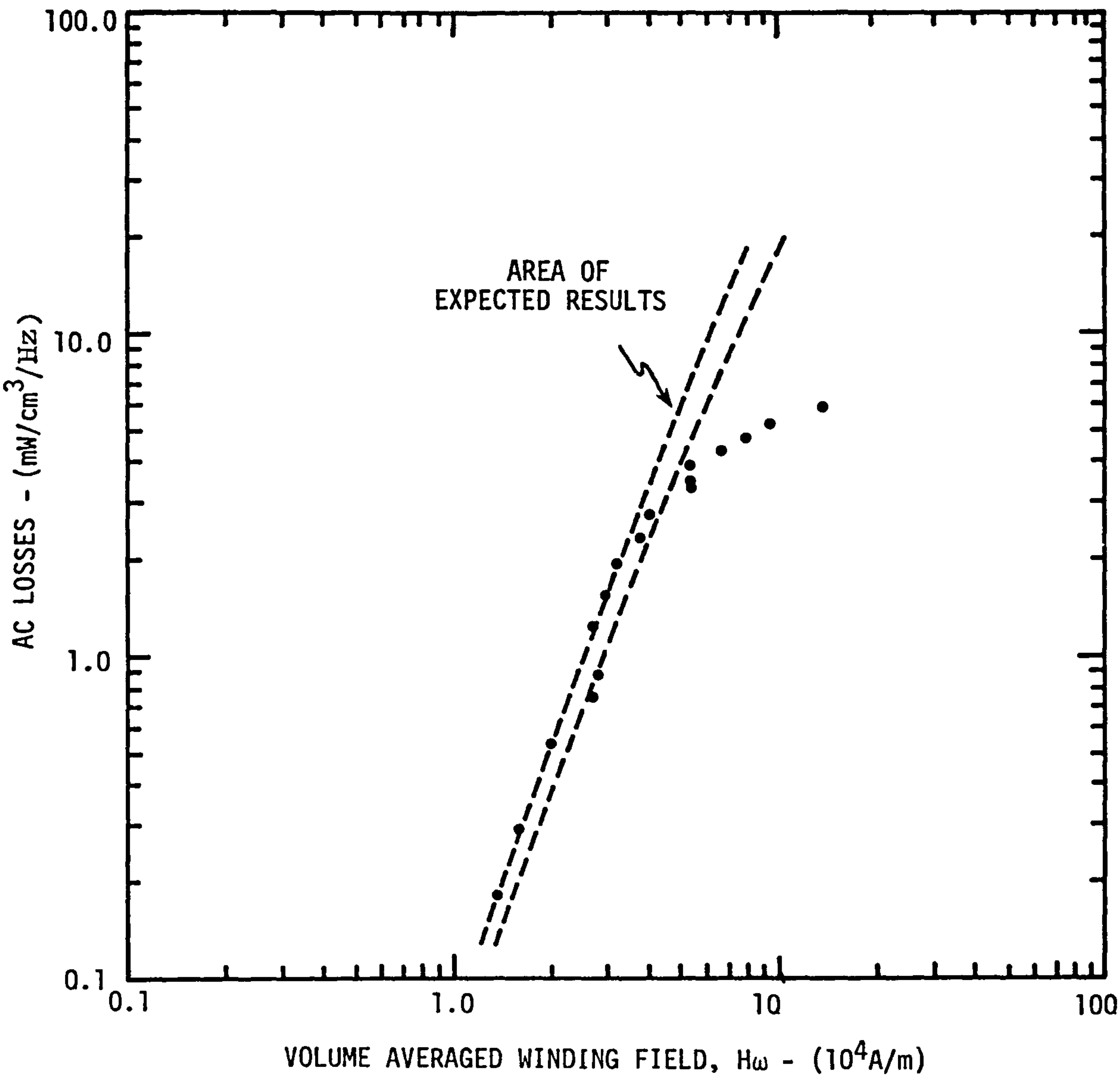


Figure 13. Measured AC Losses Versus Hω - Run 24

V. SUMMARY AND CONCLUSIONS

Evidently, the s.s. bands around the test coil were the source of additional helium boil-off due to a transformer action and hence caused erroneously high AC loss measurements in the first run. However, removal of these bands for the second run produced data which are consistent with previous results on small-scale multifilamentary superconducting coils. This test of a large size coil strongly indicates that the predicted scaling laws[4] are valid. These results thus show a direct determination of the magnitude of AC losses from a superconducting coil of a size required for operation of larger magnetic suspension systems, and the design of such a suspension facility should now be carried out with a much greater confidence.

The tests were limited in the range of magnitude of losses measurable due to a "saturation" effect of gases and pressures within the dewar, possibly due to long vent lines of inadequate diameter. Manifold pressure measurements of the dewar and hood vent systems indicated a maximum pressure differential during a high helium gas boil-off situation of about 206 Pa . This would represent a difference in the liquid levels in the dewar and hood vent lines of at least 15 cm . The level change would greatly alter the boil-off characteristics and could account for the saturation type flows experienced.

VI. REFERENCES

1. Zapata, R. N., "Magnetic Suspension Techniques for Large Scale Aerodynamic Testing," Paper 39 in AGARD-CP-174, March 1976, pp. 39.1 - 39.14.

2. Kilgore, R. A., et al., "The Cryogenic Transonic Wind Tunnel for High Reynolds Number Research," Paper 1 in AGARD-CP-174, March 1976, pp. 1.1 - 1.20.

3. Zapata, R. N., et al., "Development of A Superconductor Magnetic Suspension and Balance Prototype Facility For Studying the Feasibility of Applying This Technique to Large Scale Aerodynamic Testing," NASA CR-2565, July 1975.

4. Pierce, T. V., Jr., and Zapata, R. N., "Superconductor Coil Geometry and AC Losses," Journal of Applied Physics, Vol. 47, No. 8, August 1976, pp. 3745-6.

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Final Report

16 Abstract

These results show a direct determination of the magnitude of AC losses from a superconducting coil of a size required for operation of larger magnetic suspension systems, and the design of such a suspension facility should now be carried out with a much greater confidence. This test of a 50 cm diameter superconducting coil strongly indicates that the predicated scaling laws are valid.

Evidently, the stainless steel bands around the test coil were the source of additional helium boil-off due to a transformer action and, hence, caused erroneously high AC loss measurements in the first run. However, removal of these bands for the second run produced data which are consistent with previous results on small-scale multifilamentary superconducting coils.

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