HOMOPOLAR MOTOR-GENERATOR INERTIAL ENERGY STORAGE SYSTEMS

Prepared by

H.G. Rylander and H.H. Woodson

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Center for Electromechanics
The University of Texas at Austin
Balcones Research Center
Bldg. 133, EME 1.100
Austin, TX 78758
512/471-4496

HOMOPOLAR MOTOR-GENERATOR INERTIAL ENERGY STORAGE SYSTEMS

Homopolar motor-generator designs are now under investigation as a possible source of inexpensive pulsed power from inertial energy storage. Figure 1 shows a schematic of such a machine. Briefly, the machine is first motored slowly to a predetermined speed by supplying a current to the armature. Stored kinetic energy from the rotor is then used to produce a generated pulse from the same rotor by switching the load to the armature brushes. Machines of this type are attractive for the following reasons:

1) the homopolar motor-generator combines the inertial energy store and conductor in one rotor, thereby eliminating the need to transmit torque along a shaft as in the case where a separate flywheel is used with a conventional AC or DC machine.
2) there is no need to rectify the output as required by an alternator.
3) the homopolar machine can produce the very large current pulses (10^5 to 10^6 Amp) required by the confinement fields of the large fusion devices.

Based on the results from our small bench model (0.5 M.J.), we have designed and are now in the process of constructing a 5 M.J. single rotor machine. In addition, we have designed a 50 M.J. machine, have studied the feasibility of a 2000 M.J. machine and have made an investigation of the problems associated with a fast discharge machine which would release 30 M.J. in 1.4 ms. A summary of these machines is given in the following sections.

0.5 M.J. BENCH MODEL

This machine is motored up to a design speed of 6000 RPM using a 150 KW SCR power supply, and then, upon disconnecting the power supply and connecting a load (short circuit), current pulses of up to 13,000 A with a rise time of 25 ms are generated. Figure 2 shows this machine with associated power supplies and accessories. Figure 3 shows a record of a discharge pulse through a "short circuit" showing an i_{max}= 8.8 KA. After extensive tests on this machine, it has been modified to make tests on a control system to provide an electromagnetic thrust bearing using the field coils.

5 M.J. MACHINE

Schematics of this machine are shown in Figures 4 and 5. It is basically the same design as the bench model with refinements as needed to correct design deficiencies. A digital data acquisition unit and controller is to be used with this machine. Several investigations are scheduled for this machine including voltage shaping for a flat top discharge. Predicted performance of this machine is shown in Figure 6. Maximum current is 150,000 A for a "short circuit" load with a peak voltage of 42 volts at 5580 RPM.

50 M.J. MACHINE

A preliminary design of a 50 M.J. machine is shown in Figure 7 using a split rotor as shown in Figure 8. Predicted performance of this machine loaded with the toroidal magnetic field solenoid of the Texas Turbulent Tokomak is shown in Figure 9. This machine was designed to store 55 M.J. of energy and generate a maximum current of 35,000 A at 210 V.

2000 M.J. MACHINE

Proposals for large power needs prompted a feasibility study for a 2000 M.J. machine to deliver 2,000,000 A at 1000 V. The resulting designs required two rotors 15 feet in diameter weighing 70 tons each. A large machine of this type is quite feasible.

FAST DISCHARGE MACHINE

Since very little stress was produced in the rotor with one second discharge times it was decided to investigate the minimum discharge time obtainable with this type of design. The problems associated with discharge times from 1 to 10 ms are now under investigation and it looks as if a machine can be made to discharge 30 M.J. in 1.4 ms with a peak voltage of 1240 V.

COST ESTIMATES

Machine	Cost	Cost/Joule
5 M.J.	$ 25,000	$0.005/Joule
50 M.J.	$ 180,000	$0.0036/Joule
2000 M.J.	$2,200,000	$0.0011/Joule

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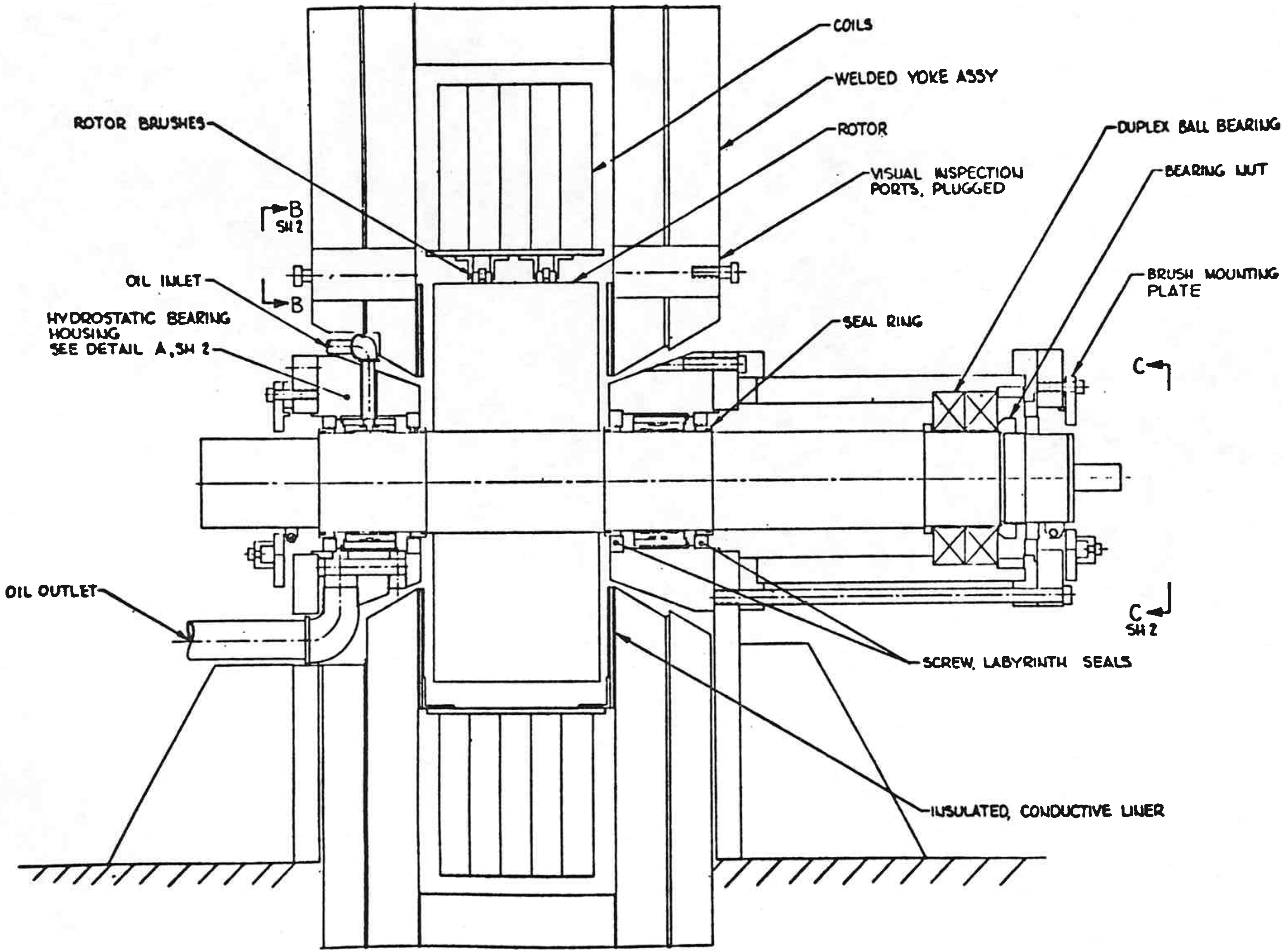


Fig. 1- Schematic of 0.5 M.J. Machine

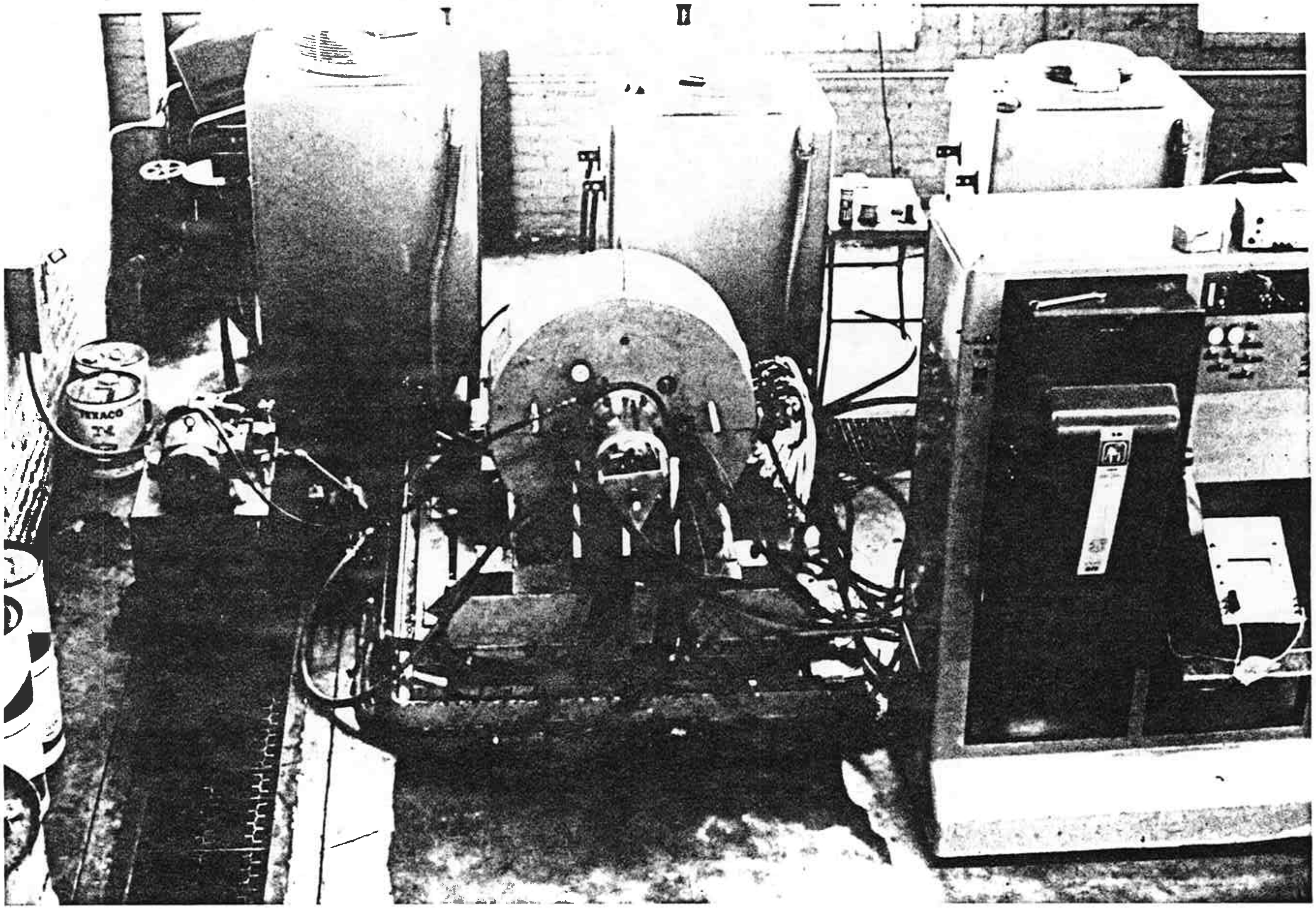


Fig. 2- 0.5 M.J. Machine With Power Supplies and Auxiliaries

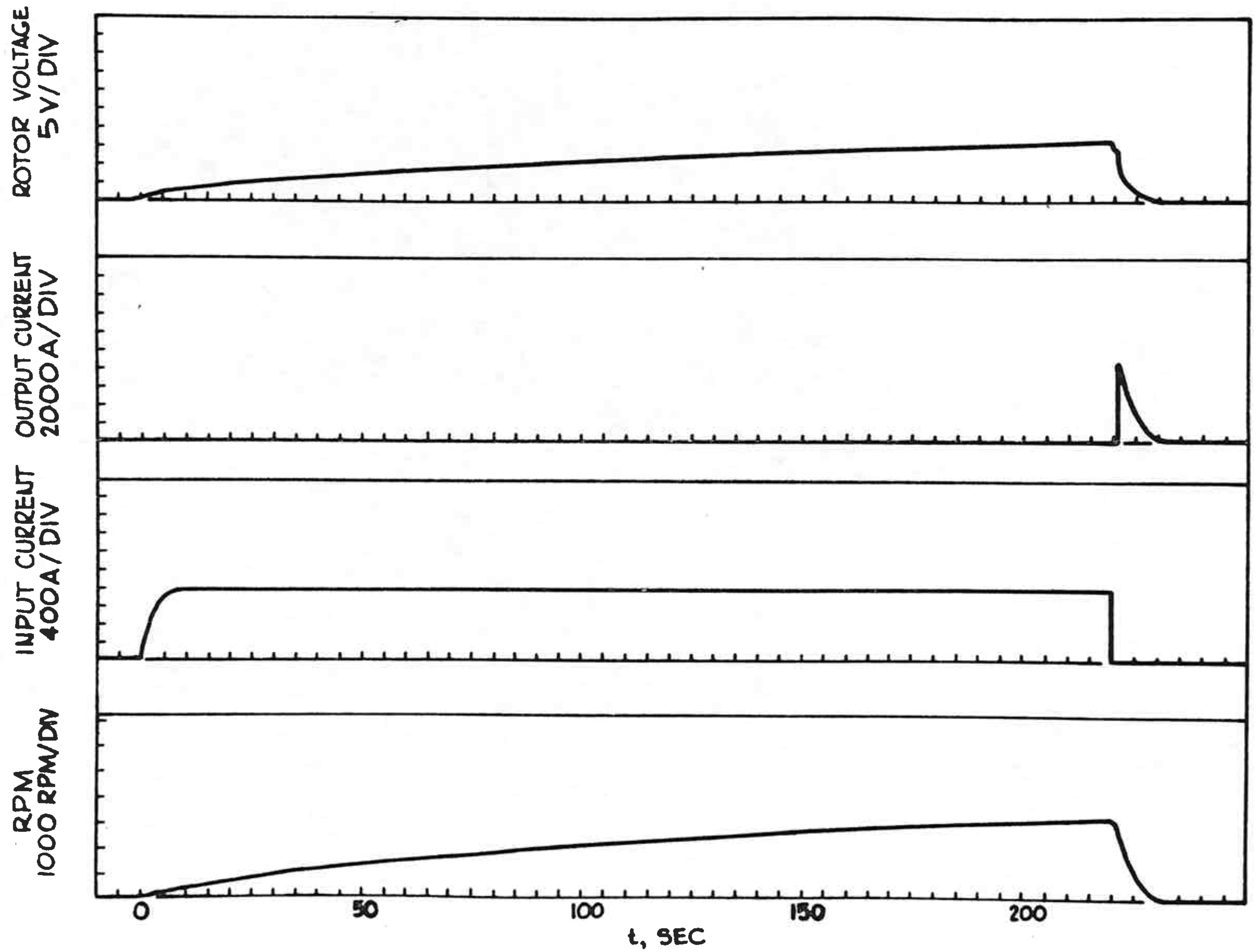
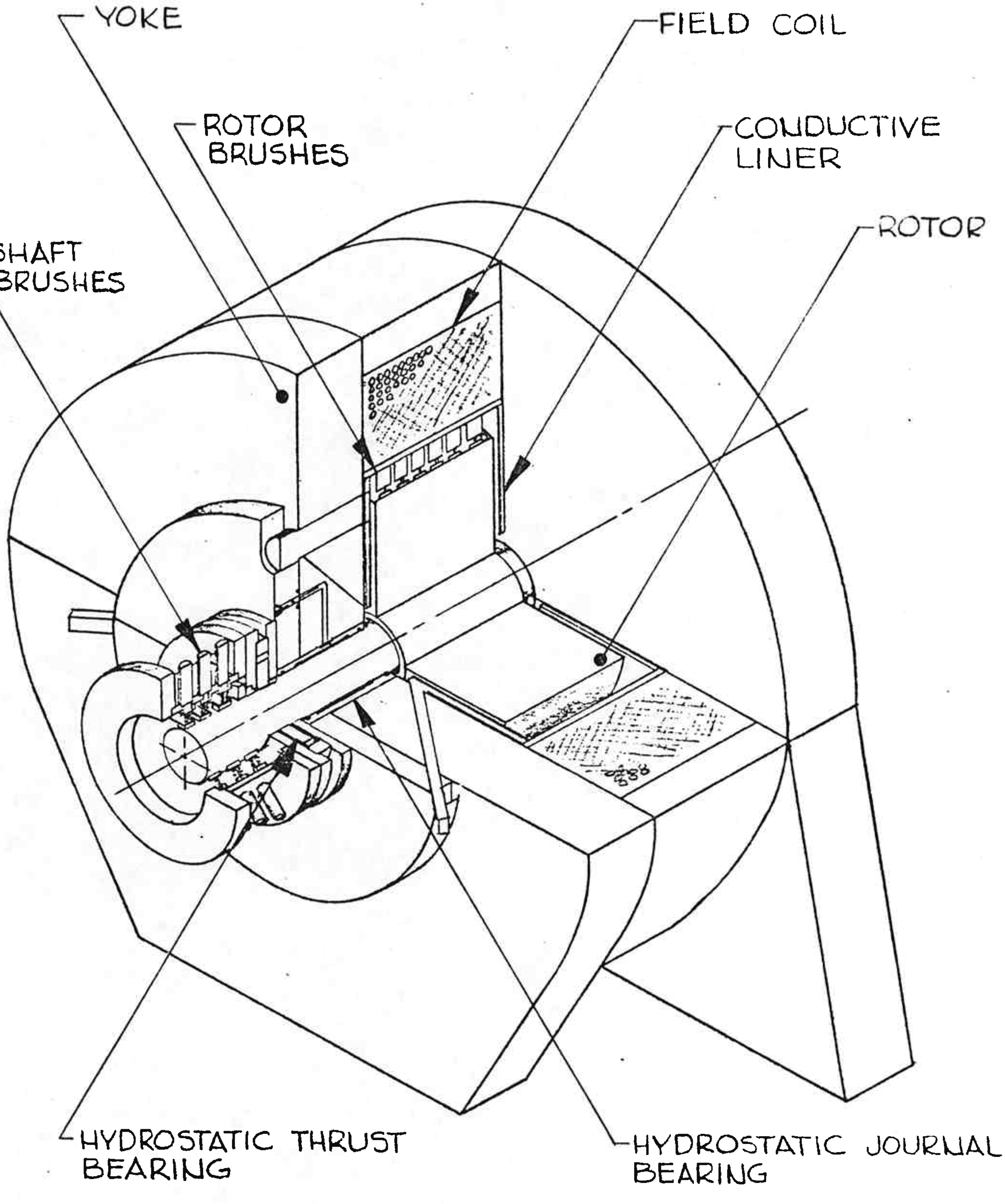
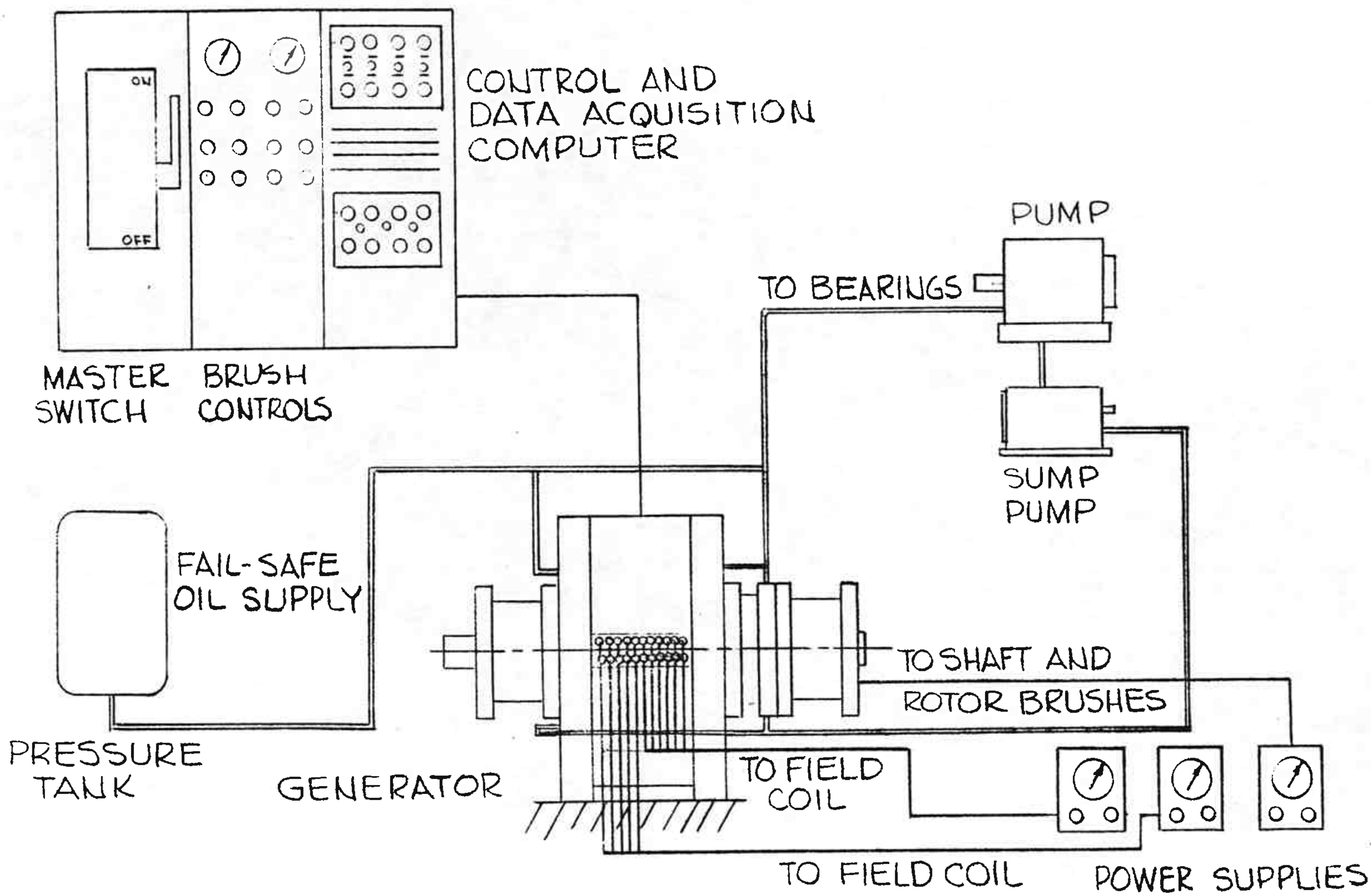


Fig.3 -Performance Data From 0.5 M.J. Machine



5 MJ HOMOPOLAR MOTOR GENERATOR

Fig. 4



5MJ HOMOPOLAR MOTOR GENERATOR
GENERAL LAYOUT

Fig. 5

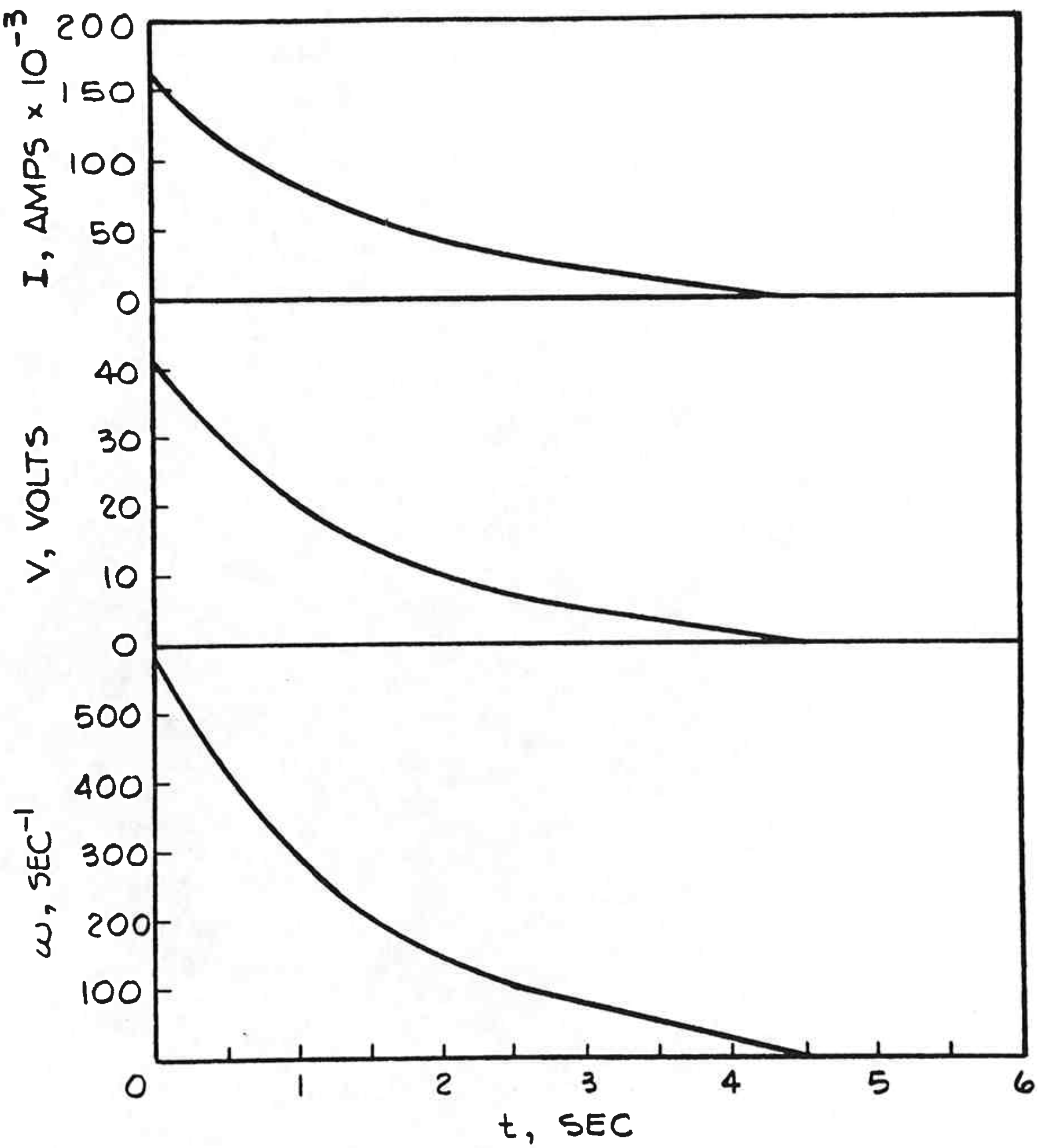


Fig. 6 Estimated Performance of 5 M.J. Machine

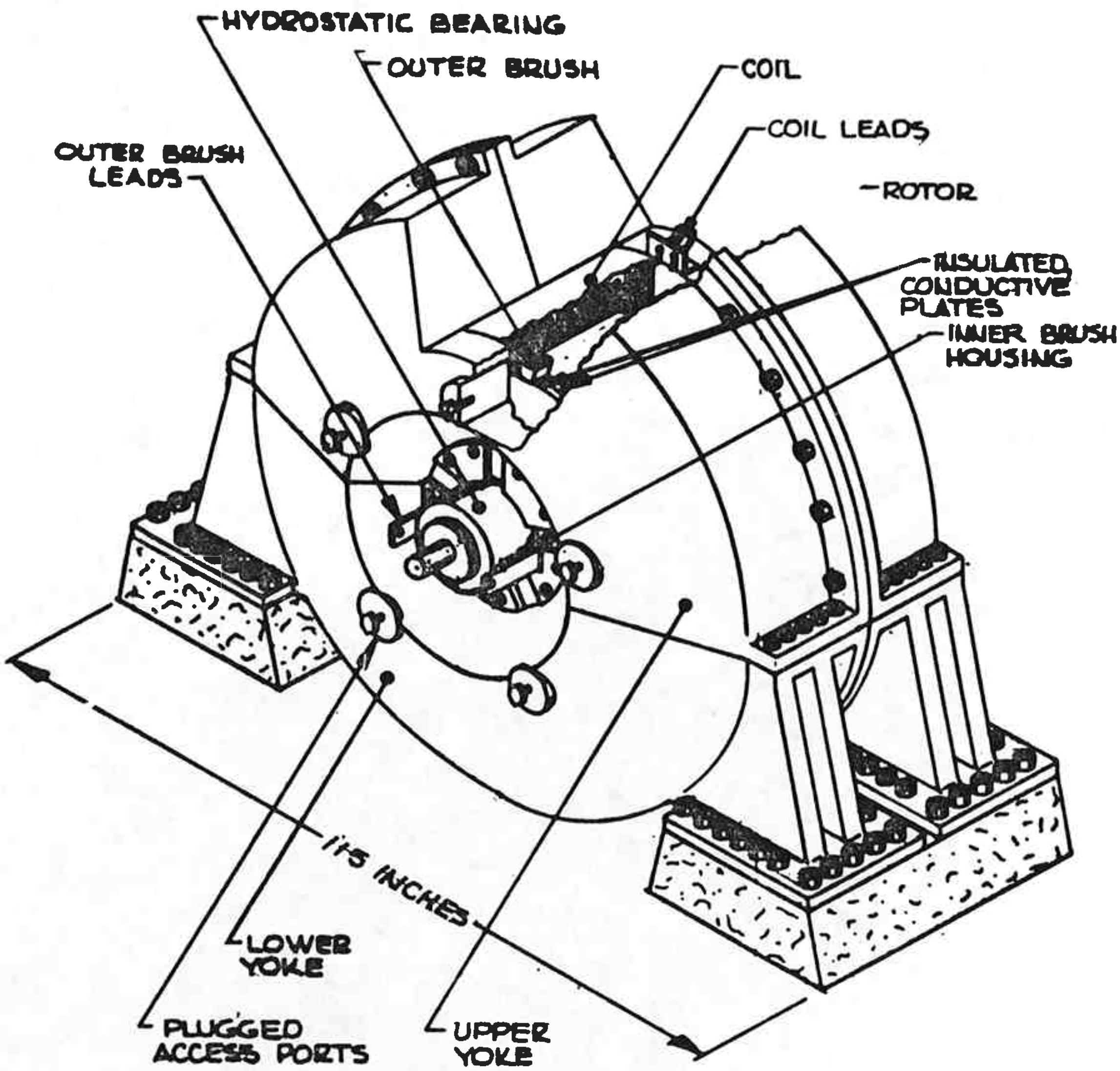


Fig. 7 Schematic for 50 M.J. Machine

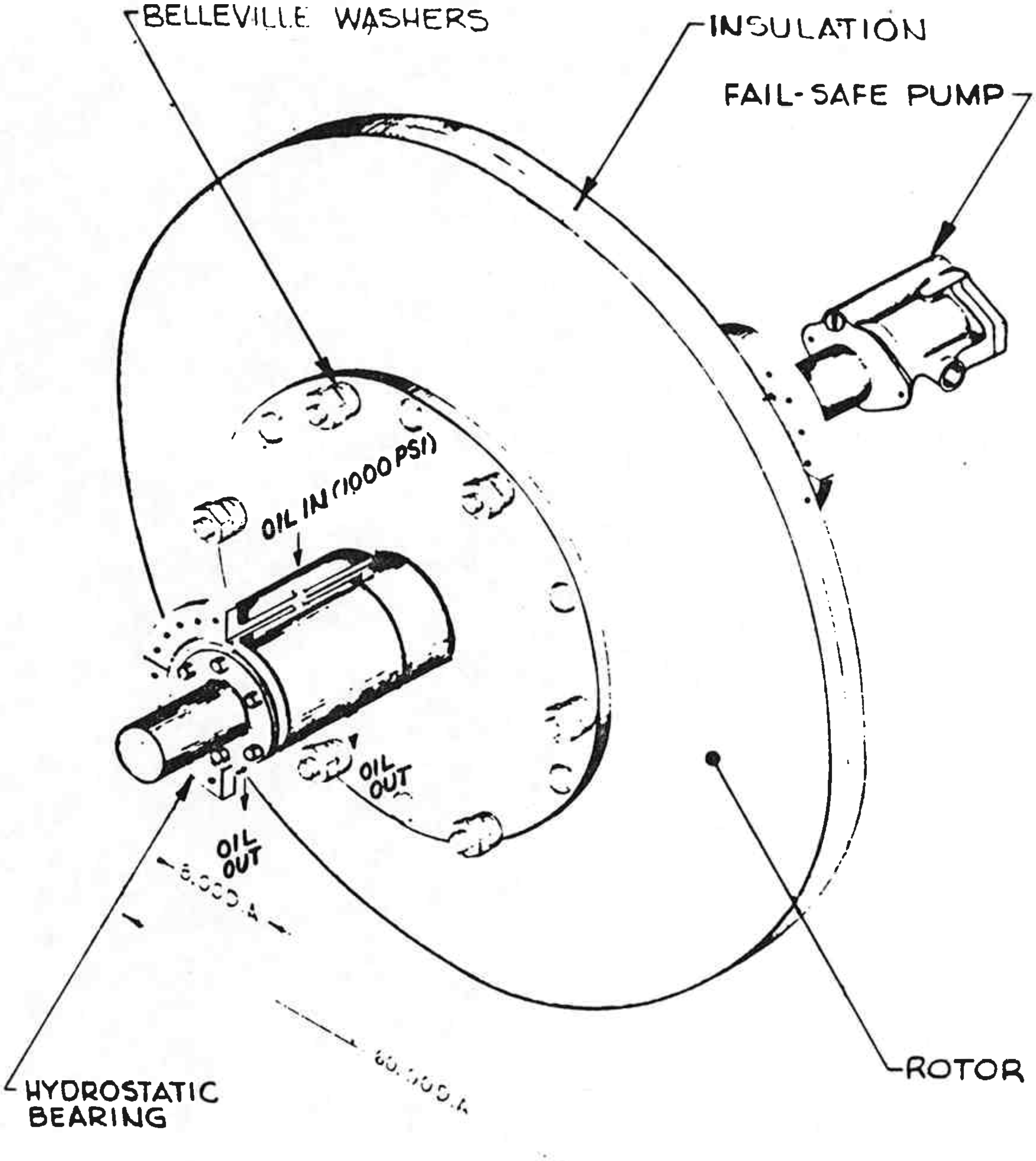


Fig. 8-Split Rotor for 50 M.J. Machine