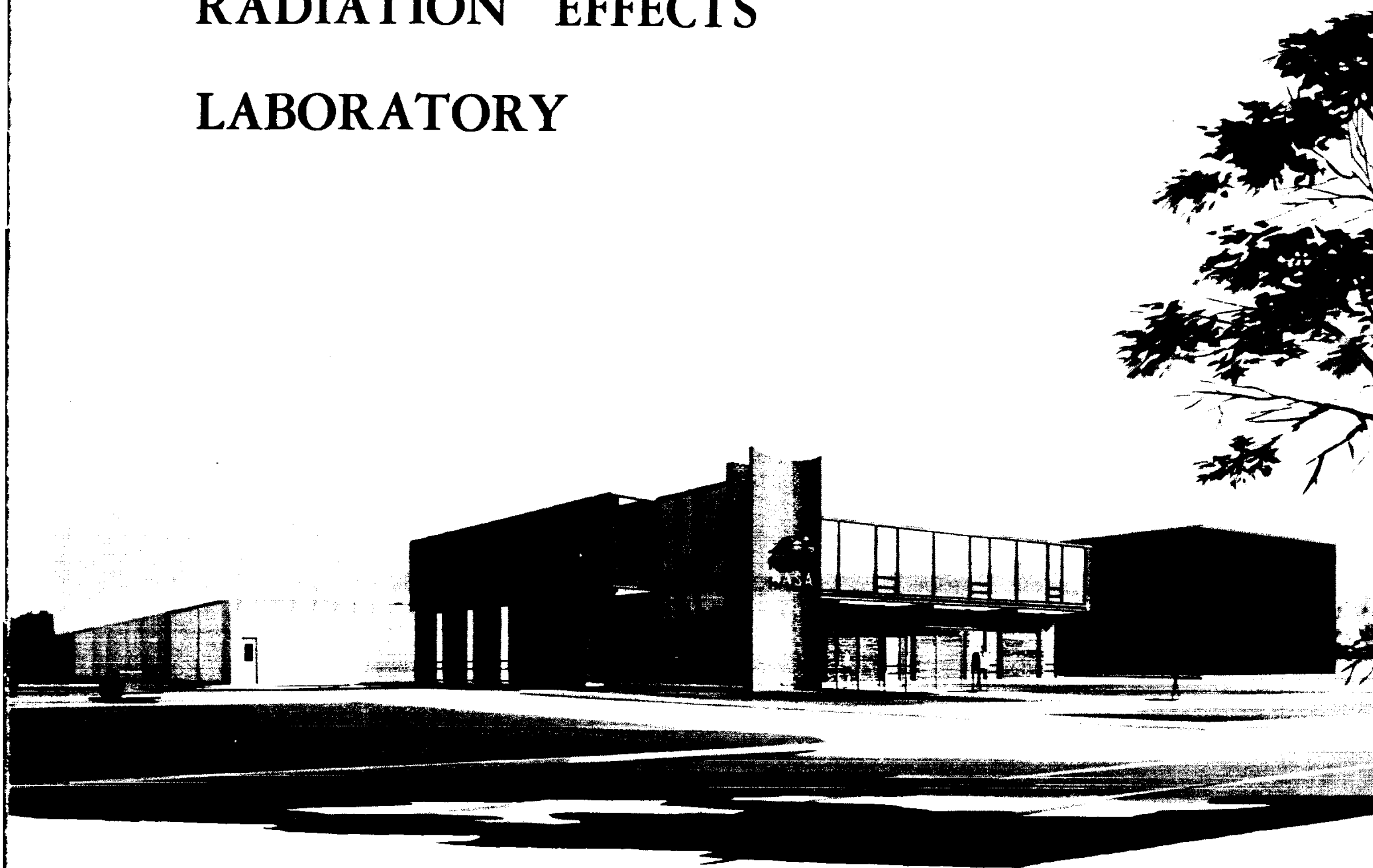
SPACE

RADIATION EFFECTS

LABORATORY



Operated by

THE COLLEGE OF WILLIAM AND MARY IN VIRGINIA

For

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

SREL - USERS HANDBOOK

CONTENTS

INTRODUCTION

I GENERAL INFORMATION

II CYCLOTRON

III CYCLOTRON BEAMS

IV EQUIPMENT POOL

V ELECTRON ACCELERATORS

VI COMPUTER

INTRODUCTION

The SREL User's Handbook is designed to provide information needed by those who plan experiments involving the accelerators at this laboratory. Thus the Handbook will contain information on the properties of the machines, the beam parameters, the facilities and services provided for experimenters, etc. This information will be brought up to date as new equipment is added and modifications accomplished.

This Handbook is influenced by the many excellent models prepared at other accelerator laboratories. In particular, the CERN Synchrocyclotron User's Handbook (November 1967) is closely followed in some sections, since the SREL Synchrocyclotron is a duplicate of the CERN machine. We wish to thank Dr. E. G. Michaelis for permission to draw so heavily on his work, particularly in Section II of this Handbook.

We hope that the Handbook will prove useful, and will welcome suggestions and criticism.

ROBERT T. SIEGEL

SECTION I GENERAL INFORMATION

A. Scheduling Procedures

B. Organization of the Laboratory

C. Laboratory Supervisory Staff

D. Storage of User Equipment at SREL

E. Telephone System

SECTION I GENERAL INFORMATION

A. SCHEDULING PROCEDURES

1. The accelerators at the Space Radiation Effects Laboratory (SREL) are available for use by qualified experimenters associated with universities, government laboratories, and other organizations. The accelerator time available for experimental use is divided into two equal portions. One portion is allocated to experiments approved by Langley Research Center of the National Aeronautics and Space Administration, and the other portion is allocated to experiments approved by the Laboratory. In the following paragraphs, experiments proposed for the two portions are denoted by "NASA-sponsored Experiments" and "Institutional Experiments" respectively.

2. Experimenters desiring to have use of the internal or external accelerator beams at SREL should follow the procedure described in paragraphs 3, 4, and 5 below. The decision as to whether a particular experiment is to be classified as "NASA-sponsored" or "Institutional" will be arrived at for each experiment upon receipt of the request. However, experimental groups from agencies of the Federal Government or whose support is based on a contract with an agency of the United States Government may expect to have their experiments at SREL classified as "NASA-sponsored", while most other sources of support (e.g., Federal grants) will lead to designation of the experiments as "Institutional". Experimenters should follow this principle in directing their written requests, and will be informed immediately if their request is changed from the "NASA-sponsored" to the "Institutional" category or vice versa.

3. Formal submission of a request for accelerator time at SREL must include submission of completed SREL Accelerator Use Request (Form S/2/1) and SREL Experiment Summary Sheet (Form S/7/0), copies of which forms follow Page I A 4. Each form shall be submitted in duplicate.

Request may be submitted for either "prime use" or "parasite use" of the accelerators. The prime user has first priority over beam characteristics and use of Laboratory equipment, as execution of his experiment requires. Parasite users may utilize beams produced simultaneously or in parallel with prime user beams, and have lower priorities over Laboratory equipment designated on the schedule as P, P', P'', etc.

4. Forms (see paragraph 3 above) for experiments to be performed during the NASA portion of available time ("NASA-sponsored Experiments") should be submitted to:

Director
Langley Research Center
Attn: Technical Representative of the Contracting Officer
Contract NASI-5700, Mail Stop 117
Langley Station
Hampton, Virginia 23365

5. Forms (see paragraph 3 above) for experiments to be performed during the institutional portion of available time ("Institutional Experiments") should be submitted to:

Director
Space Radiation Effects Laboratory
11970 Jefferson Avenue
Newport News, Virginia 23606

6. Use requests for institutional experiments are considered by the SREL Users Advisory Committee (UAC) on the basis of scientific merit and feasibility. The UAC meets monthly, and is composed of one voting member and one alternate from each of the following organizations:

College of William and Mary
Langley Research Center (NASA)
Medical College of Virginia
University of Virginia
Virginia Polytechnic Institute

The UAC also includes one voting member and one alternate appointed from among Laboratory users who reside outside the state of Virginia. These two members are elected to one-year terms on the UAC by the out-of-state users of the Laboratory. The UAC members from the organizations listed above are appointed by their respective administrations.

7. Upon approval of a SREL Accelerator Use Request for a NASA-sponsored or an Institutional experiment, the Laboratory undertakes to include the approved time for the experiment on the accelerator schedules. The SREL Experiment Summary Sheet serves as a guide to the Laboratory during this scheduling process. In general, the cyclotron schedule is determined several months in advance, while the schedule for the smaller accelerators at the Laboratory is fixed some weeks in advance. The Laboratory prepares accelerator schedules in close consultation with the users, with Langley Research Center, and with the SREL Users Advisory Committee.

8. Completed monthly schedules are sent to all users as soon as available, usually being sent via mail along with the SREL Newsletter, which is issued at the beginning of each month. Minor revisions necessitated by accelerator malfunction, changes in user requirements, etc., are posted in colored ink on a master schedule board in the main first floor hallway of the Laboratory (adjacent to the entrance to the Proton Readout Area and Control Room). Major revisions and notices of immediate importance are sent to all users as special mailings.

9. The cyclotron is operated on a seven-day per week, twenty-four hours per day schedule, with a sixteen hour period for maintenance every alternate week, generally on Monday. The electron accelerators operate on a five-day per week schedule.

10. There are three areas related to experimentation at SREL which are particularly important after the scheduling process is complete and as the date for actual experimentation approaches. These areas all involve coordination between the experimenter and the Laboratory, and it is in the interest of the experimenter to be aware of the necessity for making proper arrangements regarding:

1) USE OF THE SREL DATA ACQUISITION SYSTEM (see Section VI of this Handbook)

2) USE OF THE SREL EQUIPMENT POOL (see Section IV of this Handbook)

3) SET-UP OF THE EXPERIMENT ON THE FLOOR

Although the two forms used in the approval and scheduling process contain considerable information about the experimental set-up, it is important that users contact the Experimental Support Section of the SREL staff (c.f. Page I E 3) in order to insure that the desired set-up is thoroughly known to the staff, and that it is feasible to prepare the set-up as required by the schedule. Users should expect to provide information and drawings (with all dimensions related to positioning of their equipment clearly specified) as far in advance as possible of the scheduled date for the run, with six (6) weeks the desired lead time.

11. Experimenters desiring to store equipment at SREL for extended periods should consult Section I D of this Handbook.

Space Radiation Effects Laboratory

ACCELERATOR USE REQUEST

1) Title of Proposed Experiment: ______________________________

____

2) Principal Investigator: ______________________________

a. Affiliation: ______________________________

b. Telephone Number: ______________________________

c. Address: ______________________________

3) Experimental Group Members and Affiliations: ______________________________

____

____

4) Accelerator Required (Circle): Linac Dynamitron Synchrocyclotron Neutron Generator

5) Time Requirements (Number 8 Hour Shifts): Prime__________ Parasite__________

a. Set-Up Time in Target Area: ______________________________

b. Irradiation Time: ______________________________

c. Tear-Down Time in Target Area: ______________________________

6) Desired Schedule Dates: ______________________________

7) Experiment: New______ Continuation of SREL Experiment Number__________

8) Sponsoring Government Agency, Grant or Contract Numbers, Names of Monitors:

____

____

9) Machine Requirements:

a. Type of Particles				
b. Energies (MeV)				
c. Intensity				
d. Beam Size				

10) Test Area or Cave to be Used: ______________________________

11) Arrangement of Experiment (Block Diagram with Dimensions):

12) Equipment Pool Items Required: ______

13) Data Acquisition System Required: ______

14) Special SREL Facilities, Space Equipment or Services, Not Otherwise Listed, which you desire to use: ______

15) Special Beam Requirements or Non-Standard Operations Required: ______

16) Describe Any Hazardous Materials to be Used: ______

S/7/0

Cyclotron____ Linac____ Dynamitron____

SPACE RADIATION EFFECTS LABORATORY

EXPERIMENT SUMMARY SHEET

____
Date Received at SREL

____
Experiment Number

For Scheduling Period____________

EXPERIMENT TITLE____________________

PRINCIPAL INVESTIGATOR(s)____________________

ORGANIZATION(s)____________________

Address____________________

Telephone____________________

CHOICE	# SHIFTS	PRIME OR PARASITE	DATES REQUESTED	ROOM OR BEAM AREA	BEAM AND POLARITY
1st					
2nd					
3rd					

This experiment was approved by the [ ] NASA Radiation Experiment Panel, or the [ ] SREL Users Advisory Committee, on (date) ______ for _____ prime shifts and _____ parasite shifts, of which _____ prime and _____ parasite shifts have already been used.

This run is requested to be (during, just before, just after) experiment number ________.

Nuclear Data Interface Required? ______ (Submit separate application to DAS if yes.)

Equipment Pool Needs: Scalers______, Discr.______, Coinc. Ckts.______

Other____________________

Special Requests, Hazardous Materials, Comments, etc.

____

____

____

Signed____________________

Date____________________

TO BE FILLED OUT BY EXPERIMENTER AND SUBMITTED IN DUPLICATE TO DIRECTOR, SREL

B. ORGANIZATION OF THE LABORATORY

The technical staff of the Space Radiation Effects Laboratory is organized in six Divisions, as follows:

1. Cyclotron Division

   This Division is responsible for maintenance and operation of the 600 Mev synchrocyclotron and support of experimenters using this machine. It is also responsible for study of the machine and such modification as will improve performance and reliability. It is composed of the Operation and Maintenance Section and the Experimental Support Section.

2. Electron Accelerator Division

   This Division is responsible for the maintenance, operation, and development of the 3 Mev high-current Dynamitron and the 10 Mev Electron Linear Accelerator.

3. Technical Services Division

   This Division provides various technical (i.e. engineering) services for the entire Laboratory, and is composed of the following Sections:

   a. Design Section

      This Section is responsible for the detailed design of mechanical and electrical systems to be built for the Laboratory. It also provides drafting service for the entire Laboratory.

   b. Electrical Section

      This Section is responsible for the maintenance and operation of the electrical power distribution system in the Laboratory. It is also responsible for the power sections of systems involving large electrical currents such as beam transport magnets.

B. ORGANIZATION OF THE LABORATORY

(cont'd)

c. Mechanical Section

This Section is responsible for mechanical and cooling systems in the Laboratory. It also provides mechanical, vacuum, and machine shop services for the entire Laboratory.

4. Instrumentation Division

This Division is responsible for maintenance, test, and development of electronic instrumentation in the Laboratory. It consists of the Instrumentation Maintenance Section and the Instrumentation Development Section.

5. Special Services Division

This Division is composed of two Sections, as follows:

a. Data Acquisition System (DAS) Section

This Section is responsible for providing on-line data acquisition services via the IBM 360/44 system.

b. Health Physics Section

This Section is responsible for recommending a program of radiation safety procedures in the Laboratory and on the site, and for administering the Radiation Safety program of the Laboratory. It carries on such health physics measurements as will provide basis for the safety program.

6. Administrative Services Division

This Division performs the functions of providing property administration, clerical and communication services, building maintenance, etc.

C. LABORATORY PROFESSIONAL STAFF

July, 1968

Siegel, R. T.	-	Director
Funsten, H. O.	-	Assistant Director
Welsh, R. E.	-	Assistant Director

Bish, R. E.	-	Instrumentation Division
Burtner, G. K.	-	Cyclotron Division
Felch, R. H.	-	Technical Services Division
Holt, M. D.	-	Data Acquisition Services (DAS) Section
Smedley, C. E.	-	Health Physics Section
Sowers, H. L.	-	Electron Accelerator Division
Stearns, C. M.	-	Design Engineering Section

D. STORAGE OF USER EQUIPMENT AT SREL

Since the Laboratory is pressed for space in which to store user-owned equipment, it is necessary to limit such storage. In addition, the practice of leaving valuable and delicate apparatus in the building after an experiment has inherent dangers. It is therefore necessary to establish rules concerning user-owned equipment brought into the Laboratory, as follows:

a. The Experimental Support Section must be informed in advance if any user-owned equipment or materials are to be delivered to the Laboratory before the arrival of the user group itself. This Section will assume responsibility for the equipment until the owner comes for his scheduled run. (The owner will unpack and assemble his equipment, however.)

b. Upon termination of a run, all the user-owned equipment must be removed from the premises within 24 hours. This will permit succeeding experiments to be set up rapidly.

c. If some user equipment must be shipped back to home base via common carrier, the owner will be responsible for packing and sealing it. The SREL Experimental Support Section will arrange for the actual shipment, via the means preferred by the owner.

d. It is recognized that because of recurring use, it is inconvenient to shuttle some large items of equipment back and forth to home base. A user may apply (to the Experimental Support Section) for permission to store such items on the premises for an extended, but specified, period of time. Storage will be at the owner's risk, but reasonable effort will be made to preserve the equipment intact. A form for making such application follows on the next page.

Form S/6/0

S R E L

USER REQUEST FOR ON-SITE EQUIPMENT STORAGE

DATE ______________________

USER ______________________

AFFILIATION ______________________

EQUIPMENT DESCRIPTION ____

____

____

____

____

____

TO BE STORED UNTIL ______________________
(date)

APPROVED ______________________
Director, SREL

SREL TELEPHONE SYSTEM INSTRUCTIONS

(INCOMING CALLS)

A = Weekday 8:00 a.m. - 5:00 p.m.

B = Night, weekends and holidays

From Local:

A. Dial 877-9231, 9232, 9235, or 9236
(VARC Telephone Operator)
Ask for SREL member or his extension number

B. Dial 877-9231 (Ext. 268 - Lobby)
Dial 877-9231 (Ext. 274 - Control Room)
Dial 877-9234 (Ext. 288 - Meson Control Room)
Ask for SREL member

From SCATS:

A. Dial 8 + 345-9 + SREL extension number

B. Dial 8 + 345-9268 (Lobby)
345-9274 (Control Room)
345-9288 (Meson Control Room)

From NASA/Langley:

A. Dial 4616, 4617, or 4618 (VARC Telephone Operator)
Ask for SREL member or his extension number

B. Dial 4618 (Ext. 265 - Administration Office and Lobby)
Ask for SREL member

From FTS:

A. Dial FTS 703-722-7961 (NASA/Langley Telephone Operator)
Ask for Ext. 4616, 4617, or 4618 (VARC Telephone Operator)
Ask for the SREL member or his extension

B. Dial FTS 703-722-7961 (NASA/Langley Telephone Operator)
Ask for Ext. 4618 (Ext. 265 - Administration Office and Lobby)
Ask for the SREL member

SREL TELEPHONE SYSTEM INSTRUCTIONS

(OUTGOING CALLS)

A = Weekday 8:00 a.m. - 5:00 p.m. (All extensions are in service)

B = Night, weekends, and holidays. (Only extensions as noted are in service)

To Call SREL Extensions:	A.	Dial the extension number
	B.	(All extensions except 265, 268, 274, and 288) Dial the extension number
To Call Local:	A.	Dial 9 + the telephone number
	B.	(Only extensions 268, 274, and 288 are in service) Dial the telephone number
To Call Norfolk:	A.	Dial 0 (VARC Telephone Operator) Ask for a NASA Line Dial 0 (NASA Telephone Operator) Ask for a Norfolk Line Dial the telephone number
	B.	(Only extension 265 is in service) Dial 0 (NASA Telephone Operator) Ask for a Norfolk Line Dial the telephone number
To Call Within Virginia:	A.	Dial 8 + SCATS Telephone Number Dial 8 + 703 + the telephone number of location not on the SCATS System
	B.	(Only extensions 268, 274, and 288 are in service) Same procedure as weekdays (A)
To Call Outside Virginia:	A.	Dial 0 (VARC Telephone Operator) Ask for a NASA Line Dial 39 + FTS area code and telephone number
	B.	(Only extension 265 is in service) Dial 39 + FTS area code and the telephone number

SREL TELEPHONE SYSTEM GENERAL INFORMATION

To Call Long Distance Information: (Using a local line) - Dial the area code + 555-1212

To Call Local Information: (Using a local line) - Dial 113

For Telephone Directories: FTS, SCATS and Local Directories are available in the Lobby

To Page: Dial 268 (Lobby); ask the receptionist to page

For Conference Calls: (Internal, 8:00 a.m. - 5:00 p.m. only, 5 stations maximum)
Dial 0 - (VARC Telephone Operator)
Request Same

To Transfer Calls: (Internal 8:00 a.m. - 5:00 p.m. only)
Depress the receiver hook ONCE (VARC Telephone Operator will answer)
Request Same

- -

FREQUENTLY CALLED SREL EXTENSIONS

Ext. 260	Dr. R. T. Siegel - Director
Ext. 272	Dr. H. O. Funsten - Assistant Director
Ext. 284	Dr. R. E. Welsh - Assistant Director
Ext. 230	Dr. K. Gotow - Associate Director
Ext. 228	Mr. R. E. Bish - Instrumentation Division
Ext. 282	Mr. G. K. Burtner - Cyclotron Division
Ext. 283	Mr. R. H. Felch - Technical Services Division
Ext. 287	Mr. M. D. Holt - Data Acquisition System Section
Ext. 278	Mr. W. P. Madigan - Experimental Support Section
Ext. 269	Mr. C. E. Smedley - Health Physics Section
Ext. 278	Mr. H. L. Sowers - Electron Accelerator Division

SECTION II CYCLOTRON

1.

2. "Physical Processes in Synchro-cyclotron Accelerators"
by E. G. Michaelis (from CERN Cyclotron Handbook)

PHYSICAL PROCESSES IN SYNCHRO-CYCLOTRON ACCELERATION

E. G. Michaelis

2.1 Magnetic Resonance Acceleration

The momentum $\vec{p}$ of a particle of charge e, moving with a velocity $\vec{v}$ in an electric field $\vec{E}$ and a magnetic field $\vec{B}$, varies according to the Lorentz equation

$$\frac{d\vec{p}}{dt} = e\vec{E} + e\,(\vec{V} \times \vec{B}). \tag{1}$$

The electric field $\vec{E}$ varies the magnitude of the momentum $\vec{p}$ and so accelerates or decelerates the particle. The magnetic field $\vec{B}$ changes the direction of $\vec{v}$ and $\vec{p}$ by exerting a force perpendicular to the plane of $\vec{v}$ and $\vec{B}$. (1) may be rewritten, using

$$\vec{p} = m\vec{v}$$

where

$$m = m_o\,(1 - \beta^2)^{-1/2} \tag{2}$$

and

$$\beta = v/c$$

is the ratio of the particle velocity v to the velocity of light c.
(1) then becomes

$$\frac{d}{dt}(m\vec{v}) = e\vec{E} + e\,(\vec{v} \times \vec{B}). \tag{3}$$

To resolve (3) into component-form we adopt a system of cylindrical coordinates r, Θ, z whose origin coincides with the centre of the cyclotron and whose z axis is that of the magnetic field. (See Fig. 3.)

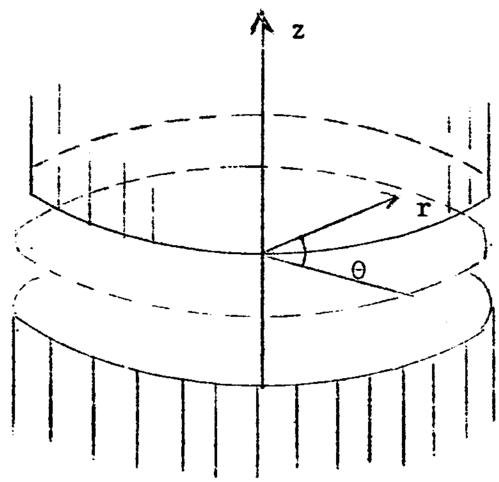


Fig. 3

Cylindrical coordinates in the cyclotron

Then the radial component of (3) is

$$\frac{d}{dt}(m\dot{r}) - mr\dot{\theta}^2 = eE_r + er\dot{\theta}B_z - e\dot{z}B_\theta, \tag{4}$$

dots denoting time derivatives.

To study the motion of an equilibrium particle we assume that the electric field is purely azimuthal and the magnetic field purely axial. Hence $E_r = B_\theta = 0$. If, furthermore, the centre of curvature coincides with the origin and we neglect the change in orbit due to any acceleration then

$$\dot{\theta} = - eB_z/m = \omega_c, \text{ say.} \tag{5}$$

Hence the particle moves with constant angular velocity about the centre of the machine. When now an alternating electric field E_θ of the same frequency ω_c is applied to an accelerating gap then particles passing it at a suitable phase gain energy at each turn and magnetic resonance acceleration occurs.

When m is measured in MeV and B_z in W/m^2 then the orbital frequency of a singly charged particle is

$$f_c = \frac{\omega_c}{2\pi} = \frac{9 \times 10^4 \; B_z}{2\pi m} \quad \text{Mc/s.}$$

For protons of rest-mass energy 938 MeV and kinetic energy E this becomes

$$f_c = \frac{14.300 \; B_z}{938 + E} \quad \text{Mc/s.}$$

The negative sign in (5) indicates that positively charged particles rotate clockwise about a field for which B_z is positive.

Also from (5)

$$mr\dot{\theta} = mv_\theta = p_\theta = - erB_z, \tag{6}$$

giving the relation between the value of the magnetic induction, the azimuthal momentum and the radius of curvature of the orbit.

For a uniform field (B_z = constant) and non-relativistic motion ($m = m_o$) an alternating electric field of a single frequency

$$\omega_o = - eB_z/m_o \tag{7}$$

accelerates particles at all radii. This is the mode of operation of a non-relativistic cyclotron. The relativistic variability of mass and the need to reduce the field with increasing radius to obtain focusing (see para 2.3) limit its operation for protons to about 20 MeV.

Various means have been employed to reach higher energies. In the synchro-cyclotron the accelerating frequency is varied periodically so that the resonance condition is maintained for a group of particles throughout the accelerating process. This condition can only be met for particles which, at a given stage of the cycle, lie in a narrow band of energies. The output of the synchro-cyclotron is therefore pulsed. The accelerating frequency is modulated according a "frequency programme", often given by a variable reactance. In the SC this element is a large tuning fork, whose prongs form part of a variable capacitor. The fork vibrates at 54 cycles per second and each vibration corresponds to the acceleration of a group of particles from zero to maximum energy.

The pulse frequency of the machine is therefore 54 c.p.s. During each cycle the accelerating frequency decreases from a value f_o at time t_o to f_1 at t_1, when the bunch of ions reaches the maximum radius. The duration of the acceleration $t_1 - t_o$ is given by the vibration of the tuning fork; it is about 8 milliseconds. The time interval between pulses is 18 milliseconds, the remaining time being required for the fork to return to its initial position.

Accelerating frequency

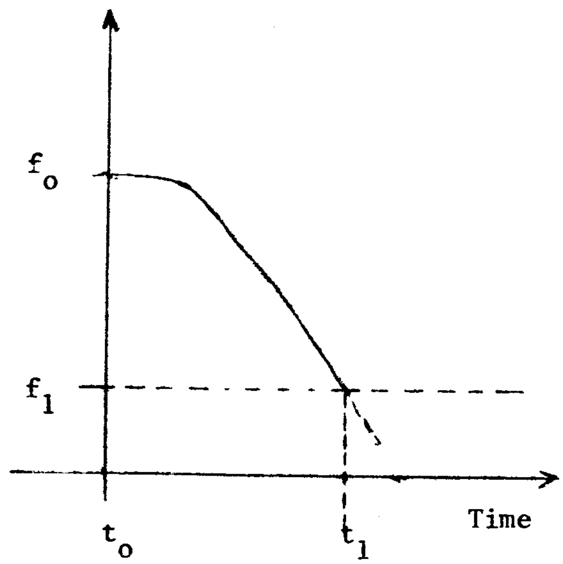


Fig. 4

2.2 The Basic Parameters of the Synchro-Cyclotron

To calculate the particle kinetic energy E from (6) we let $p_\Theta = p$ and use the relation

$$(E + m_o)^2 = p^2 + m_o^2 \; . \tag{8}$$

Here we have put c = 1 for simplicity i.e. we express energies, momenta and masses in MeV. (2), (6) and (8) then give

$$E = m_o\left[\sqrt{\left(\frac{eB_z r}{m_o}\right)^2 + 1} - 1\right] . \tag{9}$$

For B_z in Webers per square metre, r in metres and m_o in MeV (6) becomes very nearly

$$p = 300\; B_z\; r \tag{10}$$

for particles having a single electronic charge. Hence (9) can be written as

$$E/m_o = \sqrt{\left(\frac{300B_z r}{m_o}\right)^2 + 1} - 1 \qquad (11)$$

In the SC the induction $B_z = 1.83$ W/m^2 at $r = 2.24$ m, when the magnet excitation is 1900 A. For these values formula (10) yeilds $p = 1225$ MeV/c and formula (11), with $m_o = 938$ MeV, gives $E = 602$ MeV.

To estimate the frequency swing we use formulae (5) and (2) giving

$$\omega = eB_z\,(1 - \beta^2)^{1/2}/m_o, \qquad (12)$$

or, with (8)

$$\omega = \frac{eB_z}{E + m_o}. \qquad (12')$$

For the case of a uniform magentic field the frequency swing required to attain a kinetic energy E is therefore

$$f_o/f(E) = \omega_o/\omega(E) = E/m_o + 1 \qquad (13)$$

For 602 MeV protons this yields $f_o/f(E) = 1.65$. In the SC at 1900 A magnet excitation the initial radiofrequency is $f_o = 29.8$ Mc/s and f (602 MeV) = 17.0 Mc/s. Hence $f_o/f(602) = 1.76$, the slight increase being caused by the radial fall-off of the magnetic field.

Since the synchro-cyclotron has to operate over a wide band of radiofrequencies it is difficult to achieve a high accelerating potential across the dee-gap. In addition we shall see that in a frequency-modulated machine the actual energy gain per turn is only a fraction of the peak gain.

In the SC the peak voltage across the dee gap varies from about 5 kV at the beginning to about 30 kV at the end of the acceleration. Since the gap is crossed twice at each cycle the maximum energy gain per turn lies between 10 and 60 MeV; yet the actual average energy gain per turn is only 2.7 keV. The particles therefore perform about 200.000 turns before reaching their maximum radius, and their orbital radius increases by only about 10^{-2} mm per turn. The acceleration is therefore very gradual and the stability of the accelerated particles becomes important. Deviations from the ideal orbits and variations in phase of the particles with respect to the accelerating potential must be corrected. In addition a high vacuum of the order of 10^{-6} Torr is required to prevent beam losses through scattering by the residual gas.

2.3 Orbital Stability

To ensure orbital stability it is necessary that particles deviated from an ideal orbit, e.g. by their starting conditions or by gas scattering, should be returned to it by a restoring force. This force can be provided by a suitable shape of the magnetic field. In the synchro-cyclotron orbital stability is achieved by letting the magnetic field fall off with increasing radius.

Conventionally the dependence of field on radius is expressed in the form

$$B_z(r)/B_z(r_o) = (r_o/r)^n. \tag{14}$$

Hence

$$n = -\frac{r}{B_z}\frac{\delta B_z}{\delta r},$$

n is the "field index"; it is positive for a radially decreasing field.

In first approximation the motions in the axial and radial directions can be separated, and relativistic effects may be neglected in these transverse motions.

Axial Motion

The magnetic field is assumed to have a plane of symmetry at $z = 0$. If a particle having suffered a displacement z from this planeiis to be deflected towards it then the field must have a radial component B_r in the plane of symmetry. We write this as

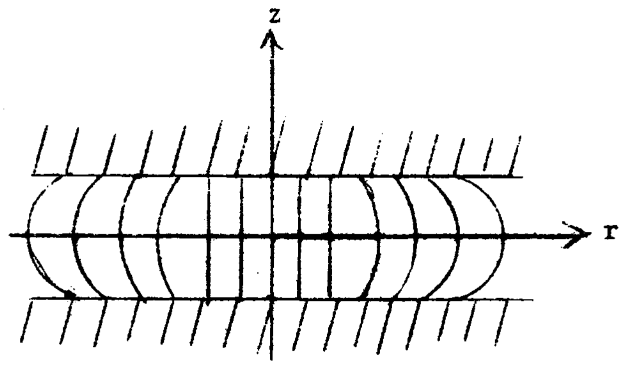


Fig. 5

$$B_r(r,z) = B_r(r,0) + \frac{\partial B_r}{\partial z} z + \dots = \frac{\partial B_r}{\partial z} z + \dots, \qquad (16)$$

the first term vanishing by symmetry. But

$$\frac{\partial B_r}{\partial z} = \frac{\partial B_z}{\partial r} . \qquad (17)$$

Hence the radial component is

$$B_r(r,z) = - \frac{B_z n}{r} z. \qquad (18)$$

Using this value in the z - component equation of (3),

$$\frac{d}{dt}(m\dot{z}) = e\dot{r}B_\Theta - er\dot{\Theta}B_r = m\ddot{z}. \qquad (19)$$

Letting $B_\Theta = 0$ one obtains with (5)

$$m\ddot{z} = - \varepsilon\omega_c B_z nz = \omega_c{}^2 nz \qquad (19)$$

indicating a simple harmonic motion in the axial direction with angular frequency

$$\omega_z = \omega_c \sqrt{n} \; .$$

Hence a particle having undergone an axial displacement oscillates about the median plane with a frequency

$$f_z = f_c \quad n \; , \tag{20}$$

where f_c is the cyclotron frequency. The particle performs "axial" or "vertical" Oscillations.

<u>Radial Motion</u>

This is again given by (4). With $E_r = B_\Theta = 0$, and making the same approximations as in the previous paragraph this becomes

$$m\ddot{r} - mr\dot{\Theta}^2 = er\dot{\Theta}B_z . \tag{21}$$

Putting

$$B_z(r) = B_z(r_o) \left(1 - \frac{r - r_o}{r_o} n \right)$$

and introducing

$$\rho = \frac{r - r_o}{r_o} , \qquad \ddot{\rho} = \frac{r}{r_o}$$

as new variable one finds

$$\ddot{\rho} - \omega_c{}^2 (n - 1) \rho = 0$$

indicating once more a simple harmonic motion of angular frequency

$$\omega_r = \omega_c \sqrt{1 - n}$$

about the equilibrium radius. The particles perform "radial oscillations" of frequency

$$f_r = f_o \sqrt{1 - n} \tag{22}$$

The axial and radial oscillations of the accelerated particles in cyclic accelerators were first studied by Kerst and Serber for the case of the betatron; hence they are called "Betatron Oscillations". The simple account of betatron oscillations presented here neglects the focusing effects of the electrical fields at the dee-gap as well as non linearities introduced by the variation of n with radius. Despite these limitations it accounts for many of the phenomena observed.

Betatron Amplitudes

The limiting aperture in cyclotrons is usually the dee-gap. In the CERN SC this is 12 cm high and about 5 m wide. By its shape the dee-gap limits the vertical oscillations while allowing large radial amplitudes.

The initial amplitudes of the betatron oscillations are given by the conditions at the start of the acceleration. Owing to the method of ion injection from a source placed below the median plane and in the absence of vertical focusing at the centre (where n = 0 and the axial restoring force vanishes) the axial oscillations are initially large, but they are damped as the acceleration proceeds and n increases. In the CERN machine an attempt is made to reduce the axial oscillations at the start of the acceleration by means of a pair of small dee-electrodes placed opposite the main accelerating dees near the machine centre. It is found that the accelerated beam is increased by choosing a suitable negative bias potential for these electrodes, suggesting a reduction of beam loss at the centre.

The restoring force for radial oscillations has its maximum at the centre, but finite amplitudes are introduced by the position of the ion source and by the relatively large electrical forces acting in this region. The radial oscillation amplitudes increase with n, and a radial beam spread is also produced by the phase oscillations to be discussed below. As a result of these effects the beam assumes an elliptical cross-section. At the normal target radius the beam in the CERN machine has a radial full width at half maximum of about 9 cm and a height of about 2 cm.

In addition to the smooth variation of the amplitudes during acceleration resonance phenomena may occur at particular values of n, which lead to the sudden growth of one or the other oscillation amplitudes. To study these one needs to examine the conditions of orbital stability somewhat more generally.

Conditions of Stability

It is instructive to consider the ratios of the betatron frequencies to the orbital frequency of the accelerated particles. Let

$$\nu_z = f_z/f_c = \sqrt{n} \qquad \nu_r = f_r/f_c = \sqrt{1 - n} \tag{23}$$

The values of ν_z and ν_r give respectively the number of axial and radial oscillations per turn. The two parameters are subject to the condition

$$\nu_r^2 + \nu_z^2 = 1 \tag{24}$$

In the synchro-cyclotron a basic condition of stability is that both ν_r and ν_z are real and therefore

$$0 < n < 1. \tag{25}$$

In sector focused and alternating gradient accelerators, the so called "strong focusing" machines, this condition is infringed. The machines in which it obtains are called "weak focusing". It has already been mentioned, however, that even in a cyclotron or synchro-cyclotron (25) is not fulfilled at the centre of the machine where the field is a maximum and hence $n = 0$, and that as a result the centre is a region of axial instability.

Furthermore the conditions (24) and (25) are necessary but not sufficient for orbital stability. Resonances may occur when either ν_r or ν_z have simple rational values or when they are in a simple ratio. In the first case the betatron oscillations are excited by the accelerating frequency, in the second case they may be coupled to each other. Both can lead to an increase in betatron oscillation amplitudes and a consequent loss of beam.

The occurrence of resonances may be illustrated by plotting ν_z against ν_r (see Fig. 6).

According to (24) the working locus of a weak focusing machine on the $\nu_r\ \nu_z$ diagram is a circle of unit radius. At the start of the acceleration $n = 0$, corresponding the point A on the diagram. During the acceleration the working point moves along the unit circle but its range is restricted by various resonance lines. The resonances $\nu_z = 1/2$ and $\nu_r = 1/2$ are lines parallel to the axes. The "coupling resonances"

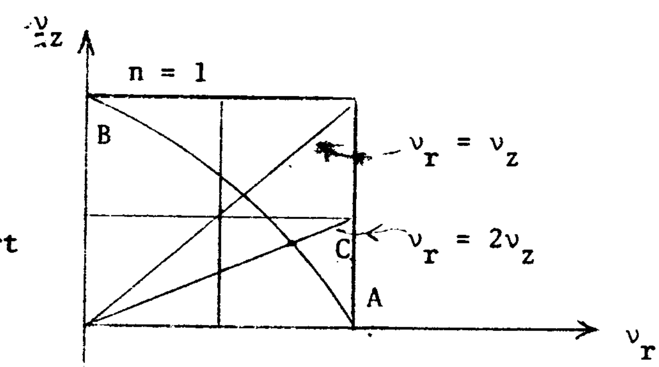


Fig. 6

$$p\nu_r - q\nu_z = 0 \qquad p,q = 1,2... \tag{26}$$

are lines passing through the origin. Important coupling resonances occur at

$$\nu_r - 2\nu_z = 0 \quad \text{or} \quad n = 0.2$$

at $$\nu_r - \nu_z = 0 \quad \text{or} \quad n = 0.5$$

Reference to the SC field data in section II 3 shows that the field gradient and hence the n-value remain small until the particles get close to the edge of the machine. For an excitation of 1900 A the $n = 0.2$ value lies at 2.27 m radius. At $n = 0.2$ either axial or radial oscillations may build up at the expense of the other. An increase of axial amplitude leads to beam loss in the dees, which limit the vertical aperture; large radial amplitudes quickly bring the particles into regions where n increases rapidly and semi-integral or integral resonances occur.

Consequently the beam becomes unstable when a part of it reaches the point $n = 0.2$ unless particular precautions are taken to keep the betatron amplitudes small and to avoid any build-up via inhomogeneities of the field or the gradient. In the CERN machine the acceleration is not usually carried beyond the $n = 0.2$ point, the maximum normal internal target radius being 2.26 m. During operation demanding beam stability over longer periods, e.g. during the slow spill of the beam, the target radius is reduced to 2.24 m.

At $n = 0.2$ we have $\nu_z = 0.45$ and $\nu_r = 0.89$. Hence in the neighbourhood of this point a particle which receives an axial deflection, say by being scattered in a target, has its maximum axial displacement after one half or three half turns in the machine, crossing the median plane in the vicinity of the target position. From the point of view of the effective use of a target it is therefore desirable to operate as closely to $n = 0.2$ as conditions of stability will permit.

The radial oscillation frequency is close to the orbital frequency itself; as a result the point of maximum radial displacement moves around the machine, making about one turn for ten orbital cycles at $n = 0.2$.

2.4 Phase Stability

It was pointed out in paragraph 2.1 that in a frequency modulated accelerator the resonance condition can only be fulfilled for a certain bunch of particles. This bunch must cross the dee-gap in such a phase that, throughout the acceleration cycle, its constituent particles acquire the energy necessary to enable them to keep in step with the frequency programme. Consider the variation of potential across the dee-gap, which is of the form

$$V(t) = V_m \sin \omega_c t$$

Assume that a value $V_o = V_m \sin \phi$, is required to provide the necessary acceleration. This value occurs twice in each cycle, namely at a phase ϕ_a when the voltage across the gap is rising and at ϕ_b when it is falling (see Fig. 7).

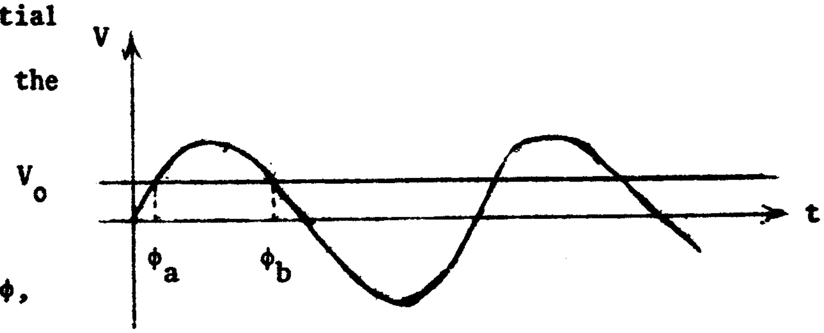


Fig. 7

We shall see that phase stability is achieved at only one of the two phase angles.

Consider first an "equilibrium particle" (EP). It crosses the dee-gap at a phase where its energy gain V_o is such that it remains in step with the modulated frequency. Since the orbital frequency in a synchrocyclotron decreases with particle energy a particle whose energy exceeds that of the EP requires a longer time to complete its orbit. If it crosses the dee-gap later than ϕ_a its energy gain exceeds that of the EP and it will be further retarded until phase coherence is lost. Similarly a particle whose energy is less than that of the EP crosses the dee-gap a little earlier at each turn and so gets progressively out of step with the accelerating field.

The reverse, however, occurs near ϕ_b. Here the particles possessing excess kinetic energy are accelerated less than the EP and the particles of lower energy are accelerated more. As a result phase stability is achieved, i.e. particles having energies which differ slightly from that of the EP are brought back to the equilibrium phase to be denoted by ϕ_o. Phase stable acceleration therefore occurs only on the falling side of the dee voltage curve.

It can be shown that during the acceleration in a synchro-cyclotron the ions carry out "phase oscillations" around ϕ_o. Their frequency for small amplitudes is

$$\omega_\phi = \omega_c \left(\frac{KeV_m \cos \phi_o}{2\pi \ (m_o + E)} \right)^{1/2} \tag{27}$$

where ω_c is given by (5) and

$$K = 1 + \frac{n}{(1 - n)\beta^2} \tag{28}$$

Here n is again the field index defined in exp. (14) and βc is the orbital velocity of the equilibrium particle.

For $E << m_o$ (27) becomes

$$\omega_\phi / \omega_o \simeq \left(\frac{KeV_m \cos \phi_o}{2\pi m_o} \right)^{1/2} .$$

KeV_m/m_o is of order 10^{-6}; hence $\omega_\phi/\omega_o << 1$ and the particles perform several hundred turns during the course of a single period of phase oscillation.

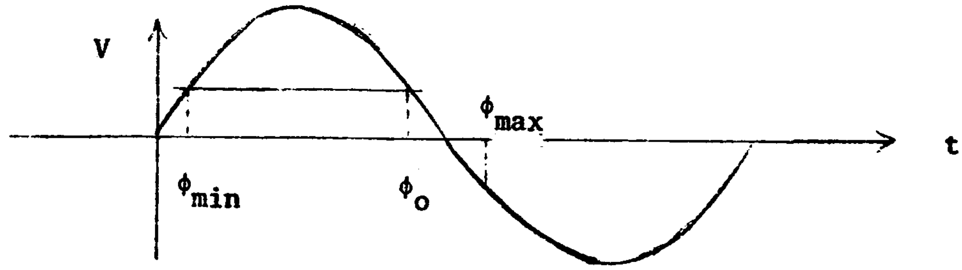


Fig. 8

A limit $\Delta\phi_m$ of the phase-oscillation amplitude is given by the condition that the energy gained by a particle passing the dee-gap before the equilibrium particle must exceed that gained by the equilibrium particle. This condition yields a minimum phase angle ϕ_{min} with respect to a given ϕ_o (see Fig. 8). ϕ_{min} in turn determines ϕ_{max}. Fig. 8 shows that $\Delta\phi_m < \pi-2\phi_o$.

The phase oscillation is damped; so the amplitude decreases during acceleration and is typically about 60^o towards the end of the cycle. Fig. 8 also illustrates that the range of stable oscillation depends on ϕ_o; it vanishes as ϕ_o approaches one of its limits. The accepted range of phase oscillations reflects itself in the number of particles accelerated in a phase stable bunch; for a given energy gain per turn $2eV_m \sin\phi_o$ it increases with increasing V_m and decreasing $\sin\phi_o$. From the point of view of beam intensity it is therefore advantageous to have a high peak voltage, which enlarges the phase acceptance. For any given V_m the phase factor adjusts itself so that the bunch can follow the frequency programme.

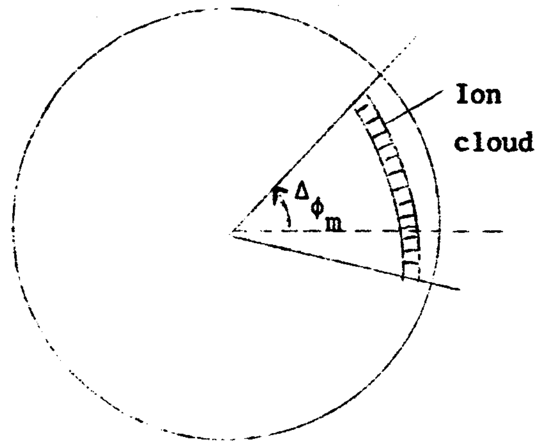


Fig. 9

The occurrence of phase oscillations is a characteristic of frequency modulated accelerators. The phenomenon was first studied in the design of synchrotrons and phase oscillations are often called "synchrotron oscillations".

They influence the characteristics of the beam of a synchro-cyclotron in several ways.

(1) The bunch of phase stable particles is a sausage-shaped ion cloud, which is restricted to a fraction $\Delta\phi_m/\pi$ of the perimeter.

(2) Unlike the betatron oscillations the phase oscillations introduce an energy spread in the beam. For a phase oscillation amplitude $\Delta\phi_m$ the spread in particle energy is given by

$$\frac{\Delta E}{(E + m_o)} = \Delta\phi \left(\frac{eV_m \cos \phi_o}{2\pi K(E + m_o)} \right)^{1/2} \tag{29}$$

where K is given by (28).

(3) The energy spread leads to a radial spread

$$\frac{\Delta r}{r} = \frac{\Delta\phi}{(1 - n)\beta^2} \left(\frac{eV_m \cos \phi_o}{2\pi U} \right)^{1/2} . \tag{30}$$

During a phase oscillation cycle a particle therefore varies both its azimuthal and radial position with respect to the equilibrium particle. With $eV_m \cos \phi_o \cong 10$ keV we find $\Delta E \cong 2$ MeV and $\Delta r \cong 5$ mm at 200 cm radius in the SC. The energy spread due to synchrotron oscillations is therefore about 4 MeV. The radial spread is seen to be small compared to that due to betatron oscillations.

2.5 Targeting and Duty Cycle

For pion production the synchro-cyclotron is frequently used with an internal target. Such a target is placed at the largest radius compatible with stability and at an azimuth which is chosen so that particles of selected momenta pass down certain beam channels after deflection in the fringing field of the machine.

Details about the momenta selected by the different meson channels and the corresponding target positions are given in section II 4.

The interaction of the circulating ions with the target is largely governed by the betatron oscillation phenomena. The radial velocity due to the acceleration is given by

$$\frac{dr}{dt} = - \frac{r}{f_o(n + (1 - n)\,\beta^2)} \cdot \frac{df_c}{dt} \qquad (31)$$

where f_o is the cyclotron frequency, r the radius of the equilibrium orbit and βc the velocity of the ions. df_o/dt is given by the frequency programme.

The data listed in section B 7 for r = 224 cm and a field excitation of 1.9 kA show n = 0.094 and f_c = 16.89 Mc/s. At this frequency $df_c/dt = 1.33 \times 10^9$ cycles/s^2, giving a radial velocity of about 2.65×10^4 cm/s or a radial gain per turn of 1.6×10^{-3} cm. So the outward movement per cycle is very small compared with a radial oscillation amplitude of a few centimetres.

As a result the first particles to strike the inner edge of the target are those having the largest radial oscillation amplitude, and they strike the target tangentially when they have their maximum outward displacement.

At $n = 0.2$ the azimuth of this maximum displacement moves around the circumference once in about 11 orbital periods. During this period the equilibrium radius increases by about 0.2 mm. Particles just having missed the inner edge of target will therefore at most reach that distance beyond it.

Unless a particle undergoes a nuclear interaction in the target it will emerge after an ionization loss of a few MeV. In addition it is subject to multiple scattering; this will normally change the amplitude and phase of its betatron oscillations. It follows a slightly eccentric orbit and after a number of revolutions once more strikes the target. This process is repeated until the multiple scattering angle becomes so large that the particle hits one of the defining apertures or undergoes a large-angle nuclear scatter.

Thanks to these "multiple traversals" the target length traversed is largely independent of its thickness. The effect is increased by efficient vertical focusing and targets are therefore preferably placed at the largest usable n value.

A 600 MeV proton striking a 1 cm Be target may make 10 - 20 traversals, requiring 100 - 200 revolutions and may therefore produce secondaries for a few microseconds after its first impact.

However, the burst length is determined by the dimensions of the ion cloud rather than the behaviour of individual particles. With a typical half width at half height of about 5 cm and a radial velocity of 2.6×10^4 cm/sec the entire cloud traverses the target in about 200 μsec.

With a period of 18 msec the ratio of burst length to burst separation, i.e. the duty cycle, is therefore of the order of 1%. This is reduced further by the limited RF phase angle available for phase stability and the overall duty cycle is therefore less than 0.5%.

From the point of view of many experiments this is a severe handicap, but successful attempts have been made to overcome it and to lengthen the ejection time, e.g. by employing a vibrating target (see Section II4) or by the installation of a second radio-frequency system providing a slow acceleration at the end of the cycle (see Section B 3). With these devices duty cycles in excess of 30% have been achieved.

- - - - - - - - - -

For more detailed accounts of the topics discussed here see e.g.

Segre, Experimental Nuclear Physics, Wiley, 1959, Vol. III, Part XII, Article by E.M. McMillan.

M.S. Livingston, High Energy Accelerators, Interscience Tracts on Physics and Astronomy, No. 2, 1954, p. 60.

M.S. Livingston and J.P. Blewett, Particle Accelerators, McGraw Hill, 1962, p. 351.

B.L. Cohen, Cyclotrons and Synchrocyclotrons, Encyclopaedia of Physics, Springer, 1959, Vol. 44, p. 105.

R. Kollath, Teilchenbeschlenniger, Vieweg, 1962.

III SREL CYCLOTRON BEAMS

1. Beam Transport Identification Code

2. Beam Descriptions

3. "External Beam Current Measurements on the Synchrocyclotron", L. W. Swenson and W. H. Hendrick, SREL Internal Report SC-1

BEAM TRANSPORT IDENTIFICATION

Magnet Type	Description	Identification Nos.
H 18 x 36	Bending Magnet - 18" x 36" pole area 6" gap - H yoke	M4, M5, M6, M7 M8X (9" gap)
	Steering Magnet - 9" x 15" pole - C yoke	M1
	Bending Magnet - 9" x 15" pole area - H yoke	M2, M3
8 x 24 Q	Quadrupole Singlet 8" bore x 24" yoke	Q1, Q2, Q3, Q4, Q5, Q6, Q9, Q10, Q13, Q14, Q15, Q16, Q18, Q21, Q22, Q25, Q26
8 x 16 Q	Quadrupole Singlet 8" bore x 16" yoke	Q1A, Q2A, Q7, Q8, Q11, Q12, Q19, Q20, Q23, Q24
	Quadrupole Singlet 12" bore x 12" yoke	Q28X, Q29X

Bending Magnets M1 - M7 are included in proton Transport System

Quadrupole Magnets Q1 - Q26 are included in proton Transport System

BEAM DESCRIPTIONS

The following pages include descriptions of beams used at the SREL cyclotron by various experimental groups. Each group is asked to fill out a three-page form containing information on the various parameters associated with their beam set-up. The completed forms are compared with those for the established beams listed in this section, and if the parameters are sufficiently different from those of established beams, a new beam designation will be assigned, and the appropriate information added to this section.

The Beam Number designations indicate the primary particle of interest, i.e., CM = Cyclotron Meson, CP = Cyclotron Proton, etc.

In the Proton Transport Settings (Item 10 of each Beam Description), the following conversion table should be used to give the current in amperes from the listed shunt readings:

Power Supply	
P.S. #1 thru #6:	6 amps/MV
P.S. #7 thru #9:	4 amps/MV
P.S. #10 thru #12:	5 amps/MV
P.S. #13 thru #20:	3 amps/MV

SUMMARY OF CYCLOTRON BEAM DESCRIPTIONS

Beam No.	Description	Intensity
CM-1	200 MeV/c π^- - Vibrating Target	Maximum
CM-2	" " "	Maximum
CM-3	" π^+ " "	Maximum
CM-4	200 MeV/c π^- - Harp Target	Maximum
CM-5	176 MeV/c π^+ - Harp Target	Maximum
CM-6	165 MeV/c π^+ - Internal Target (replaces beam CM-5)	Maximum
CM-7	Backwards (100 MeV/c) μ^- from Muon Channel	Maximum
CP-1	600 MeV proton	Low
CP-2	"	Maximum
CP-3	500 MeV proton	Maximum
CP-4	400 MeV proton	Maximum
CP-5A	600 MeV - Calibration Beam - Proton	Very Low
CP-5B	500 MeV - Calibration Beam - Proton	Very Low
CP-5C	400 MeV - Calibration Beam - Proton	Very Low
CP-5D	300 MeV - Calibration Beam - Proton	Very Low
CP-5E	320 MeV - Calibration Beam - Proton	Very Low
CP-5F	200 MeV - Calibration Beam - Proton	Very Low
CP-5G - 5P	159, 105, 79, 74, 64, 54, 48, 41, 35 MeV - Calibration Beam - Proton	Very Low
CP-6	129 MeV Protons - degraded from 300 MeV	Maximum
CP-7	600 MeV protons - POLARIZED	Maximum
CP-8	300 MeV protons with 300 MeV Platter	Maximum

Beam No. [illegible]

SREL CYCLOTRON BEAM INFORMATION

1. Expt. No. IO-107 Date 10/31/67 Signed Minehart

2. Particle: Proton____, π^+____, π^- X , Neutron____, Other____

3. Nominal Beam Energy: 100 Mev

4. Area: CTA____, PTA____, MA X ; Platter 300____, 600____, Aux. X

5. Degrader: BD-1____, BD-2____, Copper____Inches; Regenerator Position____

6. Main Magnet: N____, R X , Shunt____mv

7. Diverter: ±____amp on shunt; ____amp on meter

8. Internal Beam Intensity: ____on Monitor____, 4 mv. on TC Flip

9. External Beam Intensity: ____on Monitor____, ____on Monitor____, ____on Monitor____, ____on Monitor____, ____on Monitor____.

10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
	17			
	18			
	19			
	20			

11. Internal Target Information
Radius Motor Reading 2.2[illegible] Radius [illegible] inches
Azimuth Motor Reading [illegible] Azimuth [illegible]
Description of Target Vibrating Target

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used	M3 X	Q29 X	Q28 X	
Position*	34'	11'5 3/8"	13' 1 3/8"	
Bending Angle *	60°			
Current (Amp)	150	125	127	
Polarity**	+	D	F	

*Measured from center line of cyclotron to some convenient reference point.
**For bending magnets indicate field + or -; for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details
a. Central Momentum 200MeV/c Peak Intensity: 280,000/sec ({12} rate with 5"x5" counters)
Width of Magnet Curve: 10 %
b. Defining Apertures in Shielding (Position, Size)
None

c. Range Information
Slowing Down Material: CH_2
Stopping Material: Li^7
Stopper Dimensions: 4"x4" & 7.4 cms
Range Data:

Particle	π^-		
Peak Range CH_2 equiv.	28.9 gm/cm^2		
FWHM			
Maximum Stopping Rate	80 per gm/sec		

13. Beam Details Continued

d. Other characteristics - beam profile if known (give position at which measured); whether parallel, convergent (give focal position), or divergent, with details.

An He-filled bag from the thin meson window through the quadrupoles, wall, and bender increased the intensities quoted above by ≈ 20%

14. Draw a layout of your set-up, showing magnets, blockhouse, shielding, counters, etc. Give distances from fiducial marks on walls, dimensions, etc.

15. Comments:

Beam No. CM-2

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. TC-113 Date 11-9-67 Signed John Kane
2. Particle: Proton____, π^+____, π^- X , Neutron____, Other____
3. Nominal Beam Energy: 200 Mev/c
4. Area: CTA____, PTA____, NM X ; Platter 300____, 600 X , Aux.____
5. Degrader: BD-1____, BD-2____, Copper____ Inches; Regenerater Position Full Out
6. Main Magnet: N____, R X , Shunt 73.53mv
7. Diverter: @17.87 ~~amp~~ mv on shunt; 31 amp on meter
8. Internal Beam Intensity: ____on Monitor____, 3.4 mv. on TC Flip
9. External Beam Intensity: ____on Monitor____, ____on Monitor____, ____on Monitor____, ____on Monitor____, ____on Monitor____.
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
	17			
	18			
	19			
	20			

11. Internal Target Information
 Radius Meter Reading 1.55 Radius 87.2 inches
 Azimuth Meter Reading 9.25 Azimuth 2° W inches
 Description of Target Vibrating Beryllium Target
 Amplitude = .82 MA Bias = 0.0

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used	Q 28X	Q 29X	M 8X	
Position*	In Quad	Out Quad	Bender	
Bending Angle				
Current (Amp)	130	100	152	
Polarity**	F	D	+	
Helipot:	2.80	2.20	2.975	

*Measured from center line of cyclotron to some convenient reference point.

**For bending magnets indicate field + or -: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details
 a. Central Momentum 200 Mev/c Peak Intensity: 590 K/sec
 Width of Magnet Curve: 10 %
 b. Defining Apertures in Shielding (Position, Size)
 1. 5"x6" monitored hole in shielding blocks
 2. 4"x4" hole in lead collimator 10" from shielding blocks
 c. Range Information
 Slowing Down Material: Polyethylene
 Stopping Material: Liquid Helium and Stainless Steel
 Stopper Dimensions: 6" right cylinder - Liquid Helium
 Range Data:

Particle	π^-	μ^-	
Peak Range Polyethylene	5 3/4"	10"	*
FWHM	2 1/2"	(2-3)"	
Maximum Stopping Rate	52 K/sec	4 K/sec	

* In addition to the listed range there was 2" of H_2O and 1 gm/cm^2 of stainless steel in the beam.

S/3/1

Beam No. CM - 3

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. TC 105 Date 10/2/67 Signed T. Witten
2. Particle: Proton____, π^+ X , π^- ____, Neutron____, Other____
3. Nominal Beam Energy: 100 Mev π^+ Beam
4. Area: CTA____, PTA____, NM X ; Platter 300____, 600 X , Aux.____
5. Degrader: BD-1____, BD-2____, Copper____Inches; Regenerator Position Full Out
6. Main Magnet: N X , R____, Shunt____mv
7. Diverter: ⊕ 12.59 amp on shunt; 17.5 amp on meter
8. Internal Beam Intensity: ____on Monitor____, ____mv. on TC Flip
9. External Beam Intensity: ____on Monitor____, ____on Monitor____, ____on Monitor____, ____on Monitor____, ____on Monitor____.
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
	17			
	18			
	19			
	20			

11. Internal Target Information
Radius Meter Reading 1.93 Radius 87 inches
Azimuth Meter Reading 9.53 Azimuth 1° W inches
Description of Target Vibrating Beryllium Target

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used	Q 28X	Q 29X	M 8X	
Position*	Normal	Normal	Normal	
Bending Angle			60°	
Current (Amp)	130	100		
Polarity**			↑	

Helipot setting 3.00
*Measured from center line of cyclotron to some convenient reference point.
**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details
a. Central Momentum 200 Mev/c Peak Intensity: 20 K/sec
Width of Magnet Curve: ______ %
b. Defining Apertures in Shielding (Position, Size)
9" x 9" Aperture after M 8X

c. Range Information
Slowing Down Material: CH_2
Stopping Material: Aluminium
Stopper Dimensions: 0.25"
Range Data:

Particle	π^+	μ^+	
Peak Range	11.25"	16" CH_2	
FWHM	~ 7" 10 Mev	≈2.50"	
Maximum Stopping Rate	2.5 K/sec	400/sec	

13. Beam Details Continued

d. Other characteristics - beam profile if known (give position at which measured); whether paralle, convergent (give focal position), or divergent, with details.

Beam contained 25% muons and 1% positrons.

14. Draw a layout of your set-up, showing magnets, blockhouse, shielding, counters, etc. Give distances from fiducial marks on walls, dimensions, etc.

15. Comments:

Beam No. CM-4

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. IC 104 Date 2-9-68 Signed D. Jenkins
2. Particle: Proton ____, π^+ ____, π^- X, Neutron ____, Other ____
3. Nominal Beam Energy: 100 MeV
4. Area: CTA ____, PTA ____, NM ____; Platter 300 ____, 600 ____, Aux. X
5. Degrader: BD-1 ____, BD-2 ____, Copper ____ Inches; Regenerater Position ____
6. Main Magnet: N ____, R X, Shunt 74 mv
7. Diverter: ±20.43 amp on shunt; -40 amp on meter
8. Internal Beam Intensity: ____ on Monitor ____, 2.8 mv. on TC Flip #3
9. External Beam Intensity: ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____.
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
	17			
	18			
	19			
	20			

BEAM NO. CM-4

11. Internal Target Information

Radius Meter Reading 1.18 Radius 86.1 inches

Azimuth Meter Reading 5.70 Azimuth 1° East

Description of Target Harp with Be Blocks

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used	M8X	Q28x	Q29x	
Position*	normal	normal	normal	
Bending Angle				
Current (Amp)	150	140	100	
Polarity**	↓	F	D	
Helipot Setting	7.72	3.10	2.55	

*Measured from center line of cyclotron to some convenient reference point.

**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details

a. Central Momentum: 200MeV/C Peak Intensity: 115 stops/gm-sec

Width of Magnet Curve: ______ %

b. Defining Apertures in Shielding (Position, Size)

c. Range Information

Slowing Down Material: CH_2

Stopping Material: Na, CH_2

Stopper Dimensions: 6" X 6"

Range Data:

Particle	π^-	μ^-	
Peak Range	≈7"	11 1/2"	
FWHM	2 1/2"	≈3"	
Maximum Stopping Rate	120/gm-sec	20/gm-sec	

Range and FWHM given in terms of CH

13. Beam Details Continued

    d. Other characteristics - beam profile.if known (give position at which measured); whether paralle, convergent (give focal position), or divergent, with details.

14. Draw a layout of your set-up, showing magnets, blockhouse, shielding, counters, etc. Give distances from fiducial marks on walls, dimensions, etc.

15. Comments:

Beam No. CM-5

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. 105 Date 3-17-68 Signed K. Gotow
2. Particle: Proton____, π^+ X, π^-____, Neutron____, Other____
3. Nominal Beam Energy: 86 MeV
4. Area: CTA____, PTA____, NM X; Platter 300____, 600 X, Aux.____
5. Degrader: BD-1____, BD-2____, Copper____Inches; Regenerater Position____
6. Main Magnet: N 493V, R____, Shunt 72.70 mv
7. Diverter: (+) 14 amp on shunt; +9.70 amp on meter
8. Internal Beam Intensity: ____on Monitor____, 2.8 mv. on TC Flip
9. External Beam Intensity: ____on Monitor____, ____on Monitor____, 30K/sec. max. 4" x 8" scin.
____on Monitor____, ____on Monitor____, ____on Monitor____.
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
	17			
	18			
	19			
	20			

11. Internal Target Information
Radius Meter Reading 1.6 Radius 87.5 Inches
Azimuth Meter Reading 5.55 Azimuth 0° [illegible]
Description of Target Harp

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used	Q28X	Q29X	M8X	
Position*				
Bending Angle				
Current (Amp)	130	100	400	
Polarity**				

*Measured from center line of cyclotron to some convenient reference point.
**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

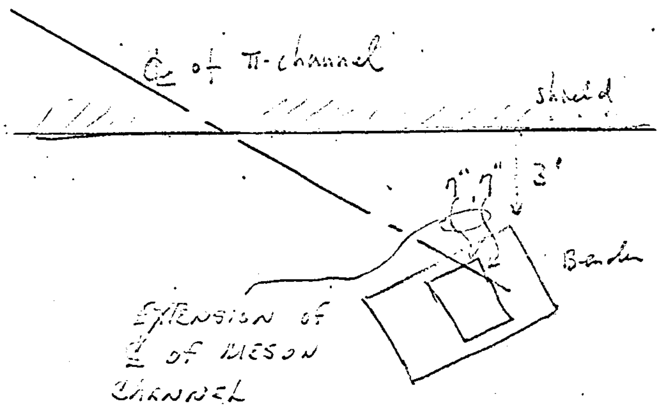
13. Beam Details
a. Central Momentum: 176mev/c Peak Intensity: 48K/sec
Width of Magnet Curve: 11.5 % (FWHM)
b. Defining Apertures in Shielding (Position, Size)
The above were measured with an 8" x 8" defining counter approximately 6' away from the bender
c. Range Information
Slowing Down Material: Al.
Stopping Material: cu (1/32")
Stopper Dimensions: 12" x 12"
Range Data:

Particle	π+			
Peak Range (Al. equiv.)	27.4			gm/cm^2
FWHM (Al. equiv.)	±0.3"			(±5MeV)
Maximum Stopping Rate				

13. Beam Details Continued

d. Other characteristics - beam profile if known (give position at which measured); whether parallel, convergent (give focal position), or divergent, with details.

14. Draw a layout of your set-up, showing magnets, blockhouse, shielding, counters, etc. Give distances from fiducial marks on walls, dimensions, etc.



The bender position for this experiment.

15. Comments:

Replaces Beam CM-5 S/3/1

Beam No. CM-6

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. IC-105 Date Dec. 30, 1968 Signed K. Gotow

2. Particle: Proton ____, π^+ X, π^- ____, Neutron ____, Other ____

3. Nominal Beam Energy: 165 Mev/C

4. Area: CTA ____, PTA ____, NM A-1; Platter 300 ____, 600 X, Aux. ____

5. Degrader: BD-1 ____, BD-2 ____, Copper ____ Inches; Regenerater Position out

6. Main Magnet: N X, R ____, Shunt +73.30 mv

7. Diverter: +17.31mu amp on shunt; +25 amp on meter

8. Internal Beam Intensity: ____ on Monitor ____, 7.6 mv. on TC Flip #3 (0.3 μα/mv)

9. External Beam Intensity: ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____.

10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
	1			
M6	2	17.66		
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
	17			
	18			
	19			
	20			

11. Internal Target Information

Radius Meter Reading ________ Radius 85 inches

Azimuth Meter Reading ________ Azimuth 3.5°W inches

Description of Target Vibrating target

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used	Q in	Q out	M6	π-Bender (M8X)
Position*	Normal	radius in	the center line	of channel
Bending Angle			60°	45°
Current (Amp)	60 amp	60 amp	17.65 mv	300 amp
Polarity**	VF	VD	↑	↑

*Measured from center line of cyclotron to some convenient reference point.

**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details

a. Central Momentum: 186 Mev/c ↑ Peak Intensity: 100 k/sec

Width of Magnet Curve: ± 11%

b. Defining Apertures In Shielding (Position, Size)

8" X 8" counters at 25" from the 1st bender pole edge.

c. Range Information (at S_2 see next page)

Slowing Down Material: Copper

Stopping Material: 1/2" Scintillator

Stopper Dimensions: 8 X 8 (S_2 counter, see page 3)

Range Data:

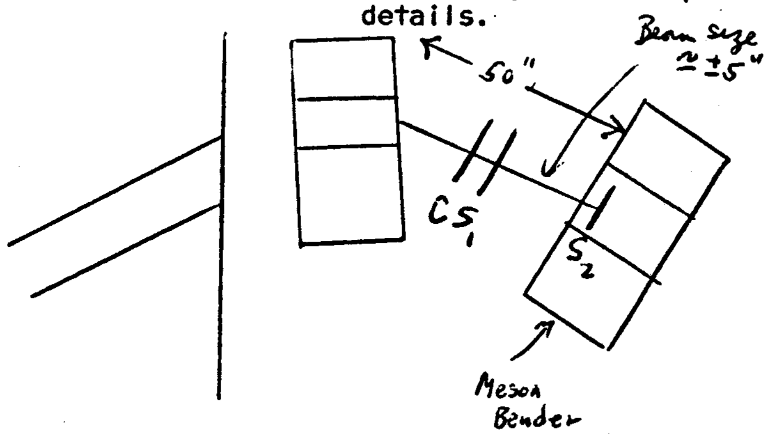
Particle	π^+	μ^+	e^+
Peak Range	1 1/8"	1 7/8"	
FWHM	≈1/4"	1/4"	
Maximum Stopping Rate			

Intensity: $\pi^+ : \mu^+ = e^+ = 1:0.5 : 0.17$

$E\pi$ = 83 Mev

13. Beam Details Continued

d. Other characteristics - beam profile if known (give position at which measured); whether paralle, convergent (give focal position), or divergent, with details.



RATES:

$S_1C \simeq 100^k$/sec

$S_1C\ S_2 \simeq 50^k$/sec

C_2S_1=8" X 8"

S_2=6" X 6"

14. Draw a layout of your set-up, showing magnets, blockhouse, shielding, counters, etc. Give distances from fiducial marks on walls, dimensions, etc.

15. Comments:

In this experiment the 165 Mev/c beam was used with a smaller radial position of the target, Hence a higher beam momentum was obtained, which was required for this experiment.

Beam No. CM-7

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. IC-104 Date Jan. 7, 1969 Signed D. Jenkins
2. Particle: Proton ____, π^+ ____, π^- ____, Neutron ____, Other Muon
3. Nominal Beam Energy: Stopping (Backward decay)
4. Area: CTA ____, PTA ____, NM ____; Platter 300 ____, 600 X, Aux. ____
5. Degrader: BD-1 ____, BD-2 ____, Copper ____ Inches; Regenerater Position Full Out
6. Main Magnet: N X, R ____, Shunt 73.48 ↑ mv
7. Diverter: +19,90 mu ↑ amp on shunt; + 30 amp on meter
8. Internal Beam Intensity: ____ on Monitor ____, 6.8 mv. on TC Flip #3 (.3 μa/mu
9. External Beam Intensity: ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____.
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
	17			
	18			
	19			
	20			

11. Internal Target Information

Radius Meter Reading 1.5 Radius ________ inches

Azimuth Meter Reading 6.47 Azimuth ________ inches

Description of Target Vibrating target, DC=0 AC=22-25

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used	Channel	A	B	Bend
Position*				
Bending Angle				
Current (Amp)	1500	950	1275	2.20 on dial
Polarity**				

*Measured from center line of cyclotron to some convenient reference point.

**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details

a. Central Momentum: 100 Mev/c ↑ Peak Intensity: ________

Width of Magnet Curve: ________ %

b. Defining Apertures in Shielding (Position, Size)

6" X 6" Collimator after bending magnet

c. Range Information

Slowing Down Material: CH_2

Stopping Material: ZnO

Stopper Dimensions: 9" X 9"

Range Data:

Particle	μ		
Peak Range	≃4"CH_2		
FWHM	1 1/2"	CH_2	
Maximum Stopping Rate	≃150/gm-sec		

13. Beam Details Continued

d. Other characteristics - beam profile if known (give position at which measured); whether paralle, convergent (give focal position), or divergent, with details.

The magnetic field in the bending magnet was adjusted so that we looked at muons which decayed in the backward direction.

14. Draw a layout of your set-up, showing magnets, blockhouse, shielding, counters, etc. Give distances from fiducial marks on walls, dimensions, etc.

The muon channel was used.

15. Comments:

Run 12/11/68 - 12/20/68

Beam No. CP - 1

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. IC-110 Date 10/20/67 Signed C. Perdrisat
2. Particle: Proton X , π^+ ____, π^- ____, Neutron ____, Other ____
3. Nominal Beam Energy: 600 MeV - Low Intensity (10^7-10^8/sec)
4. Area: CTA ____, PTA X , NM ____; Platter 300 ____, 600 X , Aux. ____
5. Degrader: BD-1 ____, BD-2 ____, Copper ____ Inches; Regenerator Position IN
6. Main Magnet: N X , R ____, Shunt 74.04mv
7. Diverter: ± ____ amp on shunt; ____ amp on meter
8. Internal Beam Intensity: ____ on Monitor ____, ____ mv. on TC Flip
9. External Beam Intensity: 22×10^{-9} on Monitor 1 2.2×10^{-9} on Monitor 5 , ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____.
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
M2/M3	1	43.64	260	N
M6	2	50.02	300	N
M7	3	48.58	294	N
Q1A/Q2A	4	27.03	162	N
Q 17	5	31.26	186	N
Q 3	6	23.30	138	N
Q2/Q4	7	35.85	145	N
Q18/Q22	8	56.22	224	N
Q15/Q16	9	45.80	188	N
Q 1	10	35.92	180	N
Q 19	11	68.79	344	N
Q 20	12	64.50	324	N
Q 5	13	59.28	177	N
Q 6	14	53.61	164	N
Q 21	15	74.84	224	N
Q 23	16	58.39	178	N
Q 24	17	81.18	243	N
Q 25	18	68.92	207	N
Q 26	19	53.90	162	N
M 1	20	2.26	6	N

13. Beam Details Continued

d. Other characteristics - beam profile if known (give position at which measured); whether parallel, convergent (give focal position), or divergent, with details.

Horizontal FWHM ≈ 1"

Vertical FWHM ≈ 1.5"

Very slightly divergent over ≈ 10 feet distance

R.F. Beam pulse width 40-100 μsec

Beam energy from Cerenkov measurement

$E = 594.8 \pm 1.5$ Mev (measured on similar beam in combined target area)

ΔE (FWHM) = 8.5 Mev

14. Draw a layout of your set-up, showing magnets, blockhouse, shielding, counters, etc. Give distances from fiducial marks on walls, dimensions, etc.

15. Comments:

Beam No. CP - 2

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC 107 Date 10/18/67 Signed J. Cline
2. Particle: Proton X , π^+ ____, π^- ____, Neutron ____, Other ____
3. Nominal Beam Energy: 600 Mev - Full Intensity
4. Area: CTA ____, PTA X , NM ____; Platter 300 ____, 600 X , Aux. ____
5. Degrader: BD-1 ____, BD-2 ____, Copper ____ inches; Regenerator Position IN
6. Main Magnet: N X , R ____, Shunt 73.52 mv
7. Diverter: $\pm$ ____ amp on shunt; ____ amp on meter
8. Internal Beam Intensity: ____ on Monitor ____, ____ mv. on TC Flip
9. External Beam Intensity: $5x10^{-6}$ on Monitor 1 , $3.2x10^{-6}$ on Monitor 5 , ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____. (Cf. item 13)
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
M2/M3	1	43.67	262	N
M 6	2	50.07	300	N
M 7	3	50.85	305	N
Q1A/Q2A	4	27.02	162	N
Q 17	5	31.28	186	N
Q 3	6	23.32	140	N
Q2/Q4	7	35.85	143	N
Q18/Q22	8	56.24	225	N
Q15/Q16	9	45.80	185	N
Q 1	10	35.93	180	N
Q 19	11	68.81	345	N
Q 20	12	64.55	325	N
Q 5	13	59.29	177	N
Q 6	14	53.66	162	N
Q 21	15	74.84	222	N
Q 23	16	58.41	174	N
Q 24	17	81.14	242	N
Q 25	18	68.90	207	N
Q 26	19	53.90	162	N
M 1	20	2.25	6	N

11. Internal Target Information

Radius Meter Reading________ Radius________ Inches

Azimuth Meter Reading________ Azimuth________ Inches

Description of Target________________________

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used				
Position*				
Bending Angle				
Current (Amp)				
Polarity**				

*Measured from center line of cyclotron to some convenient reference point.

**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details

a. Central Momentum:________ Peak Intensity: (1.75 - 2) x 10" protons/sec

Width of Magnet Curve: ________ % with BM-5 at 4.5 x 10^{-5}

b. Defining Apertures in Shielding (Position, Size)

____

____

c. Range Information

Slowing Down Material: ________________

Stopping Material: ________________

Stopper Dimensions: ________________

Range Data:

Particle			
Peak Range			
FWHM			
Maximum Stopping Rate			

13. Beam Details Continued

d. Other characteristics - beam profile if known (give position at which measured); whether paralle, convergent (give focal position), or divergent, with details.

Profile presumably similar to that of Beam CP-1

14. Draw a layout of your set-up, showing magnets, blockhouse, shielding, counters, etc. Give distances from fiducial marks on walls, dimensions, etc.

15. Comments:

Beam No. CP - 3

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC 107 Date 10/19/67 Signed J. Cline
2. Particle: Proton X , π^+ ___ , π^- ___ , Neutron ___ , Other ___
3. Nominal Beam Energy: 500 Mev
4. Area: CVA ___ , PTA X , NM ___ ; Platter 300 ___ , 600 X , Aux. ___
5. Degrader: BD-1 X , BD-2 ___ , Copper 2.5 inches; Regenerator Position IN
6. Main Magnet: N X , R ___ , Shunt 73.48mv
7. Diverter: $\pm$ ___ amp on shunt; ___ amp on meter
8. Internal Beam Intensity: ___ on Monitor ___ , ___ mv. on TC Flip
9. External Beam Intensity: 7.8×10^{5} on Monitor 1 , ___ on Monitor ___ , ___ on Monitor ___ , ___ on Monitor ___ , ___ on Monitor ___ .
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
M2/M3	1	42.83	258	N
M 6	2	42.88	258	N
M 7	3	43.24	258	N
Q1A/Q2A	4	15.55	96	N
Q 17	5	50.20	300	N
Q 3	6	18.16	108	N
Q2/Q4	7	13.49	52	N
Q18/Q22	8	48.47	192	N
Q15/Q16	9	25.88	104	N
Q 1	10	21.92	110	N
Q 19	11	33.11	165	N
Q 20	12	34.15	170	N
Q 5	13	53.83	162	N
Q 6	14	44.49	132	N
Q 21	15	83.22	249	N
Q 23	16	22.51	69	N
Q 24	17	33.27	99	N
Q 25	18	65.68	198	N
Q 26	19	59.85	180	N
M 1	20	10.88	33	N

This page includes all presently available information on beam CP - 3

Beam No. CP - 4

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC 107 Date 10/20/67 Signed J. Cline
2. Particle: Proton X , π^+ ____, π^- ____, Neutron ____, Other ____
3. Nominal Beam Energy: 400 Mev
4. Area: CTA ____, PTA X , NM ____; Platter 300 ____, 600 X , Aux. ____
5. Degrader: BD-1 X , BD-2 ____, Copper 4.75 inches; Regenerator Position IN
6. Main Magnet: N X , R ____, Shunt 73.3mv
7. Diverter: $\pm$ ____ amp on shunt; ____ amp on meter
8. Internal Beam Intensity: 8×10^{-6} on Monitor 1 , ____ mv. on TC Flip
9. External Beam Intensity: ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____.
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
M2/M3	1	43.13	258	N
M 5	2	37.08	222	N
M 7	3	37.49	222	N
Q1A/Q2A	4	15.63	96	N
Q 17	5	25.53	150	N
Q 3	6	18.70	118	N
Q2/Q4	7	15.91	64	N
Q18/Q22	8	43.13	172	N
Q15/Q16	9	19.95	80	N
Q 1	10	21.81	110	N
Q 19	11	67.95	340	N
Q 20	12	75.39	374	N
Q 5	13	59.45	177	N
Q 6	14	44.14	132	N
Q 21	15	37.20	111	N
Q 23	16	30.47	90	N
Q 24	17	1.0	3	N
Q 25	18	18.54	57	N
Q 26	19	45.58	138	N
M 1	20	11.40	33	N

This page includes all presently available information on beam CP - 4

Beams CP-5A- - -CP-5P are all very low intensity proton beams delivered to Proton Target Area for calibration of detectors.

S/3/1

Beam No. CP-5A

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC-105 Date 1/8/68 Signed R.J. Kurz
2. Particle: Proton X, π^+ ____, π^- ____, Neutron ____, Other ____
3. Nominal Beam Energy: 600 MeV
4. Area: CTA ____, PTA X, NM ____; Platter 300 ____, 600 X, Aux. ____
5. Degrader: BD-1 X, BD-2 ____, Copper 0 Inches; Regenerater Position Full In
6. Main Magnet: N X, R ____, Shunt 74.00mv
7. Diverter: (+)-9.15 amp on shunt; ____ amp on meter
8. Internal Beam Intensity: ____ on Monitor ____, ____ mv. on TC Flip
   1x10-10 to 1x10-8 on BM3
9. External Beam Intensity: ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____.
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
M2/M3	1	43.68		N
~~M6~~	2	48.90		N
M7	3	48.90		N
Q1A/Q2A	4	27.05		N
Q17	5	11.99		N
Q3	6	23.34		N
Q2/Q4	7	Shunt 35.84/21.80		N
Q18/Disconnected Q22	8	~~21.43~~		N
OFF	9	-		-
Q1	10	35.92		N
OFF	11	-		-
OFF	12	-		-
OFF	13	-		-
OFF	14	-		-
"	15	-		-
"	16	-		-
"	17	-		-
Q25	18	65.86		N
Q26	19	66.05		N
M1	20	2.27		N

Beam No. CP-5A

11. Internal Target Information

Radius Meter Reading ________ Radius ________ inches
Azimuth Meter Reading ________ Azimuth ________ inches
Description of Target ________________________________

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used				
Position*				
Bending Angle				
Current (Amp)				
Polarity**				

*Measured from center line of cyclotron to some convenient reference point.
**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details

a. Central ~~Momentum~~ Energy 585MeV Peak Intensity: 3000/sec. in 1/2"diam. BM3 @4.0x10^{-9}A.

Width of ~~Magnet~~ Range Curve: 20 MeV

b. Defining Apertures in Shielding (Position, Size)

1" wide x 4" high lead collimator in front of BM3

BC2 Collimator; Left 8.0, Right 10.5, Top 13.5, Bottom 11.5

c. Range Information: Integral

Slowing Down Material: Copper

Stopping Material: -

Stopper Dimensions: -

Range Data:

Particle	P^+		
Peak Range	9.40"		
FWHM	0.4"		
Maximum Stopping Rate	-		

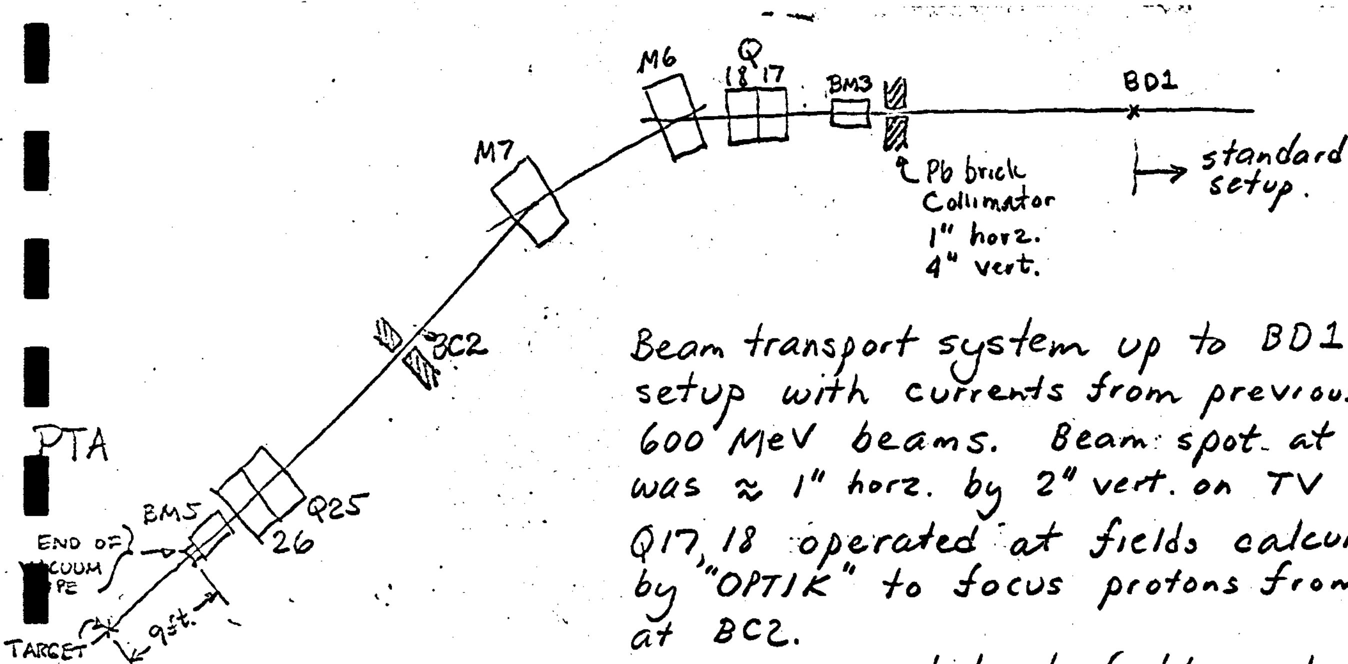
13. Beam Details Continued

d. Other characteristics - beam profile if known (give position at which measured); whether paralle, convergent (give focal position), or divergent, with details.

NOTE: The following information was obtained for beam CP-5E, but is assumed to be valid for all beams in this CP-5 series. Polaroid Picture: 9 ft. from end of vacuum pipe 30 minute exposure at maximum intensity

Horizontal FWHM - 1/2"
Vertical FWHM - 1"
Vertical Center - 1/2" below beam setup line which was established by level transit from center of end of beam vacuum pipe.

14. Draw a layout of your set-up, showing magnets, blockhouse, shielding, counters, etc. Give distances from fiducial marks on walls, dimensions, etc.



Beam transport system up to BD1 was setup with currents from previous 600 MeV beams. Beam spot at BM2 was ≈ 1" horz. by 2" vert. on TV

Q17, 18 operated at fields calculated by "OPTIK" to focus protons from BD1 at BC2.

Q25,26 operated at fields calculated by "OPTIK" to focus protons from BC2 at TARGET.

M6 and M7 fields were equal and adjusted to maximize intensity at TARGET with no degrader at BD1. For degraded beams M6 and M7 fields were scaled by momentum.*

15. Comments:

*For degraded beams BD1 adjusted to maximize intensity at TARGET after M6 and M7 were set.

Calculated properties of beam system after BD1

Position	Horiz. Magnification	Vert. Mag.	Dispersion ($\Delta X/\Delta p/p$)
BC2	-.57	-.48	224.7 inches
TARGET	+.27	+.99	-105.9 inches

cf Beam CP-5A

S/3/1

Beam No. CP-5B

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC105 Date 1/8/68 Signed R.J. Kurz

2. Particle: Proton X, π^+ ___, π^- ___, Neutron ___, Other ___

3. Nominal Beam Energy: 500 MeV

4. Area: CTA ___, PTA X, NM ___; Platter 300 ___, 600 X, Aux. ___

5. Degrader: BD-1 X, BD-2 ___, Copper 1.5 inches; Regenerater Position ___
   +87 dial on No. 1 wedge

6. Main Magnet: N X, R74.00, Shunt ___ mv see 600 MeV

7. Diverter: (+) 9.15 amp on shunt; ___ amp on meter "

8. Internal Beam Intensity: ___ on Monitor ___, ___ mv. on TC Flip

9. External Beam Intensity: ___ on Monitor ___, ___ on Monitor ___, ___ on Monitor ___, ___ on Monitor ___, ___ on Monitor ___.
   See 600 MeV

10. Proton Transport Magnet Settings See Beam CP-5A for magnets up to BD1

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
M2/M3	1	43.68		N
M6	2	44.60		N
M7	3	44.60		N
Q1A/Q2A	4	27.05		N
Q17	5	10.74		N
Q3	6	23.34		N
Q2/Q4	7	35.84/21.80 shunt		N
Q18/ Q22 ~~Disconnected~~	8	19.17		N
OFF	9	-		-
Q1	10	35.92		N
OFF	11	-		-
OFF	12	-		-
OFF	13	-		-
OFF	14	-		-
OFF	15	-		-
OFF	16	-		-
OFF	17	-		-
Q25	18	58.91		N
Q26	19	59.06		N
M1	20	2.27		N

Beam No. CP-5B

11. Internal Target Information

Radius Meter Reading ________ Radius ________ inches

Azimuth Meter Reading ________ Azimuth ________ inches

Description of Target ____

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used				
Position*				
Bending Angle				
Current (Amp)				
Polarity**				

*Measured from center line of cyclotron to some convenient reference point.

**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details

a. Central Energy ~~Momentum~~ Range: 510MeV Peak Intensity: 100/sec in 1/2" diam. BM2 @ 5.6×10^{-9} A.

Width of ~~Magnet~~ Curve: 14 MeV

b. Defining Apertures in Shielding (Position, Size)

See Beam CP-5A

c. Range Information : Integral

Slowing Down Material: Copper

Stopping Material: -

Stopper Dimensions: -

Range Data:

Particle	p^+		
Peak Range	7.73"		
FWHM	0.35"		
Maximum Stopping Rate	-		

For beam profile and experimental set-up, see beam CP-5A.

cf Beam CP-5A

S/3/1

Beam No. CP-5C

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC105 Date 1/8/68 Signed R.J. Kurz

2. Particle: Proton X, Π^+ ____, Π^- ____, Neutron ____, Other ____

3. Nominal Beam Energy: 400

4. Area: CTA ____, PTA X, NM ____; Platter 300 ____, 600 X, Aux. ____

5. Degrader: BD-1 X, BD-2 ____, Copper 3.75 inches; Regenerater Position ____
+58 Dial No. 1 wedge

6. Main Magnet: N X, R ____, Shunt 74.00mv see Beam CP-5A

7. Diverter: ±9.15 amp on shunt; ____ amp on meter See 600 MeV

8. Internal Beam Intensity: ____ on Monitor ____, ____ mv. on TC Flip

9. External Beam Intensity: ____ on Monitor ____, ____ on Monitor ____, See Beam CP-5A
____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____.

10. Proton Transport Magnet Settings See Beam CP-5A for magnets up to BD1

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
	1			
M6	2	39.02		N
M7	3	39.02		N
	4			
Q17	5	9.44		N
	6			
	7			
Q18	8	16.77		N
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
	17			
Q25	18	51.58		N
Q26	19	51.70		N
	20			

Beam No. CP-5C

11. Internal Target Information

Radius Meter Reading ________ Radius ________ inches

Azimuth Meter Reading ________ Azimuth ________ inches

Description of Target ____________________

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used				
Position*				
Bending Angle				
Current (Amp)				
Polarity**				

*Measured from center line of cyclotron to some convenient reference point.

**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details

a. Central ~~Momentum~~ Energy: 415MeV Peak Intensity: 2000/sec in 1/2" diam @ BM2 $3.0x10^{-8}$A.

Width of ~~Magnet~~ Range Curve: 16 MeV ~~%~~

b. Defining Apertures in Shielding (Position, Size)

See Beam CP-5A

c. Range Information: Integral

Slowing Down Material: Copper

Stopping Material: -

Stopper Dimensions: -

Range Data:

Particle	P^+		
Peak Range	5.65"		
FWHM	0.30"		
Maximum Stopping Rate	-		

For beam profile and experimental set-up see Beam CP-5A.

cf Beam CP-5A

S/3/1

Beam No. CP-5D

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC105 Date 1/8/68 Signed R.J. Kurz

2. Particle: Proton X , π^+ ____, π^- ____, Neutron ____, Other ____

3. Nominal Beam Energy: 300

4. Area: CTA ____, PTA X , NM ____; Platter 300 ____, 600 X , Aux. ____

5. Degrader: BD-1 X , BD-2 ____, Copper 5.75 Inches; Regenerater Position ____

6. Main Magnet: N X , R ____, Shunt 74.00 mv +62 Dial on No. 1 wedge

7. Diverter: ±9.15 amp on shunt; ____ amp on meter

8. Internal Beam Intensity: ____ on Monitor ____, ____ mv. on TC Flip

9. External Beam Intensity: ____ on Monitor ____, ____ on Monitor ____, See Beam CP-5A
____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____.

10. Proton Transport Magnet Settings. For Magnets up to BD1 see Beam CP-5A

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
	1			
M6	2	33.07		N
M7	3	33.07		N
	4			
Q17	5	8.07		N
	6			
	7			
Q18	8	14.20		N
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
	17			
Q25	18	43.60		N
Q26	19	43.73		N
	20			

Beam No. CP-5D

11. Internal Target Information

Radius Meter Reading ________ Radius ________ inches

Azimuth Meter Reading ________ Azimuth ________ inches

Description of Target ________________________________

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used				
Position*				
Bending Angle				
Current (Amp)				
Polarity**				

*Measured from center line of cyclotron to some convenient reference point.

**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details

BM2

a. Central ~~Momentum:~~ Energy 315 MeV Peak Intensity: 600/sec in 1/2"diam. @ 5.0×10^{-8} A.

Width of ~~Magnet~~ Range Curve: 20 MeV

b. Defining Apertures in Shielding (Position, Size)

See Beam CP-5A

____

c. Range Information: Integral

Slowing Down Material: Copper

*Stopping Material: -

Stopper Dimensions: -

Range Data:

Particle	P		
Peak Range	3.65"		
FWHM	0.30"		
Maximum Stopping Rate	-		

For profile and experimental set-up, See Beam CP-5A.

cf Beam CP-5A

S/3/1

Beam No. CP-5E

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC105 Date 1/8/68 Signed R.J. Kurz
2. Particle: Proton X , π^+ ____, π^- ____, Neutron ____, Other ____
3. Nominal Beam Energy: 320
4. Area: CTA ____, PTA X , NM ____; Platter 300 X , 600 ____, Aux. ____
5. Degrader: BD-1 X , BD-2 ____, Copper 0 Inches; Regenerater Position ____
6. Main Magnet: N X , R ____, Shunt 68.70mv
7. Diverter: (+) − 15.1 amp on shunt; ____ amp on meter
8. Internal Beam Intensity: ____ on Monitor ____, ____ mv. on TC Flip
9. External Beam Intensity: ____ on Monitor ____, ____ on Monitor ____, See Item 13. ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____.
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
M2/M3	1	33.60		N
M6	2	33.25		N
M7	3	33.25		N
Q1A/Q2A	4	9.61		N
Q17	5	8.35		N
Q3	6	10.48		N
Q2/Q4	7	23.37		N
Q18/Q22 ~~Disconnected~~	8	14.80		N
OFF	9	-		
Q1	10	24.84		N
OFF	11	-		
"	12	-		
"	13	-		
"	14	-		
"	15	-		
"	16	-		
"	17	-		
Q25	18	45.70		N
Q26	19	45.73		N
M1	20	10.94	N O T E →	R

Beam No. CP-5E

11. Internal Target Information
Radius Meter Reading ________ Radius ________ inches
Azimuth Meter Reading ________ Azimuth ________ inches
Description of Target ________________________________

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used				
Position*				
Bending Angle				
Current (Amp)				
Polarity**				

*Measured from center line of cyclotron to some convenient reference point.
**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details
a. Central ~~Momentum~~ Energy: 320 MeV Peak Intensity: See below
Width of ~~Magnet~~ Range Curve: 8.5 MeV
b. Defining Apertures in Shielding (Position, Size)
See 600 MeV

c. Range Information : Differential
Slowing Down Material: Copper + 2 - 1/8" thick Pilot B scintillators
Stopping Material: PVT (Pilot B)
Stopper Dimensions: .125" Thick
Range Data:

Particle	p		
Peak Range	3.67"		
FWHM	.16"		
Maximum Stopping Rate	-		

Intensity Information:

	in 1/2" diam (protons/sec)	in 2" diam (protons/sec)	BM1 amps	BM2 amps	BM3 amps
	11	78	1.7×10^{-8}	8.5×10^{-9}	1.1×10^{-10}
	120	880	1.6×10^{-7}	8.5×10^{-8}	1.0×10^{-9}
MAXIMUM →	2500	11300	3.0×10^{-6}	1.8×10^{-6}	2.4×10^{-8}

For Beam profile and experimental set-up, see Beam CP-5A.

cf Beam CP-5A

S/3/1

Beam No. CP-5F

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC105 Date 1/8/68 Signed R.J. Kurz

2. Particle: Proton X, π^+ ___, π^- ___, Neutron ___, Other ___

3. Nominal Beam Energy: 200 MeV

4. Area: CTA ___, PTA X, NM ___; Platter 300 X, 600 ___, Aux. ___

5. Degrader: BD-1 X, BD-2 ___, Copper 2.0 Inches; Regenerater Position ___

6. Main Magnet: N X, R ___, Shunt ___ mv +41 Dial on No. 1 wedge

See 320 MeV

7. Diverter: ± 15.1 amp on shunt; ___ amp on meter

8. Internal Beam Intensity: ___ on Monitor ___, ___ mv. on TC Flip

9. External Beam Intensity: ___ on Monitor ___, ___ on Monitor ___, ___ on Monitor ___, ___ on Monitor ___, ___ on Monitor ___. See Item 13.

10. Proton Transport Magnet Settings· See Beam CP-5E for magnets up to BD1

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
	1			
M6	2	25.70		N
M7	3	25.70		N
	4			
Q17	5	6.45		N
	6			
	7			
Q18	8	11.36		N
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
	17			
Q25	18	34.85		N
Q26	19	34.93		N
	20			

11. Internal Target Information

Radius Meter Reading ________ Radius ________ inches

Azimuth Meter Reading ________ Azimuth ________ inches

Description of Target ____________________

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used				
Position*				
Bending Angle				
Current (Amp)				
Polarity**				

*Measured from center line of cyclotron to some convenient reference point.

**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details

a. Central ~~Momentum~~ Energy: 204MeV Peak Intensity: See Below

Width of ~~Magnet~~ Range Curve: 4.3 MeV

b. Defining Apertures in Shielding (Position, Size)

See Beam CP-5A

c. Range Information : Differential

Slowing Down Material: Copper + 2 - 1/8" thick Pilot B scintillators

Stopping Material: PVT (Pilot B)

Stopper Dimensions: .125" Thick

Range Data:

Particle	P		
Peak Range	1.70"		
FWHM	.06"		
Maximum Stopping Rate	-		

Intensity Information:

	in 1/2" diam. (protons/sec)	in 2" diam (protons/sec)	BM1 (amps)	BM2 (amps)	BM3 (amps)
	35	300	1.2×10^{-7}	6.5×10^{-8}	1.1×10^{-10}
	450	3300	1.1×10^{-6}	6.4×10^{-7}	1.1×10^{-9}
MAXIMUM →	1300	7600	2.9×10^{-6}	1.9×10^{-6}	3.5×10^{-9}

For beam profile and experimental set-up, see Beam CP-5A.

Beam No. CP-5G through CP-5P

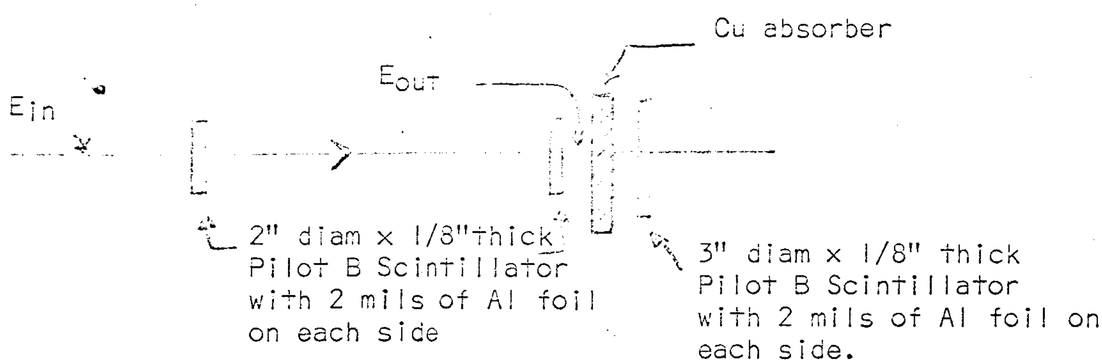
SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC-105 Date 1/8/68 Signed R.J. Kurz
2. Particle: Proton X , π^+ ____, π^- ____, Neutron ____, Other ____
3. Nominal Beam Energy: See table below
4. Area: CTA ____, PTA X , NM ____; Platter 300 ____, 600 ____, Aux. ____
5. Degrader: BD-1 ____, BD-2 ____, Copper ____ inches; Regenerater Position ____
6. Main Magnet: N X , R ____, Shunt ____ mv

See beam CP-5E

Procedure:

320 MeV beam transport system to BD1 as for Beam CP-5E. BD1 degrader thickness set at calculated value from higher energy work. (Approximate No. 1 Wedge calibration 20 dial units = 0.1 inch.) Q17,18 and Q25,26 set at calculated values. M6, M7 fields adjusted so that 1/2 of the beam protons penetrate the following range telescope.



E_{out} resolution was estimated by replacing Cu absorber and 3" diam counter by a 1" thick CsI scintillator and measuring the pulse-height-spectrum of the protons stopping in this crystal.

TABLE OF BEAM DATA

BEAM NO.	Ein (MeV)	Eout (MeV)	Eout FWHM (%)	BD1 (in.+dial)	M6,7 (Mv)	Q17 (Mv)	Q18 (Mv)	Q25 (Mv)	Q26 (Mv)
CP-5G	158.4	155.0	-	2.50+52	22.50	5.77	10.16	31.26	31.33
CP-5A	105.4	102.0	-	3.25+46	18.40	4.44	7.81	24.03	24.08
CP-5I	79.0	74.0	7	3.50+44	15.90	4.0	6.8	21.0	21.0
CP-5J	74.0	68.0	-	3.50+50	15.35	"	"	"	"
CP-5L	64.0	57.2	7	3.50+60	14.35	3.55	6.3	19.2	19.2
CP-5M	54.2	46.0	-	3.50+64	13.32	3.1	5.5	16.8	16.8
CP-5N	48.0	38.6	9	3.50+64	12.55	"	"	"	"
Collimators same as on 600 Beam									
CP-5O	40.6	29.8	-	3.50+64	11.75	2.7	4.9	15.0	15.0
CP-5P	34.5	20.5	20	3.50+74	10.92	2.56	4.8	13.85	13.85

Maximum intensities in a 2" diam decrease with energy from 7500/sec at 155 MeV to 5/sec at 20.5 MeV.

Beam No. CP-6

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. 1C-111 Date 11-14-67 Signed S. Cleary
2. Particle: Proton X, π^+ ___, π^- ___, Neutron ___, Other ___
3. Nominal Beam Energy: 300 Mev-degraded to 129 Mev
4. Area: CTA X, PTA ___, NM ___; Platter 300 X, 600 ___, Aux. ___
5. Degrader: BD-1 X, BD-2 ___, Copper 3 Inches; Regenerater Position ___
6. Main Magnet: N X, R ___, Shunt 67.8 mv
7. Diverter: ±20.60 amp on shunt; +31 amp on meter
8. Internal Beam Intensity: ___ on Monitor ___, ___ mv. on TC Flip
9. External Beam Intensity $24X10^{-6}$ on Monitor BM1, ___ on Monitor ___, ___ on Monitor ___, ___ on Monitor ___, ___ on Monitor ___.
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
M2/M3	1	33.22	195	N
M4	2	20.14	120	N
M5	3	20.05	120	N
Q1A/Q2A	4	10.6	64	N
Q5	5	24.65	148	N
Q8	6	20.53	123	N
Q2/Q3	7	21.22	85	N
Q6/Q10	8	25.09	100	N
N.A.	9			
Q1	10	24.55	123	N
Q7	11	16.2	81	N
Q9	12	7.23	35	N
N.A.	13			
N.A.	14			
Q4	15	26.49	78	N
Q11	16	19.53	58	N
Q12	17	23.91	72	N
Q13	18	26.71	80	N
Q14	19	23.94	72	N
M1	20	9.02	27	N

Beam No. CP-6

11. Internal Target Information

Radius Meter Reading ________ Radius ________ inches

Azimuth Meter Reading ________ Azimuth ________ inches

Description of Target ____________________

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used				
Position*				
Bending Angle				
Current (Amp)				
Polarity**				

*Measured from center line of cyclotron to some convenient reference point.

**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details

a. Central Momentum: 129Mev Peak Intensity: 1.7×10^7 $p^+/cm^2/sec$

Width of Magnet Curve: ________ %

b. Defining Apertures in Shielding (Position, Size)

____

____

c. Range information

Slowing Down Material: polystyrene

Stopping Material: H_2O

Stopper Dimensions: ________

Range Data:

Particle			
Peak Range	12.2cm		
FWHM	15.5mm		
Maximum Stopping Rate			

Peak Range: 12.2 cm in H_2O

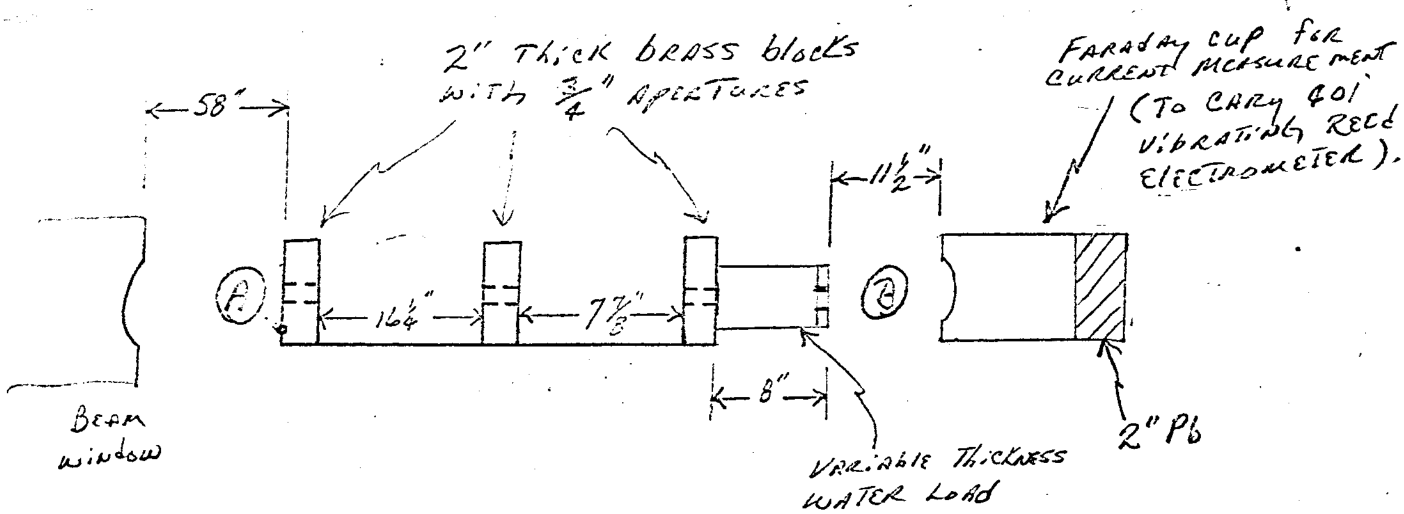
FWHM: 15.5 mm horizontal

13. Beam Details Continued

d. Other characteristics - beam profile if known (give position at which measured); whether paralle, convergent (give focal position), or divergent, with details.

Beam focus in CTA at 58" from end of beam tube. Measurements made in diverging beam after collimation to beam diameter of 3/4".

14. Draw a layout of your set-up, showing magnets, blockhouse, shielding, counters, etc. Give distances from fiducial marks on walls, dimensions, etc.



A : POSITION of Polystyrene DEGRADER (0 To 4.5")
B : POSITION of BEAM profile MEASUREMENT with semiconductor diode.

15. Comments:

Beam No. CP7

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC 106 Date 2-1-68 Signed E. Boschitz
2. Particle: Proton X, π^+ ____, π^- ____, Neutron ____, Other ____
3. Nominal Beam Energy: 600 MeV Polarized
4. Area: CTA ____, PTA X, NM ____; Platter 300 ____, 600 ____, Aux. X See Page 3
5. Degrader: BD-1 ____, BD-2 ____, Copper ____ Inches; Regenerater Position ____
6. Main Magnet: N X, R ____, Shunt +74.00 mv
7. Diverter: ±17.54mv on shunt; +26 amp on meter
8. Internal Beam Intensity: ____ on Monitor ____, 2.2 mv. on TC Flip .297 ma/mv
9. External Beam Intensity: 8.2×10^{-9} on Monitor 1, 5×10^{-10} on Monitor 5, ____ on Monitor ____, ____ on Monitor ____, ____ on Monitor ____.
10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
M2/M3	1	43.28	258	N
M6	2	48.00	292	N
M7	3	46.90	282	N
Q1A/Q2A	4	26.00	150	N
Q17	5	30.18	182	N
Q3	6	22.44	137	N
Q2/Q4	7	34.55	145	N
Q18/Q22	8	53.97	212	N
Q15/Q16	9	47.86	190	N
Q1	10	35.89	160	N
Q19	11	66.44	330	N
Q20	12	62.02	295	N
Q5	13	57.10	170	N
Q6	14	51.57	153	N
Q21	15	72.00	215	N
Q23	16	69.89	210	N
Q24	17	78.12	238	N
Q25	18	84.06	250	N
Q26	19	76.00	228	N
M1	20	0	0	N

Beam No. CP7

11. Internal Target Information

Radius Meter Reading 1.65 Radius 87.20 inches

Azimuth Meter Reading 1.90 Azimuth 336.7 ~~inches~~ degrees

Description of Target .75" x 2" x 4" Graphite Block

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used				
Position*				
Bending Angle				
Current (Amp)				
Polarity**				

*Measured from center line of cyclotron to some convenient reference point.

**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details

a. Central ~~XXXXXXXX~~ ENERGY: 545 Peak Intensity: 3×10^7 protons/sec

Width of Magnet Curve: ------ %

b. Defining Apertures in Shielding (Position, Size)

2" thick, 1/2" wide copper collimator

upstream from Q15/Q16

c. Range Information

Slowing Down Material:

Stopping Material:

Stopper Dimensions:

Range Data:

Particle			
Peak Range			
FWHM			
Maximum Stopping Rate			

13. Beam Details Continued

d. Other characteristics - beam profile if known (give position at which measured); whether parallel, convergent (give focal position), or divergent, with details.

The beam was polarized by using a carbon block inside the cyclotron at a radius of 87.2 inches and an azimuth of 336.7 degrees. Degree of polarization was 38% and was determined by the symmetry of proton scattering in a carbon and hydrogen target.

Beam was slightly divergent; measured 1" wide and 3" high 6ft. downstream from exit window.

14. Draw a layout of your set-up, showing magnets, blockhouse, shielding, counters, etc. Give distances from fiducial marks on walls, dimensions, etc.

15. Comments:

Beam No. CP-8

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC-101 Date 7-9-68 Signed ____

2. Particle: Proton X, π^+ ____, π^- ____, Neutron ____, Other ____

3. Nominal Beam Energy: 325 MeV

4. Area: CTA ____, PTA X, NM ____; Platter 300 X, 600 ____, Aux. ____

5. Degrader: BD-1 ____, BD-2 ____, Copper ____ Inches; Regenerater Position Full In

6. Main Magnet: N X, R ____, Shunt 68.67 mv

7. Diverter: + 13.87 mv on shunt; +20 amp on meter

8. Internal Beam Intensity: ____ on Monitor ____, 2.0 mv. on TC Flip #3 (0.59 μa)

9. External Beam Intensity: 2.75X10^{-6} on Monitor 1, 1.4X10^{-6} on Monitor 2, 1.8X10^{-6} on Monitor 3, 1.9X10^{-6} on Monitor 5, ____ on Monitor ____.

10. Proton Transport Magnet Settings

Magnet No.	Power Supply No.	Shunt (mv)	Current (Amperes)	Polarity (N or R)
M2/M3	1	33.29		N
M6	2	34.54		N
M7	3	32.91		N
Q1A/Q2A	4	9.60		N
Q17	5	15.54		N
Q3	6	10.46		N
Q2/Q4	7	23.37		N
Q18/Q22	8	27.18		N
Q15/Q16	9	24.75		N
Q1	10	24.87		N
Q19	11	33.22		N
Q20	12	34.74		N
Q5	13	30.98		N
Q6	14	26.08		N
Q21	15	42.26		N
Q23	16	15.77		N
Q24	17	32.99		N
Q25	18	52.56		N
Q26	19	41.63		N
M1	20	9.35		N

NOT APPLICABLE

11. Internal Target Information

Radius Meter Reading________ Radius ________ inches
Azimuth Meter Reading________ Azimuth ________ inches
Description of Target________________________________

NA

12. Bending and Focussing Magnet Information (For Meson Beams)

Magnets Used				
Position*				
Bending Angle				
Current (Amp)				
Polarity**				

*Measured from center line of cyclotron to some convenient reference point.

**For bending magnets indicate field ↑ or ↓: for q-poles indicate vertically focussing (F) or defocussing (D) for the beam being used.

13. Beam Details

a. Central Momentum:________ Peak Intensity: $4X10^{10}$ proton/sec

Width of Magnet Curve: ________% Measured with Faraday Cup. In PTA

b. Defining Apertures in Shielding (Position, Size)

____

____

c. Range Information

Slowing Down Material: ________________

Stopping Material: ________________

Stopper Dimensions: ________________

Range Data:

Particle			
Peak Range			
FWHM			
Maximum Stopping Rate			

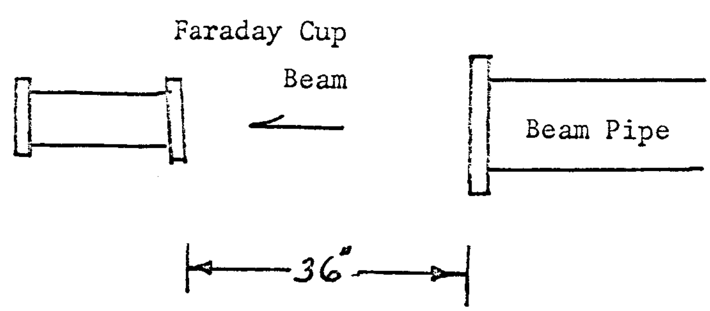
13. Beam Details Continued

d. Other characteristics - beam profile if known (give position at which measured); whether paralle, convergent (give focal position), or divergent, with details.

Beam Diameter=2".

Measured with Polaroid Film. @ 3' From Beam Pipe.

14. Draw a layout of your set-up, showing magnets, blockhouse, shielding, counters, etc. Give distances from fiducial marks on walls, dimensions, etc.



15. Comments: The Beam intensity measured by BM-5 is $1.9X10^{-6}$, the intensity at BM-2 is measured as $1.4X10^{-6}$. The discrepancy is apparently caused by saturation in the BM-2 Ion Chamber.

SREL Internal Report
SC-1
November 7, 1967

EXTERNAL BEAM CURRENT MEASUREMENTS ON THE SYNCHROCYCLOTRON

L. W. Swenson and W. G. Hendrick

600 MeV Beam

Absolute measurements of the extracted 600 MeV beam from the SREL synchrocyclotron have been made in two ways; by integrating the charge collected in a Faraday cup and from the yield of the C^{12} (p,pn) C^{11} activation. The Faraday cup used corresponds to SREL Dwg. No. MD 31-128-2. Polyethylene foils of 7.36 mg/cm^2 thickness were activated and placed in a 0.5" dia. Aluminum pill box. The pill box was placed 5.75 inches from a 3x3 NaI crystal and the annhilation radiation counted. The counting efficiency was determined by counting a calibrated Na^{22} source in the same geometry.

The first experimental set up was as follows. The extracted 600 MeV beam passed through the beam transport system, BM5 and into the Proton Target Area where it passed through an activation foil and was collected by the Faraday cup. The Faraday cup current was integrated on a condenser of known capacitance and the voltage on the condenser read by the Hewlett Packard 425A micro voltmeter. The charge collected by BM5 was integrated on an Elcor electrometer. The Argon pressure in the BM5 ion chamber was 14 psi. Typical measured values are given in Table I.

TABLE I

RUN NO.	BM5 CHARGE (Coulombs)	FARADAY CUP CHARGE (Coulombs)	ACTIVATION (Protons/sec)	BM5 / FARADAY CUP	FARADAY CUP (Protons/sec)	FARADAY CUP / Activation
1	2.57×10^{-3}	1.92×10^{-5}	1.75×10^{11}	134	2.0×10^{11}	1.14
2	6.6×10^{-4}	2.5×10^{-6}	2.71×10^{10}	264	2.6×10^{10}	0.96
3	1.31×10^{-4}	3.19×10^{-7}	3.22×10^{9}	410	3.3×10^{9}	1.02
4	2.61×10^{-5}	5.4×10^{-8}	5.05×10^{8}	483	5.6×10^{8}	1.11
5	6.36×10^{-6}	1.29×10^{-8}	1.25×10^{8}	493	1.34×10^{8}	1.07

It appears that values obtained for the beam intensity from the Faraday Cup and Activation measurements are in reasonable agreement (to within <10%) over a wide range of beam intensities. Further, the maximum external beam intentensity is about 2×10^{11} protons/sec. Comparison of the charge collected on BM5 with the Faraday Cup in Column 5 indicates a nonlinear behavior of the ion chamber for beam intensities greater than $\sim10^{9}$ protons/sec. the ratio BM5/Faraday Cup is represented in Figure I, and a calibration curve for BM5 is given in Figure 2.

The ratio BM5/Faraday Cup at low beam currents (linear region) can be understood at least qualitatively from the fact that the calculated number of ion pairs produced in the ion chamber is 420. This estimate assumes 0.5" plate spacings, 1 atm. Argon pressure and an ionization potential of 20 ev/ion pair.

A second measurement involved the following experimental arrangement. The external 600 MeV proton beam passed through the BM1 ion chamber, the remaining beam transport system and into the Combined Target Area where it traversed BM4, an activation foil and was collected by the Faraday Cup. An Elcor electrometer was used to measure the current collected by BM1, a Hewlett Packard 425 micro volt-amp meter read the current collected by BM4 and a Keithly 602 electrometer registered the Faraday Cup current. The Argon pressure in the ion chamber was 14 psi and the collection voltage 1000 volts. Typical measured values are given in Table II. The yields of the ion chambers are compared to the Faraday Cup in Figure 3.

TABLE II

BM1 (amps)	BM4 (amps)	FARADAY CUP (amps)	BM1 / Faraday Cup	BM4 / Faraday Cup	Faraday Cup (protons/sec)
2.0×10^{-7}	1.8×10^{-7}	4.8×10^{-10}	417	375	2.88×10^{9}
5.0×10^{-7}	3.8×10^{-7}	1.3×10^{-9}	385	292	7.8×10^{9}
1.0×10^{-6}	7.0×10^{-7}	2.6×10^{-9}	385	270	1.56×10^{10}
2.25×10^{-6}	1.2×10^{-6}	6.0×10^{-9}	375	200	3.6×10^{10}
9.6×10^{-8}	9.2×10^{-8}	2.2×10^{-10}	436	418	1.32×10^{9}
4.8×10^{-8}	4.8×10^{-8}	1.1×10^{-10}	436	435	6.6×10^{8}
2.0×10^{-8}	2.1×10^{-8}	4.8×10^{-11}	417	438	2.88×10^{8}
4.15×10^{-8}	4.0×10^{-9}	9.0×10^{-12}	460	445	5.4×10^{7}
1.0×10^{-8}	1.0×10^{-8}	2.3×10^{-11}	434	434	1.38×10^{8}
1.7×10^{-9}	1.68×10^{-9}	4.0×10^{-12}	425	420	2.4×10^{7}
9.0×10^{-10}	9.0×10^{-10}	2.0×10^{-12}	450	450	1.2×10^{7}
4.55×10^{-10}	4.6×10^{-10}	1.0×10^{-12}	455	460	6.0×10^{6}
8.2×10^{-6}	3.25×10^{-6}	2.5×10^{-8}	330	130	1.38×10^{11}

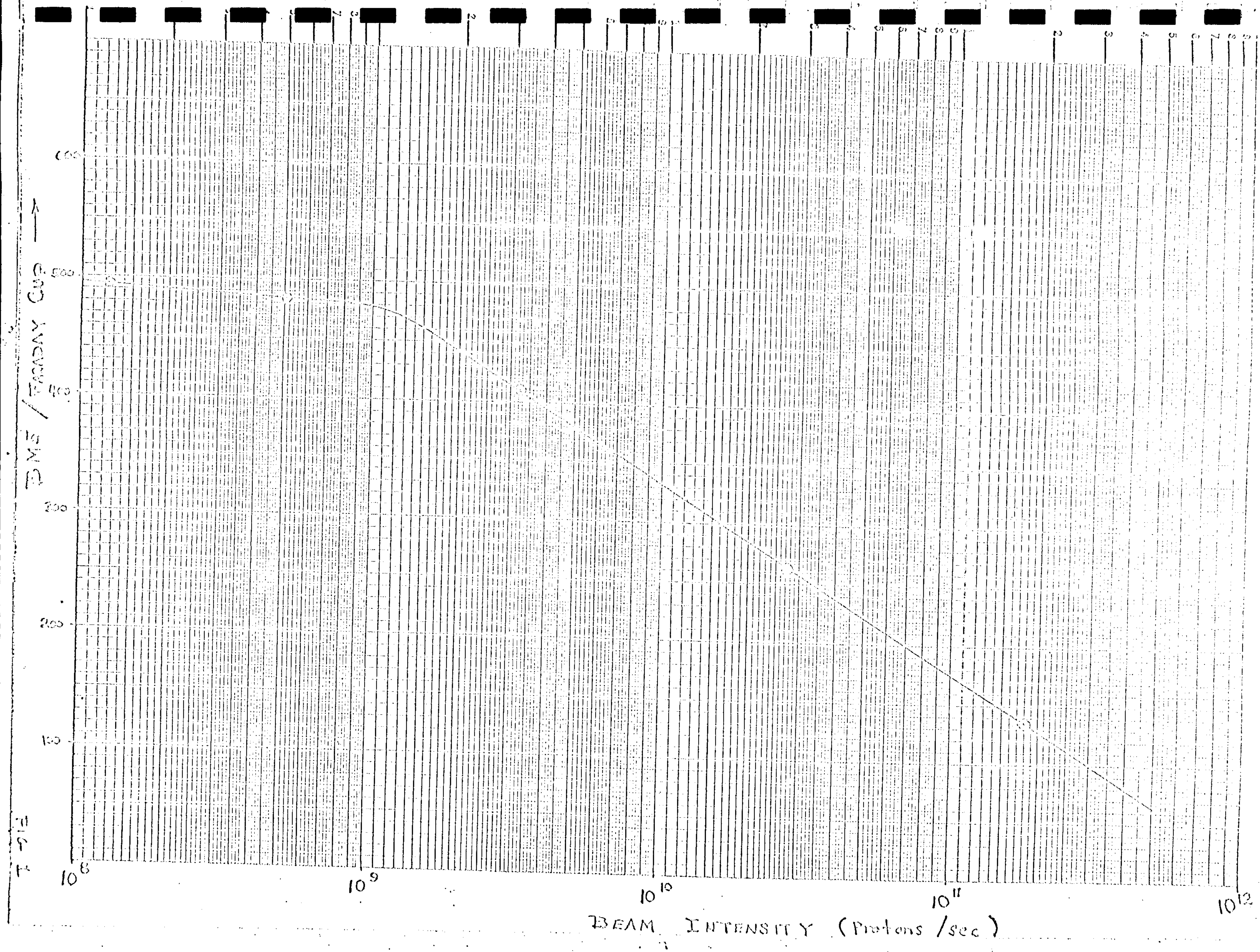
Again the nonlinearity of the ion chambers is evident for beam intensities greater than about 10^9 protons/sec. The onset of the nonlinear region and the slope of the curves in Figure 3 at high beam intensities may be expected to vary with such conditions as the type and pressure of the ion chamber gas, the distribution of ion pairs produced in the chamber, i.e., beam spot size, plate spacings and collection voltage. A calibration curve for BM4 is given in Figure 4. Additional curves for BM2 are shown in Figures 5 and 6.

300 MeV Beam

A measurement of the 300 MeV beam intensity has been made with the following experimental arrangement. The external beam passed through BM2 the remaining beam transport system through BM4 and was collected by the Faraday Cup in the Combined Target Area. The Faraday Cup current was read by a Keithly 602 electrometer, BM2 by a Hewlett Packard 425 and BM4 by an Elcor electrometer. The measured currents are represented in Table III.

BM2 (amps)	BM4 (amps)	Faraday Cup (amp)	BM2 / Faraday Cup	BM4 / Faraday Cup	Faraday Cup Protons/sec
1.1×10^{-6}	1.0×10^{-6}	3.2×10^{-9}	342	313	1.92×10^{10}

It appears that the nominal maximum beam intensity for the 300 MeV beam is about 2×10^{10} protons/sec. For this beam intensity the current readings of BM2 and BM4 agree well with reading taken at 600 MeV taking into account the change in dE/dx from 600 to 300 MeV.



DMS / FARADAY CUP →
600
500
400
300
200
100
10^8
10^9
10^{10}
10^{11}
10^{12}
BEAM INTENSITY (Protons /sec)

FIG 1

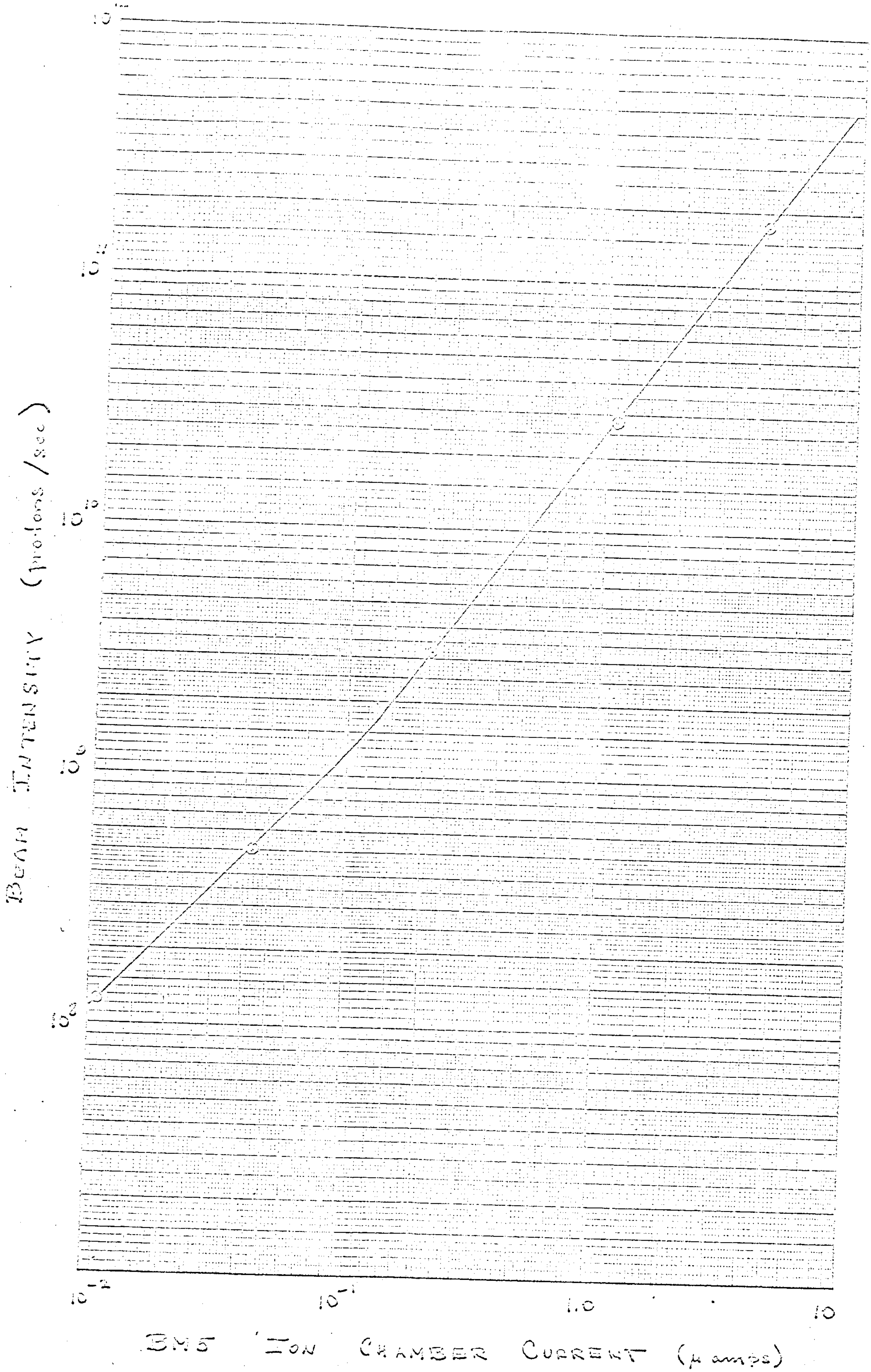

BEAM INTENSITY (protons / sec)
10^{-2}
10^{-1}
1.0
10
BM5 ION CHAMBER CURRENT (μ amps)

FIG 2

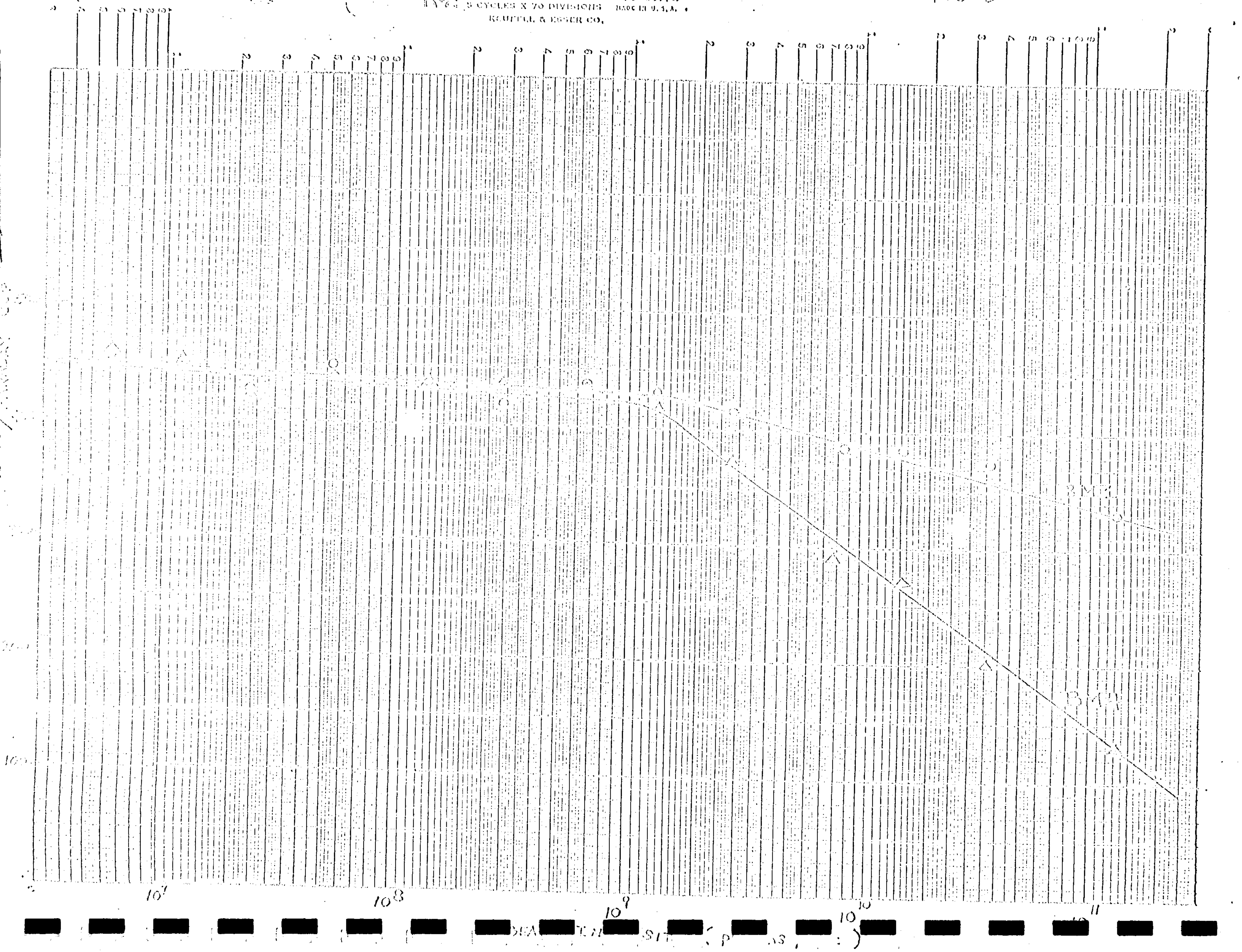
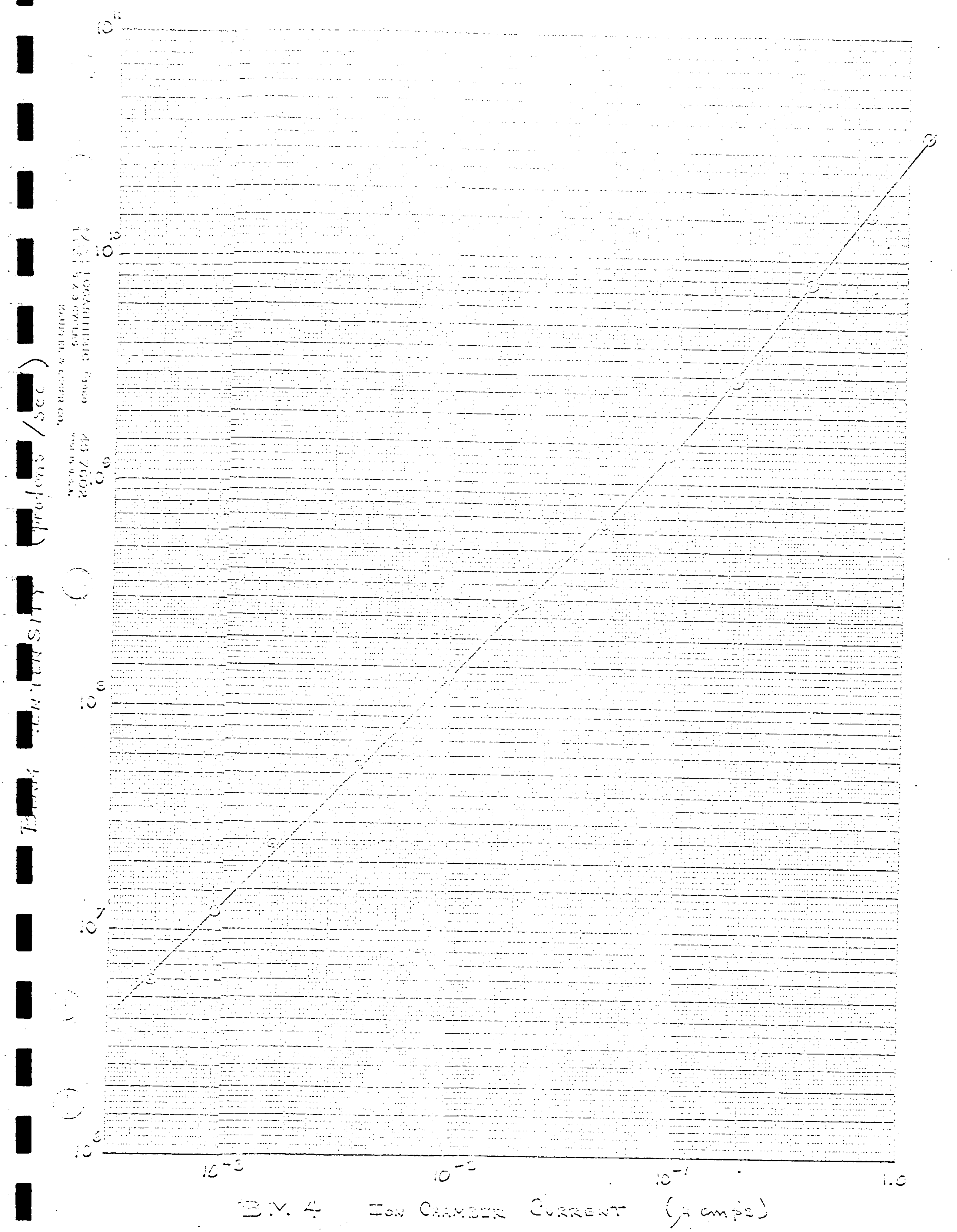
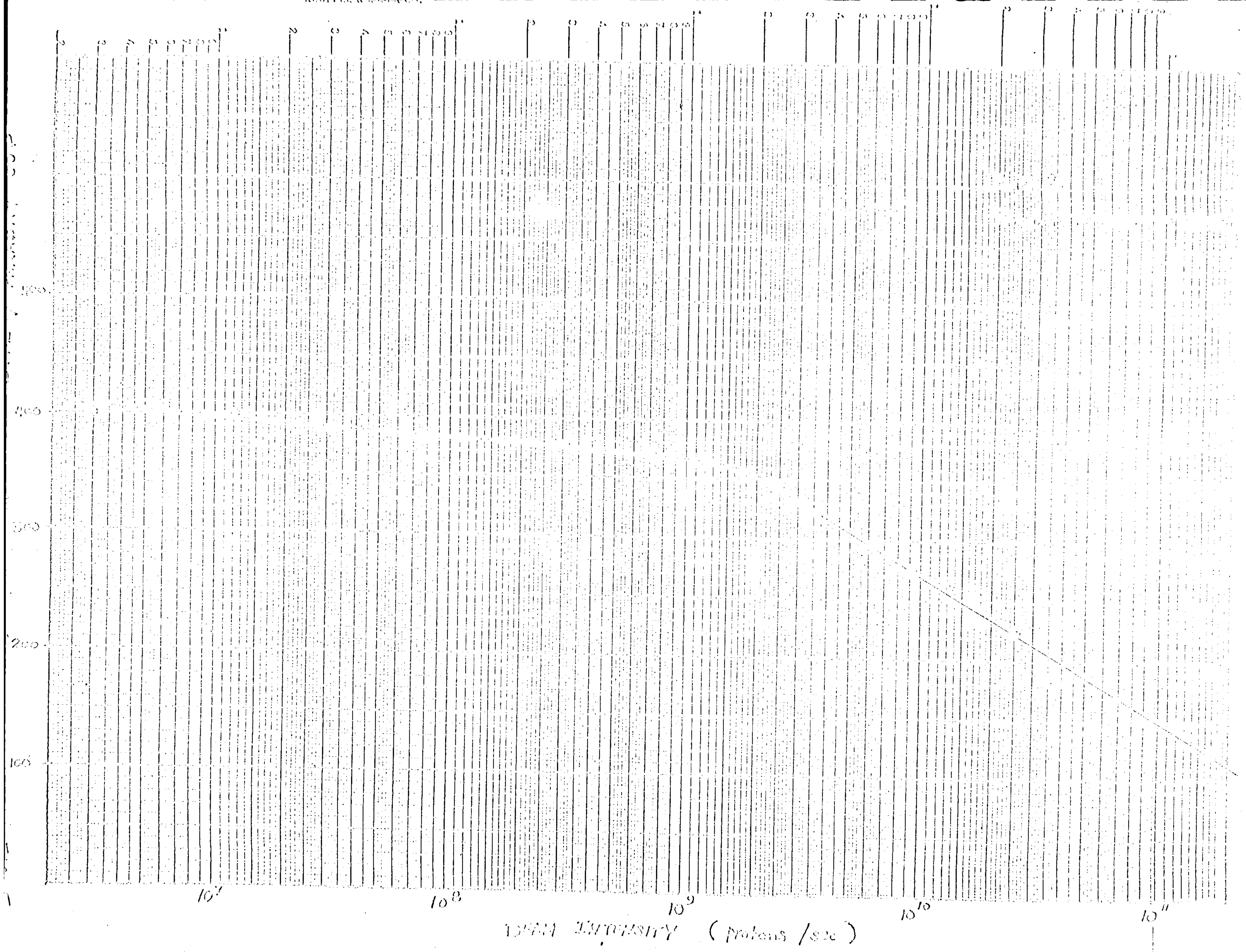

SEMI-LOGARITHMIC 46 6213
5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO.
10^7
10^8
10^9
10^{10}
10^{11}

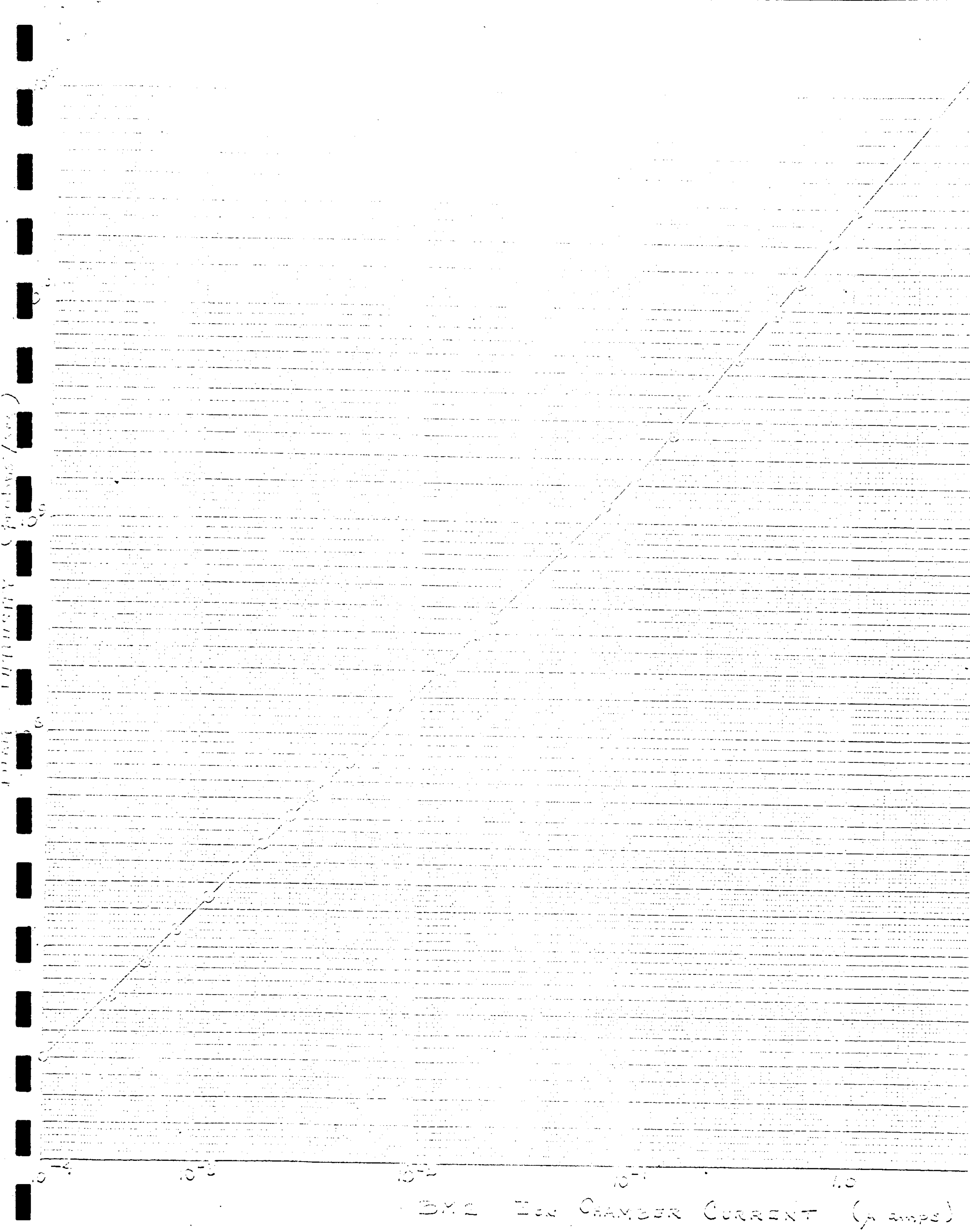
FIG. 3



Beam Intensity (protons/sec)
10^{9}
10^{8}
10^{7}
10^{6}
10^{-3}
10^{-2}
10^{-1}
1.0
B.M. 4 Ion Chamber Current (μ amps)

Fig-4


BEAM INTENSITY (protons /sec)
10^7
10^8
10^9
10^{10}
10^{11}
100
200
300
400
500



10^{-4}
10^{-3}
10^{-2}
10^{-1}
1.0
BM2 Ion Chamber Current (μ amps)

SECTION III 4

SREL CYCLOTRON TRANSPORT MAGNETS

The following pages include data on the transport magnets available for use by experimenters. The magnet designations are as given on page III 1.

BENDING MAGNET

TYPE: H18x36 - KW300

SERIAL #: NONE

MANUFACTURER: PACIFIC ELECTRIC MOTOR COMPANY

GAP IRON LENGTH (INCHES): 36

GAP WIDTH (INCHES): 18

GAP HEIGHT (INCHES): 9

MAX. OVERALL LENGTH (INCHES): 91

MAX. OVERALL WIDTH (INCHES): 57

ELECTRICAL CHARACTERISTICS PER MAGNET

CURRENT (AMP.): 583 (with adequate cooling 750 amp max.)

VOLTS: 260

RESISTANCE (OHMS): .514

POWER (KILOWATT): 300

WATER

GPM: 28.6

INLET TEMPERATURE (DEGREE FARINH): 65 - 110

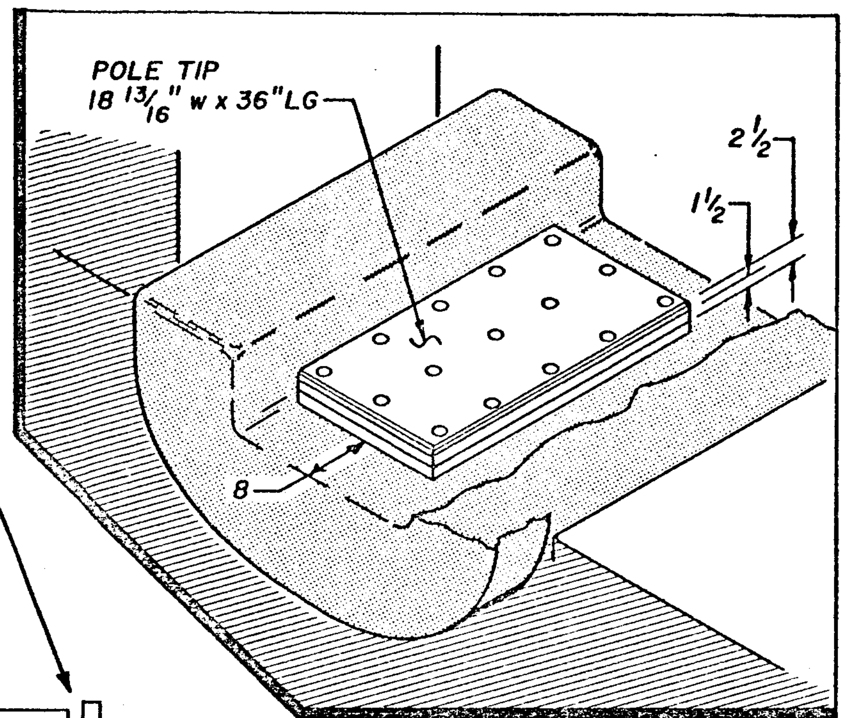
OUTLET TEMPERATURE (" "): 75 - 150

TRIP TEMPERATURE (" "): 194

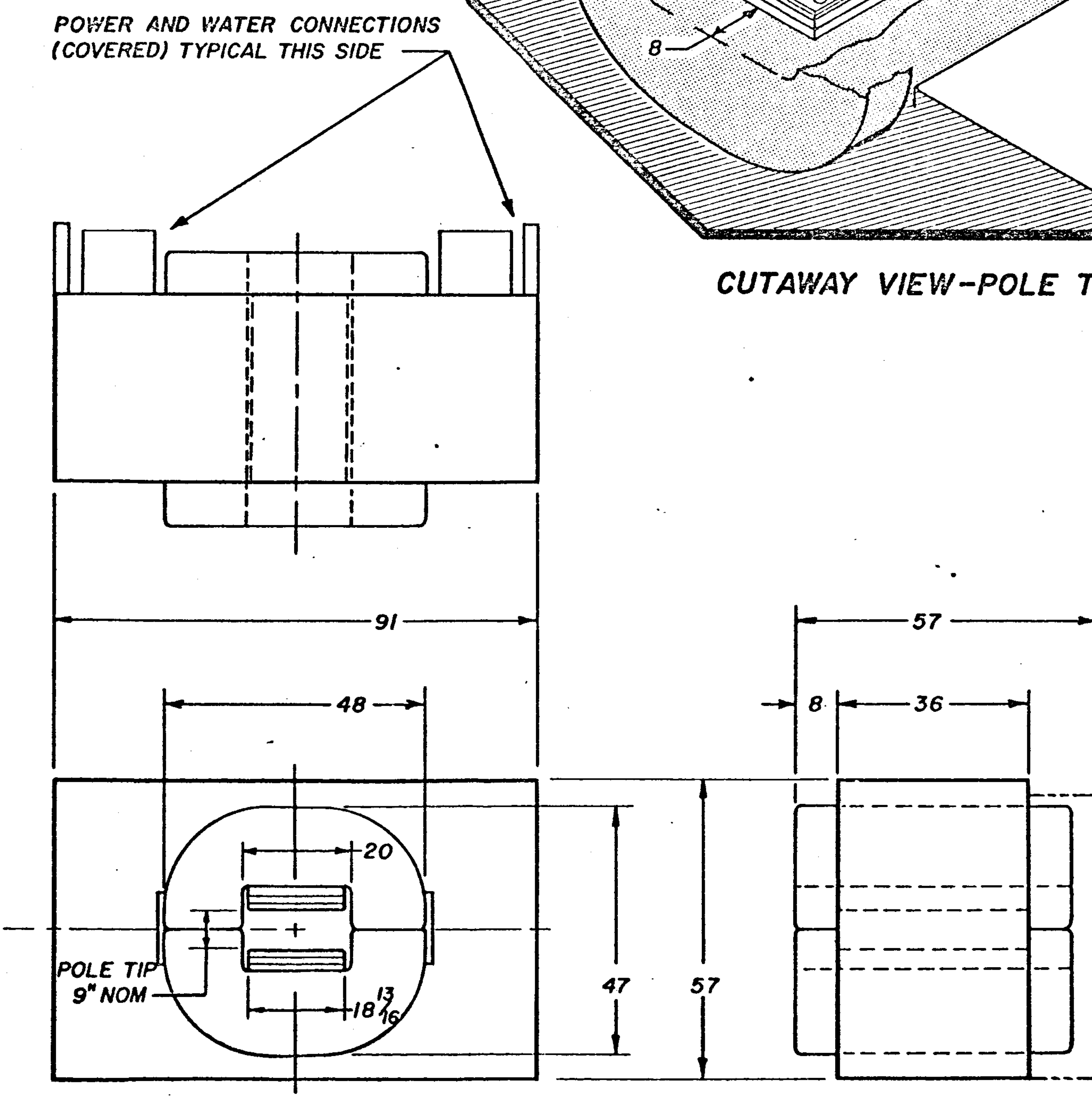
MAX. MAGNETIC POLE TIP FIELD (KILOGAUSS): 17.5

18 x 36 BENDING MAGNET
VERTICAL GAP 9"

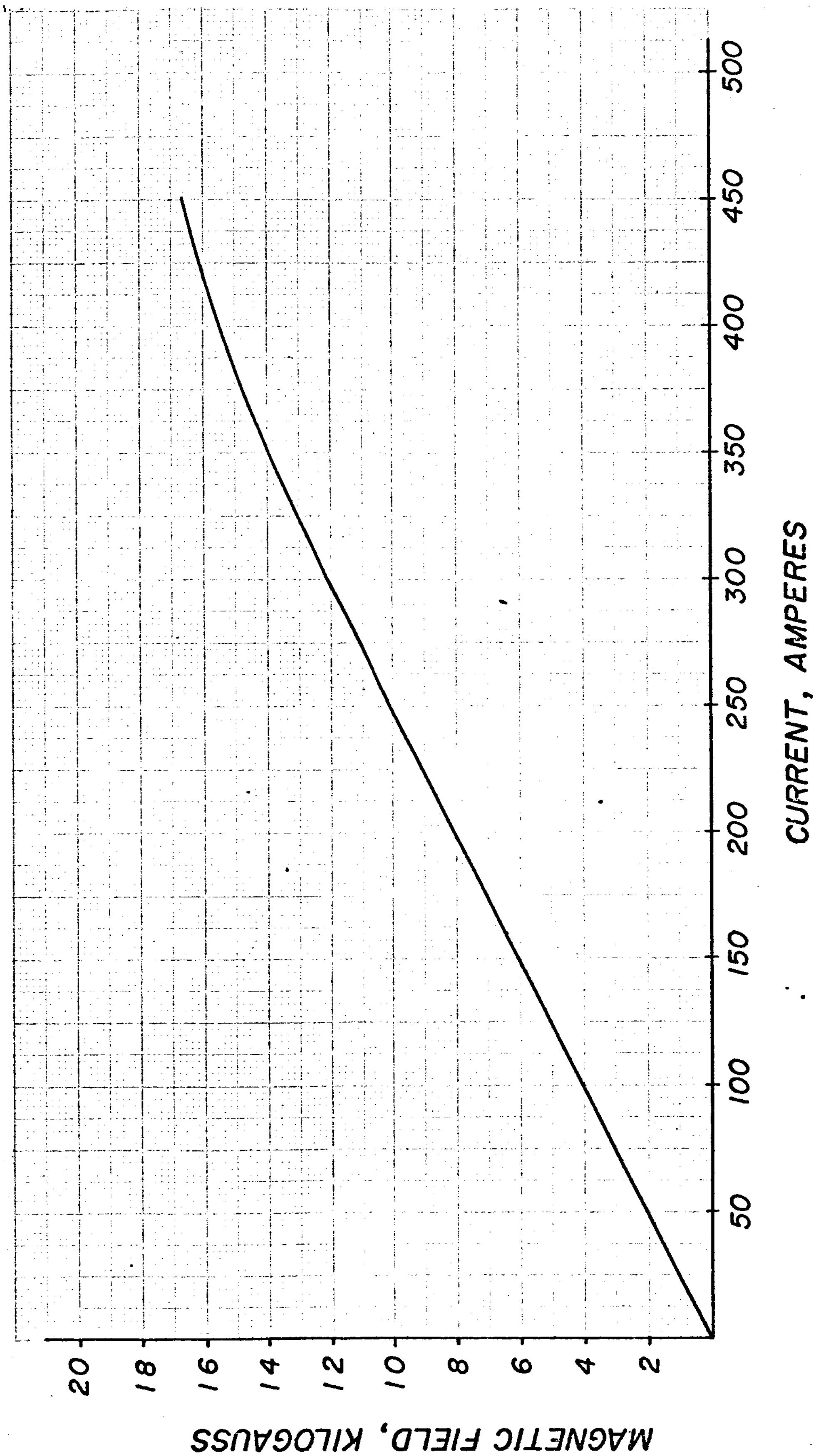
SERIAL NUMBER H18 x 36-KW300
PACIFIC ELECTRIC MOTOR CO.



CUTAWAY VIEW-POLE TIP

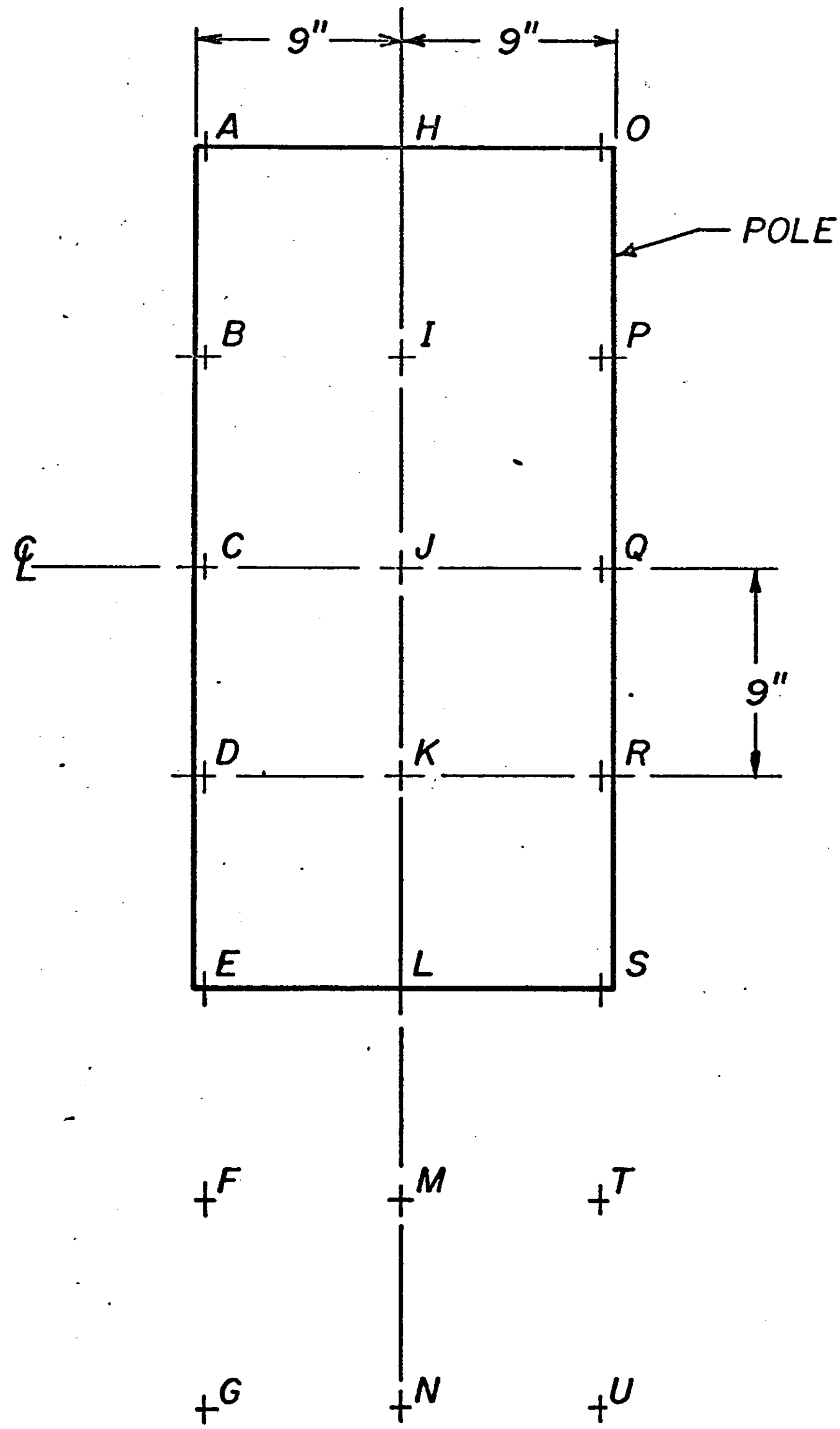


BENDING MAGNET
H18 x 36 - KW300



BENDING MAGNET
H18x36-KW300

FIELD MEASUREMENT POINTS FOR TABLES ON THE FOLLOWING PAGES ARE SHOWN BELOW:



BENDING MAGNET
H18x36-KW300

TEST DATA CURRENT : 250 AMPERES

POINT	AIR GAP 9"	12"	14"
A	5.9	4.65	4.1
B	7.45	5.85	5.2
C	7.55	5.85	5.25
D	7.45	5.85	5.2
E	5.6	4.85	4.1
F	1.4	1.33	1.28
G	.39	.3	.4
H	6.95	4.9	4.25
I	8.25	6.15	5.1
J	8.25	6.2	5.2
K	8.1	6.1	5.1
L	6.35	4.9	4.1
M	1.65	1.55	1.37
N	.44	.45	.4
O	6.	4.6	4.15
P	7.45	5.79	5.25
Q	7.45	5.85	5.3
R	7.39	5.85	5.2
S	5.67	4.6	4.
T	1.36	1.32	1.3
U	.39	.4	.33

BENDING MAGNET
H18x36-KW300

TEST DATA

CURRENT : 500 AMPERES

POINT	AIR GAP 9"	12"	14"
A	10.3	7.8	7.2
B	14.	11.1	10.2
C	14.2	11.45	10.25
D	13.56	11.2	10.3
E	9.9	8.5	7.8
F	2.56	2.55	2.5
G	.7	.7	.75
H	12.2	8.	6.8
I	15.9	12.1	10.3
J	16.	12.1	10.35
K	15.5	12.1	10.3
L	11.2	9.3	8.
M	3.	3.	2.7
N	.8	.75	.85
O	10.5	7.8	6.8
P	14.	11.4	10.1
Q	14.2	11.4	10.2
R	13.5	11.4	9.8
S	9.5	8.6	7.5
T	2.5	2.55	2.4
U	.7	.75	.5

BENDING MAGNET

TYPE: H18x36-10

SERIAL #: A1890

MANUFACTURER: SPECTROMAGNETIC INDUSTRIES

GAP IRON LENGTH (INCHES): 36

GAP WIDTH (INCHES): 18 13/16

GAP HEIGHT (INCHES): 9 NOMINAL

OTHER POSSIBLE GAP HEIGHT (INCHES): 12

MAX. OVERALL LENGTH (INCHES): 91

MAX. OVERALL WIDTH (INCHES): 57

ELECTRICAL CHARACTERISTICS PER MAGNET (9" GAP)

- CURRENT (AMP.): 583
- VOLTS: 300
- RESISTANCE (OHMS): .515
- POWER (KILOWATT): 175

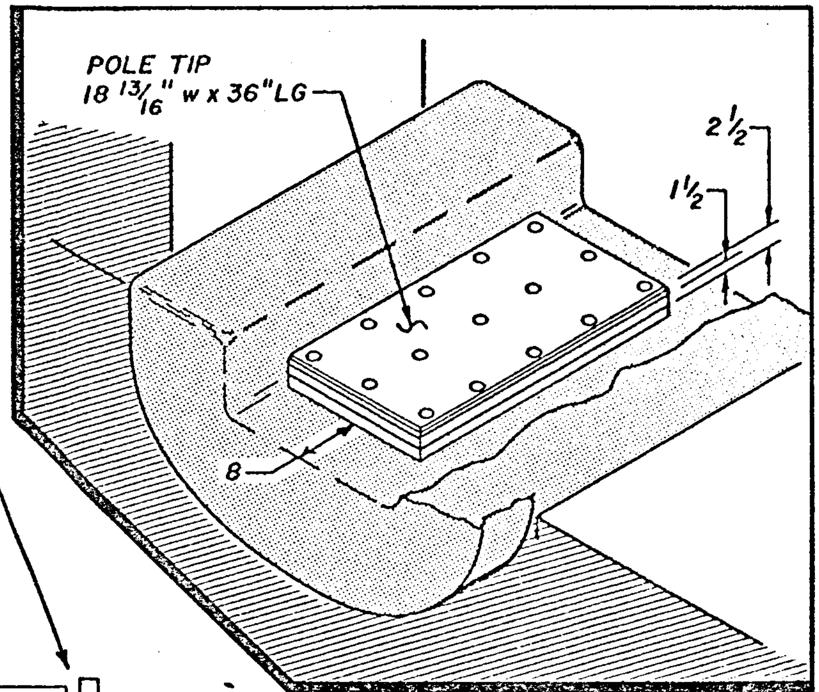
WATER

- GPM: 17
- INLET TEMPERATURE (DEGREE FARINH): 65 - 110
- OUTLET TEMPERATURE (" "): 75 - 150
- TRIP TEMPERATURE (" "): 194

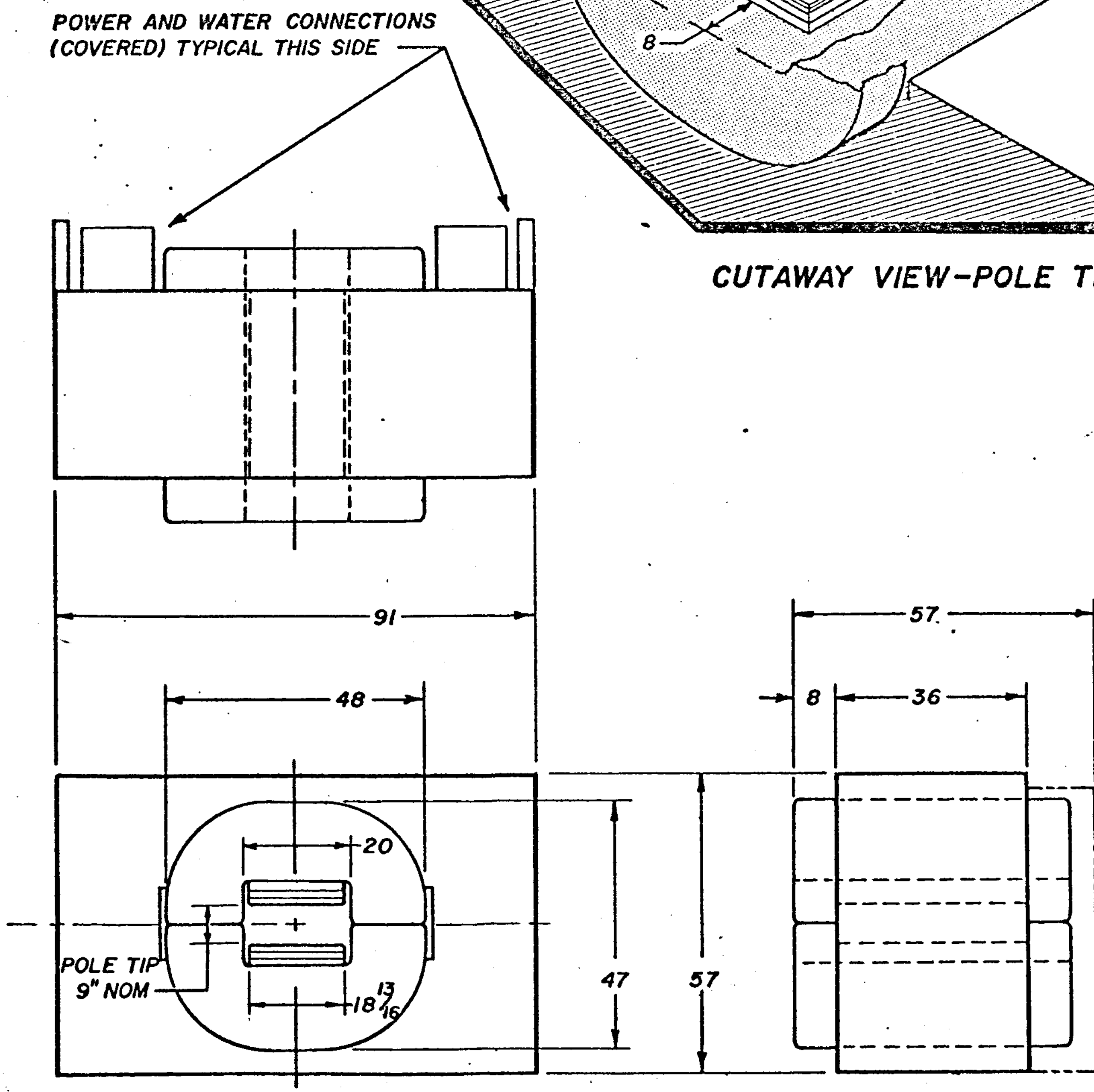
MAX. MAGNETIC POLE TIP FIELD (KILOGAUSS): 17.6

18 x 36 BENDING MAGNET
VERTICAL GAP 9"
175 KW

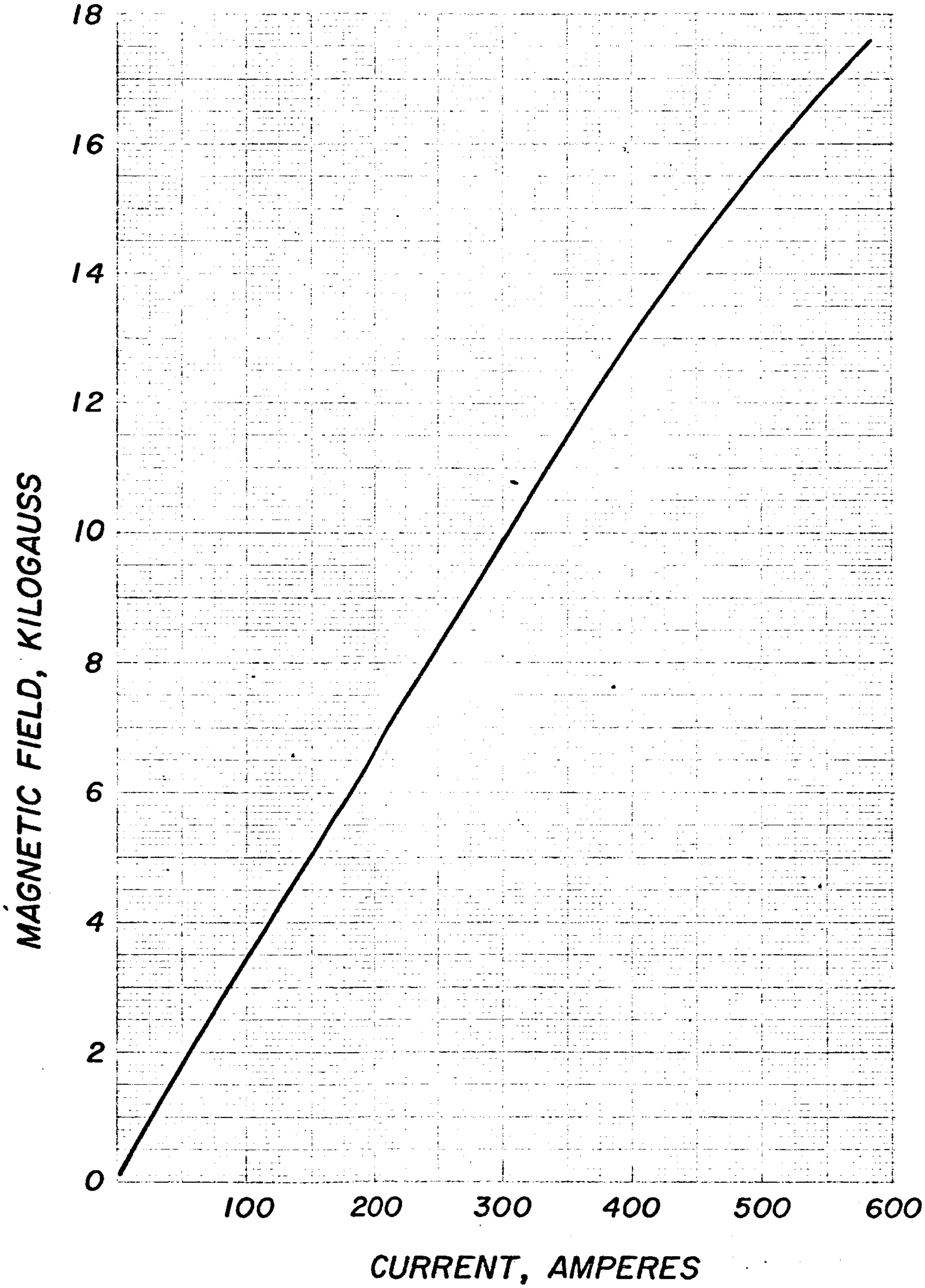
SERIAL NUMBER H-18 x 36-10
SPECTROMAGNETIC



CUTAWAY VIEW–POLE TIP

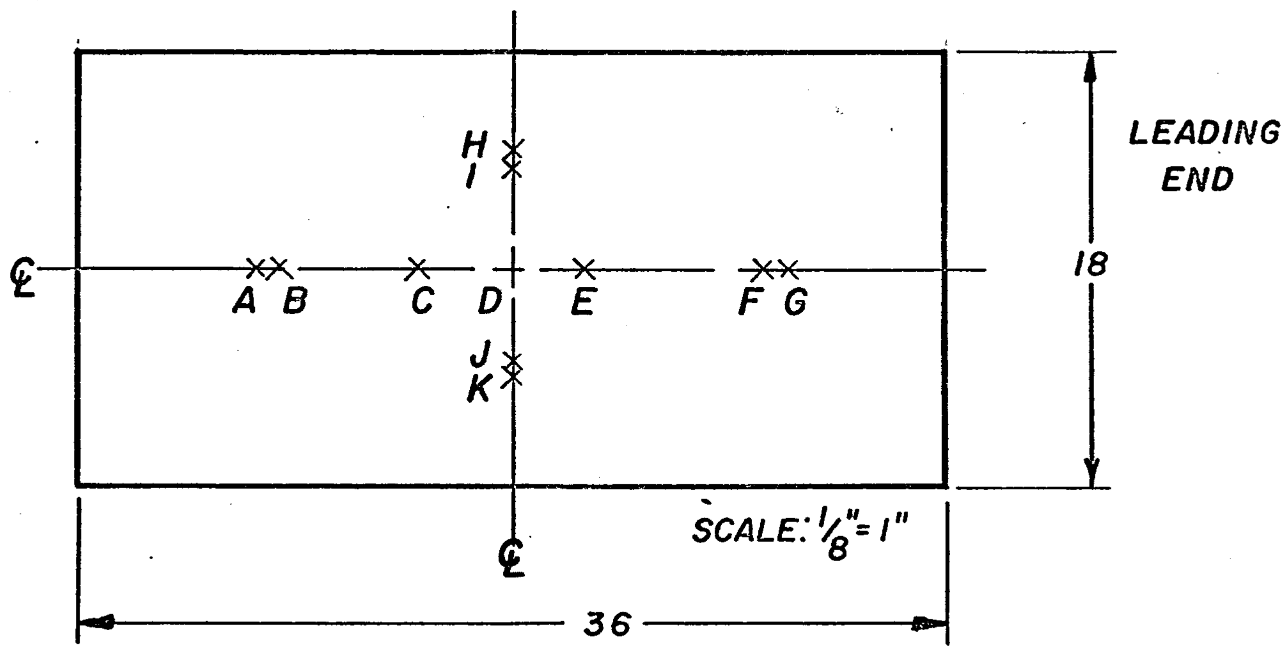


BENDING MAGNET
H-18x36-10 - KW175
MAGNETIZATION CURVE
SPECTROMAGNETIC



BENDING MAGNET
H-18 x 36-10 - KW 175

NMR PLOT AT 50% FIELD

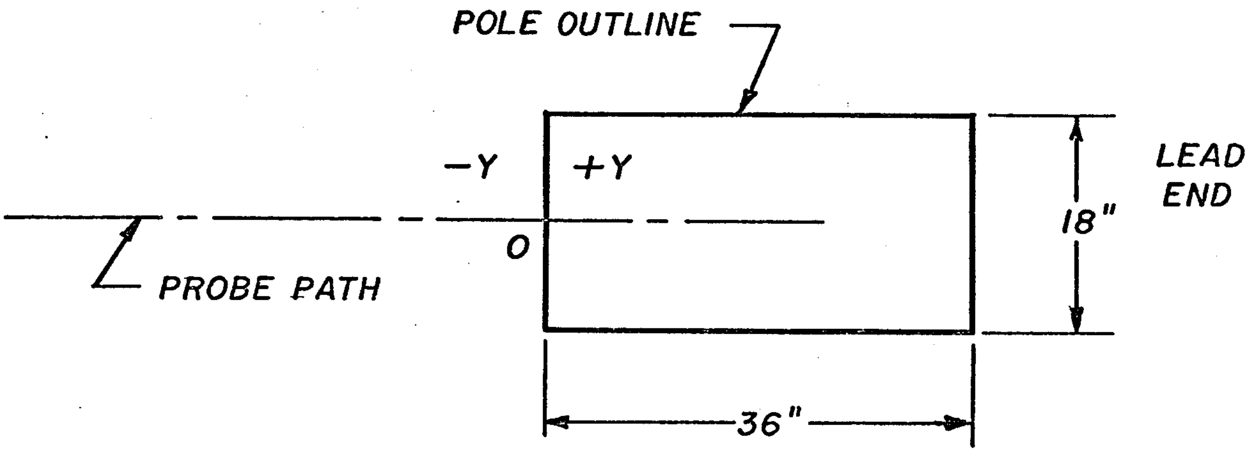


A = 8955	E = 8977	I = 8964
B = 8964	F = 8964	J = 8964
C = 8977	G = 8955	K = 8955
D = 8973	H = 8955	

ALL READINGS ARE IN GAUSS

BENDING MAGNET
H-18x36-10-KW175

FRINGE FIELD MEASUREMENTS WITH RAWSON PROBE



AT MAXIMUM FIELD			AT 50% FIELD		
FIELD			FIELD		
±Y	+Y	-Y	±Y	+Y	-Y
INCHES	GAUSS	GAUSS	INCHES	GAUSS	GAUSS
0	12645	12645	0	7298	7298
5	16489	6357	5	8886	3477
10	17378	2944	10	8978	1566
12	17495		12	8984	
15		1432	15		731
21.5		611	21.5		303

BENDING MAGNET

TYPE: H20x20

SERIAL #: S9972A

MANUFACTURER: PACIFIC ELECTRIC MOTOR COMPANY

GAP IRON LENGTH (INCHES): 20

GAP WIDTH (INCHES): 20

GAP HEIGHT (INCHES): 9 NOMINAL

OTHER POSSIBLE GAP HEIGHT (INCHES): 12

MAX. OVERALL LENGTH (INCHES): 104

MAX. OVERALL WIDTH (INCHES): 34

ELECTRICAL CHARACTERISTICS PER MAGNET (9" GAP)

CURRENT (AMP.): 570

VOLTS: 280

RESISTANCE (OHMS): .538

POWER (KILOWATT): 175

WATER

GPM: 45

INLET TEMPERATURE (DEGREE FARINH): 65 - 110

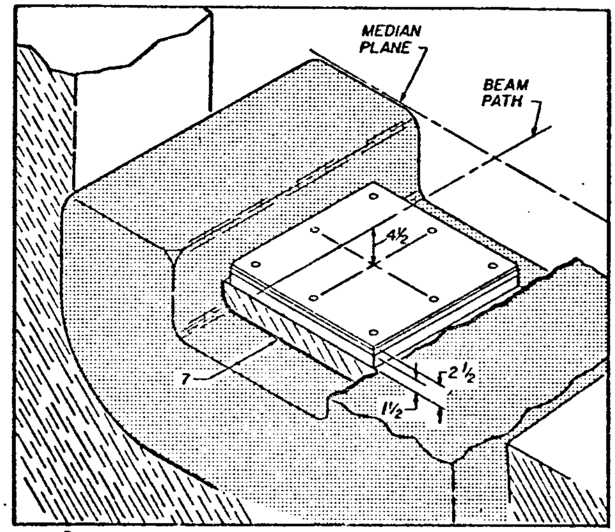
OUTLET TEMPERATURE (" "): 75 - 150

TRIP TEMPERATURE (" "): 194

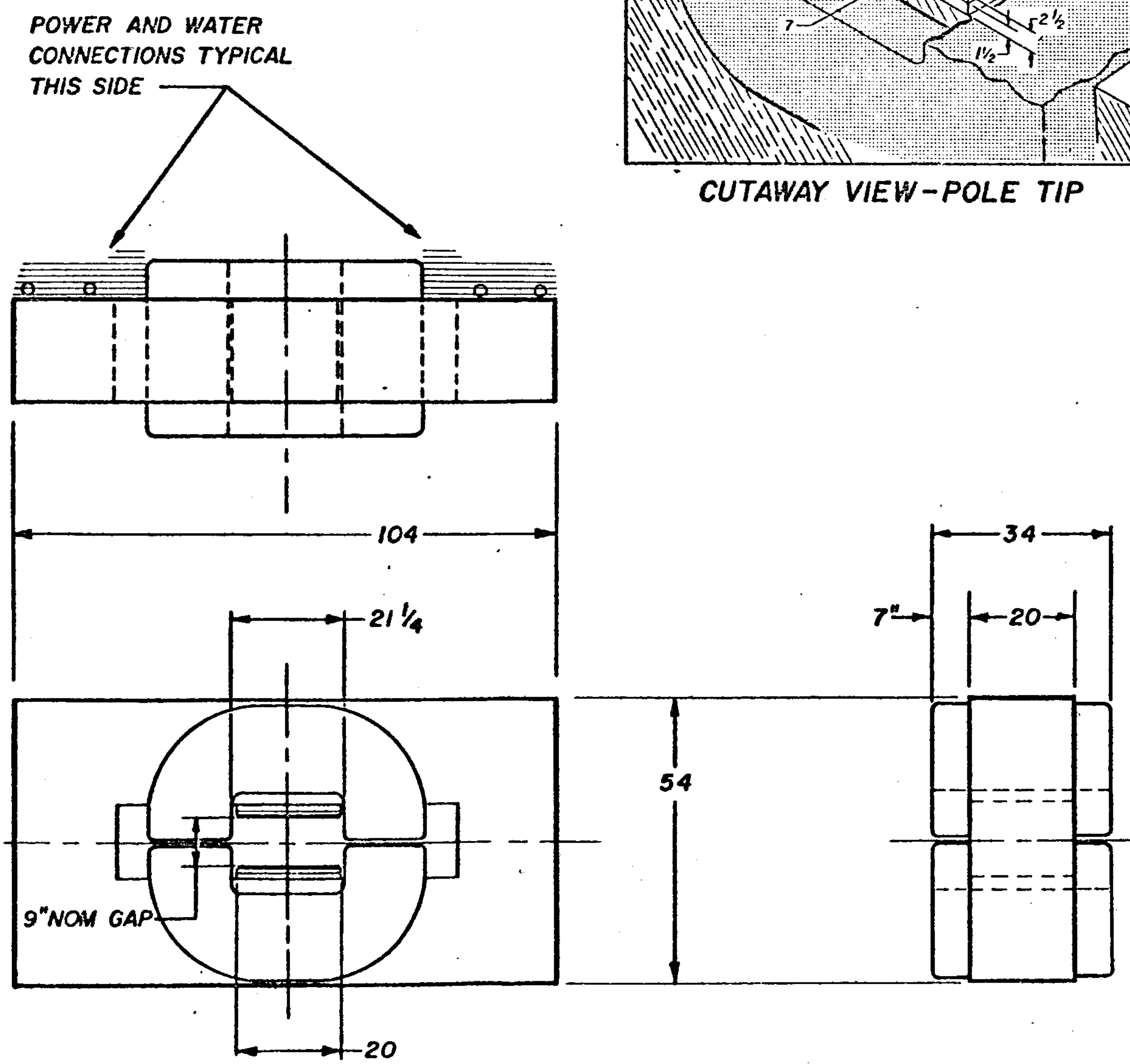
MAX. MAGNETIC POLE TIP FIELD (KILOGAUSS): 17.6

20 x 20 BENDING MAGNET
175 KW
VERTICAL GAP 9" NORMAL, 12" MAX

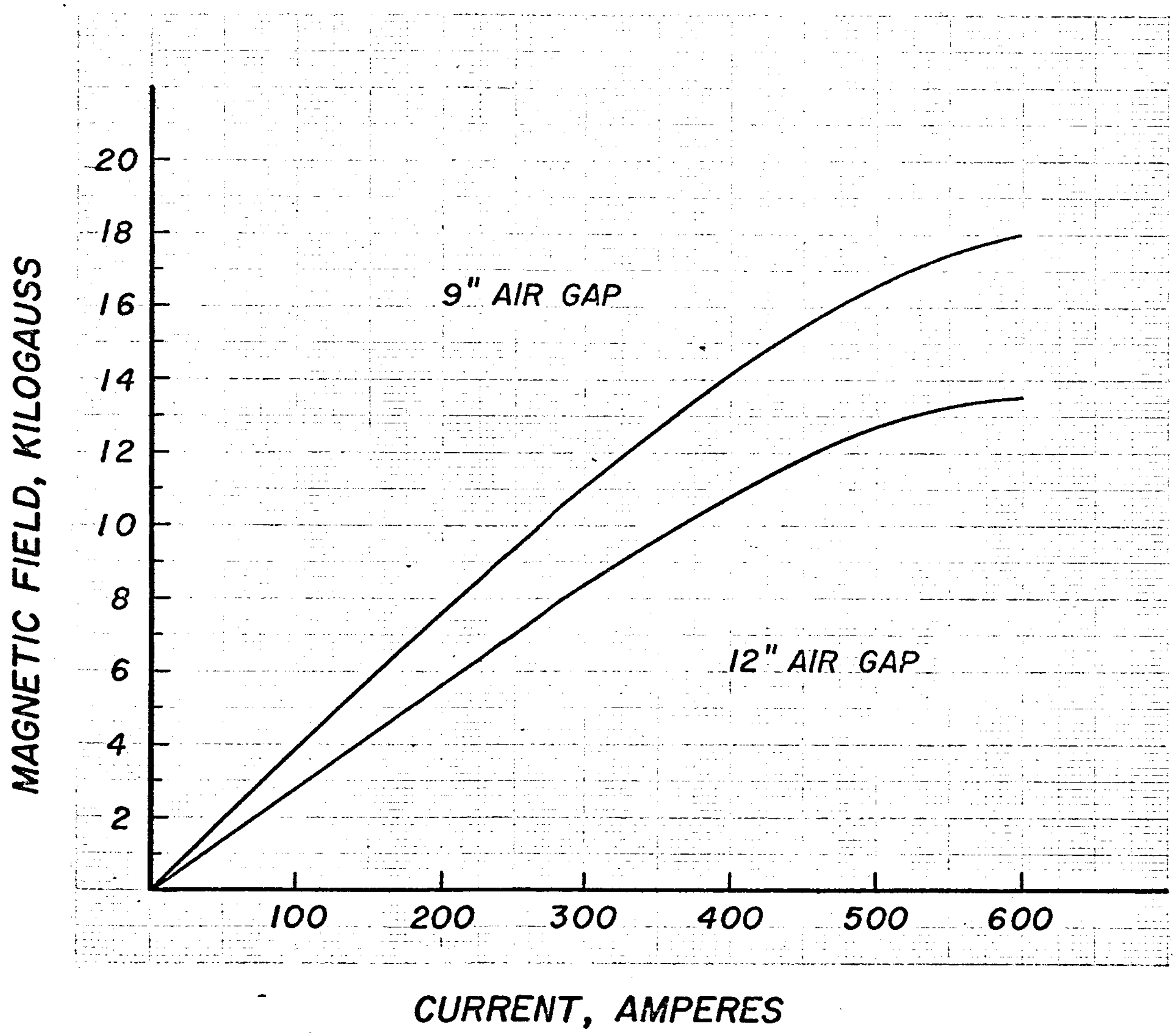
SERIAL NUMBER S-9972A



CUTAWAY VIEW-POLE TIP



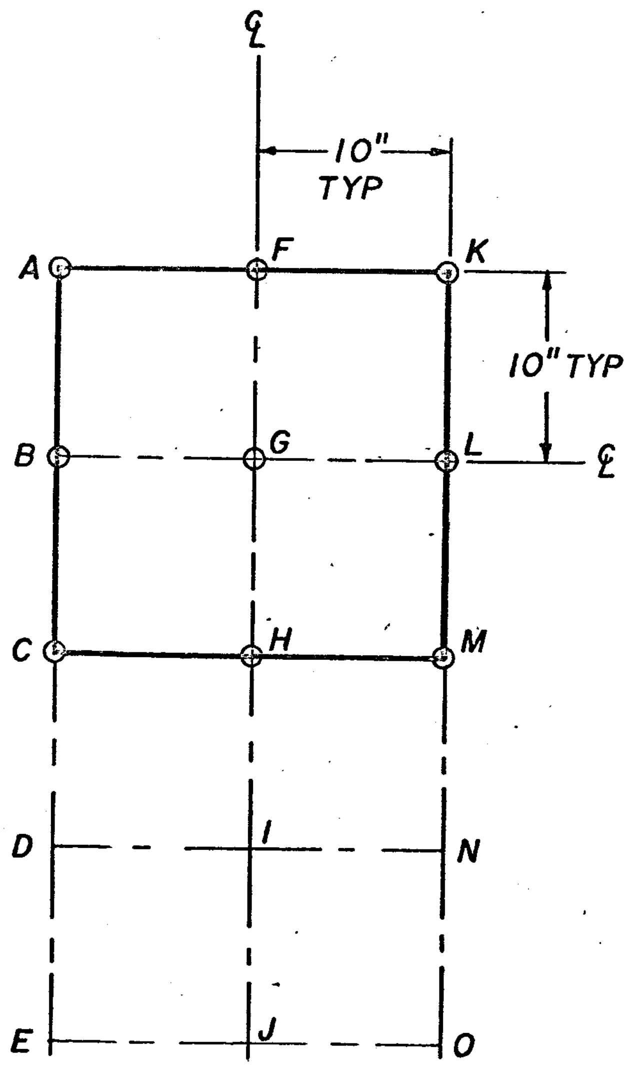
H20x20 — KW175
MAGNETIZATION CURVE
SERIAL NUMBER S-9972A



H 20x20 — KW 175
TEST DATA
SERIAL NUMBER S-9972A

AIR GAP 9"

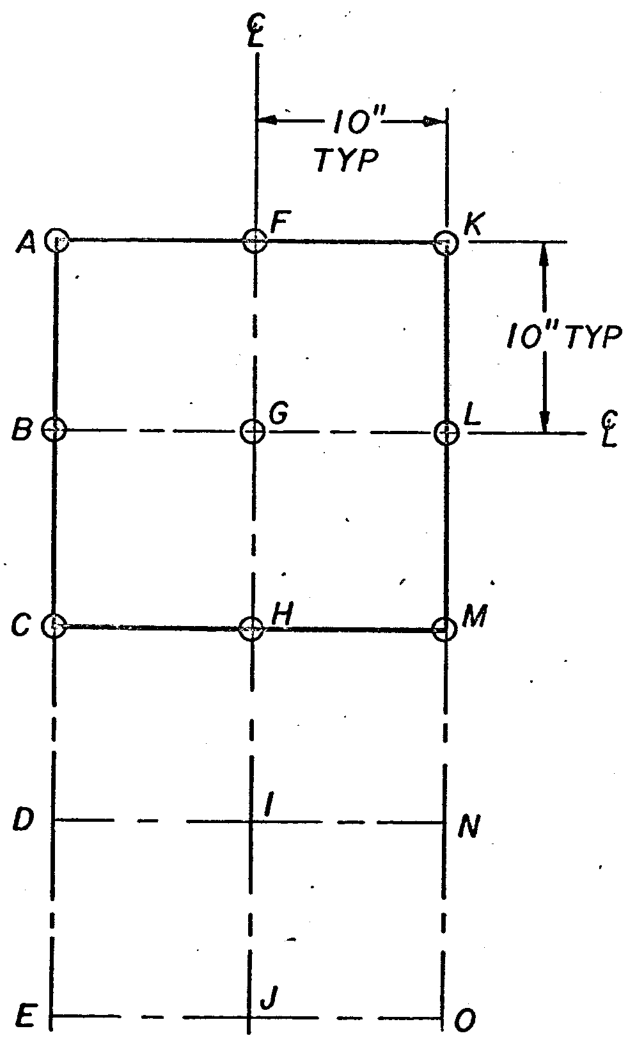
ALL READINGS IN KILOGAUSS



	150A	300A	450A	583A
A	4.0	7.35	10.3	12.0
B	4.05	9.5	13.7	15.2
C	3.8	7.35	10.3	12.0
D	0.84	1.65	2.36	2.67
E	0.22	0.415	0.572	0.673
F	4.5	8.65	12.1	14.0
G	5.6	10.85	15.4	17.8
H	4.4	8.65	12.2	13.85
I	0.995	2.0	2.86	3.24
J	0.26	0.48	0.662	0.77
K	4.0	7.35	10.2	11.8
L	4.95	9.5	13.68	15.6
M	3.85	7.25	10.0	11.7
N	0.84	1.65	2.3	2.7
O	0.22	0.405	0.58	0.665

H 20x20 — KW 175
TEST DATA
SERIAL NUMBER S-9972A

AIR GAP 12"
ALL READINGS IN KILOGAUSS



	150A	300A	450A	583A
A	3.2	6.12	8.56	9.75
B	4.0	7.8	11.22	12.58
C	3.125	6.05	8.5	9.85
D	0.83	1.62	2.3	2.59
E	0.225	0.425	0.594	0.686
F	3.44	6.7	9.5	10.7
G	4.22	8.25	11.8	13.35
H	3.44	6.7	9.65	10.8
I	0.965	1.88	2.7	3.12
J	0.26	0.409	0.705	0.808
K	3.15	6.19	8.8	10.1
L	4.0	7.85	11.26	12.87
M	3.18	6.15	8.8	9.96
N	0.85	1.64	2.3	2.64
O	0.222	0.42	0.605	0.69

IV SREL EQUIPMENT POOL

A. Rules for the Use of the Equipment Pool

B. Fast Counting Equipment ($\geq$ 100 MH_z)

C. Slow Counting Equipment ($\leq$ 50 MH_z)

D. Scintillation and Solid State Counters

E. Pulse Height Analyzers and Readout Equipment

F. Test Equipment, Power Supplies, etc.

G. Accessories

H. Scattering Chambers, Tables, etc.

A. Rules for the Use of the Equipment Pool

The equipment pool is designed for the use of experimenters at the SREL facility. It is composed of items of general utility which are added to the pool following recommendation by the SREL Users Advisory Committee.

1. An experimenter desiring to make use of a pool item during the run should forward a Pool Request Form to the Operations Section as far in advance of his scheduled run as possible. (A sample of this form is attached, and copies are available on request.) First priority on pool equipment belongs to the prime user; parasite users are given priorities in order of their specification as P, P', P", etc.

2. Upon occasion, equipment may be loaned from the pool for use by an experimenter at his home laboratory, in order that he may test it with the rest of his apparatus in advance of a scheduled run. Experimenters desiring such loan must fill out the form VP-5 (copy attached). Such loans will not be approved if they deplete the SREL stock of the items involved to a level which might interfere with experimenters running at the Laboratory. Furthermore, the items borrowed are subject to recall within 24 hours, (transportation being provided by the borrower), if circumstances require use of the equipment at SREL.

3. Users of the SREL equipment pool are requested to attach Repair Tags to equipment which fails during use. A brief description of the difficulty encountered should be written on the tag by the experimenter.

4. Experimenters may not modify, improve, deface, bend, spindle, or mutilate pool equipment. Repairs will be the responsibility of the SREL Electronics Shop, and if emergency repairs are required the cyclotron Operator on duty will arrange for them to be carried out.

SREL EQUIPMENT POOL REQUEST

Experiment No.__________________

Name of Experimenter__________________________

Address____________________

____

____

Dates for which Run is Scheduled______________ through ______________

Dates for which Equipment is Requested (fill out only if different from Schedule dates above) ______________ through ______________

Items Requested ____

____

____

____

____

Signed____________________

Date____________________

Send to: L. Lane
Space Radiation Effects Laboratory
11970 Jefferson Avenue
Newport News, Virginia 23606

SREL 11970 Jefferson Ave.
Newport News, Va.

APPROVAL FOR REMOVAL OF PROPERTY[1]
FROM
SPACE RADIATION EFFECTS LABORATORY

Form V.P.5

1. Property Description

2. Model ____________

3. Serial No. ____________

4. Manufacturer ____________

5. Identification No. ____________

6. Date to Be Removed: ____________

7. Date to be Returned: ____________

8. Purpose of Removal:

9. Condition (Include notation of any damage and statement of condition in Remarks)
( ) New
( ) Used

10. SREL Experiment No. ____________

11. Destination of Equipment: ____________

12. Remarks:

13. Remover[2]

____________ Signature ____________ Date

____________ Affiliation

14. Approval of D/SREL or his Delegate:

____________ Signature ____________ Date

15. Contracting Officer Approval (U.S. Government Property Only)

____________ Signature ____________ Date

16. Return Date: ____________

15. Condition
( ) Ordinary Wear & Tear
( ) Other (Explain in detail in Blank 10)

18. SREL Acceptance Signature: ____________

19. Date: ____________

[1] See Reverse Side for Instructions.

[2] By his signature hereon, the Remover agrees that the property described herein will be used only in connection with the experiments to be performed at SREL and that: (1) if title to the property described herein is held by the U.S. Government or by any party other than the Institution, the Commonwealth of Virginia, or any of its entities, however represented, he will save and hold harmless the Institution, and the Commonwealth of Virginia from any and all damages they may suffer as result of damage to or destruction of the property named herein before said property is returned to and accepted by SREL; (2) if title to the property described herein is held by SREL, he agrees, unless he is a SREL employee acting exclusively in the scope of his employment, that he is responsible for any and all damage to or destruction of the property named herein beyond ordinary wear and tear that occurs before said property is returned to and accepted by SREL.

B. Fast Counting Equipment

Mfr.	Model	Description	Number Available
Chronetics	21	Dual Delay	25
"	100	Powered Bin	12
"	CR-100	Extenders	6
"	101	Dual Discriminator	12
"	103	And/Or	16
"	105	Time to Pulse Height Converter	2
"	106	Dual Nanoamp	5
"	109	Prescaler	2
"	107	Dual And	4
"	111	Gate Generator	6
"	112	Dual Fan-In	5
"	114	Four Discriminator	6
"	115	Power Fanout	5
"	Nanocounter	Dual Scaler	20
"	M-150	NIMS Powered Bin	6
"	151	Deadtimeless Discr. (NIMS)	7
"	152	Logic Unit (NIMS)	14
"	154-S	Dual Discriminator (NIMS)	20
"	156	Dual Nanoamp (NIMS)	8
"	157	Dual And/Or	4
"	168	Dual Fan-In	4

B. Fast Counting Equipment (cont'd)

Mfr.	Model	Description	Number Available
EGG (ALL NIMS)	EX 100/N	Extender	4
"	M 104N	Powered Bin	6
"	M 101N	Unpowered Bin and Cable	5
"	C 126/N	Strobed Coincidence	5
"	C 144/N	Coincidence	8
"	TH 200A/N	Time to Pulse Height Converter	2
"	GG 200/N	Gate Generator	4
"	T 140/N	Quad Discriminator	3
"	TD 101/N	Differential Discriminator	4
"	LG 102/N	Linear Gate	3
"	GP 100/N	Pileup Gate	1

C. Slow Counting Equipment

Mfr.	Model	Description	Number Available
Ortec	109 A	Preamp	3
"	109 PC	Preamp	2
"	113	Scintillation Preamp	4
"	115	Preamp Power Supply	4
"	118 A	Charge Sensitive Preamp	4
"	260	Time Pickoff	2
"	401 A	Powered NIMS Bin	10
"	403	Time Pickoff	2
"	404	Inspector	2
"	407	Crossover Pickoff	2
"	408	Biased Amplifier	4
"	409	Linear Gate and Slow Coin.	2
"	411	Pulse Stretcher	4
"	413	Strobed SCA	2
"	414	Fast Coincidence	2
"	416	Gate and Delay Generator	2
"	417	Fast Discriminator	2
"	419	Precision Pulser (ARC Modular)	2
"	420	Timing SCA	4

C. Slow Counting Equipment (cont'd)

Mfr.	Model	Description	Number Available
Ortec	423	Particle Indentifier	1
"	426	Linear Gate	2
"	427	Delay Amplifier	4
"	437	Time to Amplitude Converter	2
"	428	Detector Bias Power Supply	2
"	440	Selectable Active Filter Amplifier	4

C. Slow Counting Equipment (cont'd)

Mfr.	Model	Description	Number Available
Canberra	1407	Reference Pulser	1
"	1410	Linear Amplifier	2
"	1410 A	Linear Amplifier	2
"	1416	Spectroscopy Amplifier	2
"	1435	Timing SCA	1
"	1445	Coincidence	3
"	1451	Linear Gate	3
"	1455	Logic Shaper and Delay	6
"	1463	Stretcher	7
"	1480	Linear Ratemeter	2
"	1492 D	Timer/Scaler	8

C. Slow Counting Equipment (cont'd)

Mfr.	Model	Description	Number Available
Baird Atomic - Cambridge Series			
"	CS-107	Scaler	4
"	CS-127	Scaler (15 MHz)	5
"	CS-200	Amplifier-Analyzer - H.V.	4
"	CS-400	Ratemeter	3
"	CS-905	Timer	4
ANC	IDD-100	Discriminator	2
Tennelec	TC-907B	Power Supply	1
"	TC-908	Power Supply	1
"	TC-200	Linear Amplifier	3
"	TC-250A	Biased Amplifier and Stretcher	1
"	TC-800	Precision Pulser	1
"	TC-135	FET Preamp	2
"	TC-930	Power Supply	2
Tomlinson	2000AEC	Beam Current Integrator	2

D. Scintillation and Solid State Counters

Mfr.	Model	Description	Number Available
Amperex	56 AVP	PM Tubes	3
"	58 AVP	PM Tubes	3
Ortec	216	Shield for 56 AVP	9
"	217	Shield for 58 AVP	3
"	269	PM Tube Base	8
Harshaw	12S12	3" x 3" NaI Xtal	2
"	20MB1S/A	5" x 4" NaI Xtal	2
Ortec	150-500	Si(Li) Detector	1
"	150-150	Si(Li) Detector	1
Princeton Gamma-Tech		Ge(Li) Detector	1
Linde	LD-10	Liquid N_2 Dewar	2
Solid State Radiations	100SBTM-500	Surface Barrier Transmission Mount Detector	2

E. Pulse-Height Analyzers and Readout Equipment

Mfr.	Model	Description	Number Available
Nuclear Data	ND-110	128 Channels with Victor Printer readout	1
"	ND-510	1024 Channels - in Modular Form, rolling rack-mounted, consisting of memory driver, punch-reader drive, master control, and Tektronix RM 503 Scope	1
"		4096 Channel ADC only in NIMS bin	2
RIDL	24-2	400 Channel Analyzer, on rolling table, with readout via H-P scope, Moseley Plotter, Franklin Printer, Tally or Magnetic Tape	1
Canberra	1500	Twin Digital Stabilizer	2
Kicksort	701	512 Channel Analyzer	1
"	860	Serial Converter (for 701 Analyzer) with Teletype Readout	1

F. Power Supplies and Test Equipment

Mfr.	Model	Description	Number Available
Fluke	405 B	Power Supply, 3 kv, 30 ma	9
Harrison	6525 A	Power Supply, 4 kv, 50 ma	1
Science Access.	002 A	Spark Chamber Pulser	2
Berkeley	GL-3	Pulse Generator	1
"	RP-2	Tail Pulse Generator	1
Hewlet - Packard	213 B	Fast Pulser	1
"	216 A	100 MHz Pulser	1
"	5245 L	Electronic Counter	1
"	415 B	Standing Wave Indicator	1
"	410 C	VTVM	2
General Radio	1218 B	Oscillator 900-2000 GM kz, with Power Supply	2
Tektronix	556	Oscilloscope	1
"	1A1	Plug-In	1
III	PC-33	10 MHz Pulser	1
E - H	139	20 MHz Pulser	1
Hamner		High-Voltage Distribution Box (Fan-Out)	5
Mechtronics	151	NIMS Bin (Powered)	6
Kepco	CK36-15	36 V Power Supply	6
Power Designs	3K-40	Power Supply	3

G. Accessories

Mfr.	Model	Description	Number Available
EGG	1T 100	Inverting Transformer	10
Ad-YU	10T 9B 1	Lumped Delay, 93Ω, 2 μsec	5
"	10T 5B 1	" " , 50Ω, 2 μsec	5
"	10T 9A 1	" " , 93Ω, 1 μsec	5
"	10T 5A 1	" " , 50Ω, 1 μsec	5
"	10T 5D 21	" " , 93Ω, 0.5 μsec	5
"	10T 5D 01	" " , 50Ω, 0.5 μsec	5
"	10T 9C 21	" " , 93Ω, 0.3 μsec	5
"	10T 5C 01	" " , 50Ω, 0.3 μsec	5
"	10T 9A 21	" " , 93Ω, 0.15 μsec	5
"	10T 5A 11	" " , 50Ω, 0.15 μsec	5
Lecroy	A 101	Variable 50Ω Attenuators	10

H. MISCELLANEOUS EQUIPMENT

1. Borated Polyethylene Shielding Blocks

4" x 12" x 12"	200
4" x 6" x 8"	300

2. Cathetometer - Gaertner M912, Horizontal - Vertical, reads to 0.01 mm, working distance 32 cm to ∞.

3. Portelevator Elevating Tables, 12

   Capacity 2500 lbs
   top plate 22" x 34"
   height adjustable

V SREL ELECTRON ACCELERATORS

A. Linac

B. Dynamitron

C. Neutron Generator

D. Linac Beams

E. Dynamitron Beams

F. Electron Beam Transport System

LINAC

The SREL Electron Linear Accelerator provides high energy electrons in the 3 - 10 MeV range. The electron beam produced can be used directly, or to produce γ-rays or neutrons through secondary reactions.

Basically, the electron linear accelerator consists of an injector, the accelerating waveguide, a system of electromagnetic and electrostatic lenses, a microwave RF system, and a pulse modulation system. In addition, there are the necessary power supplies, controls, and protective interlock circuits to operate the equipment. The injector produces the electrons which comprise the electron beam. The pulse modulation system operates the microwave RF system in very short bursts. The microwave RF system, operating at 1300 Megacycles (L-Band), creates the large voltage gradients within the accelerating waveguide which accelerate the electrons.

The following characteristics are applicable to the SREL linac:

Beam Energy: Continuously adjustable over the range 3 - 10 MeV.

Average DC Beam Current Measured at Machine Output:
up to 200μa at 3 and 10 MeV
up to 1000μa at 7 MeV

Beam Size at Machine Output: 1 centimeter.

Beam Emergence: 54 inches above floor level.

Angular Divergence: < 3 milliradians.

Pulse Length: The beam pulse length is continuously variable from 0.1 microsecond to 6 microseconds and stepwise in 10 nanosecond steps from 10 - 100 nanoseconds.

Pulse Repetition Rate: The pulse repetition rate is continuously variable from 10 - 360 PRS and at reduced pulse widths (3 microseconds) to 720 PPS. Single pulsing is also available.

DYNAMITRON

The Dynamitron Accelerator is a high voltage electron accelerator which provides an electron beam for direct use, or to produce γ-rays or neutrons through secondary reactions.

The Dynamitron consists of an evacuated acceleration tube powered by a constant D.C. potential supply. This power supply converts relatively low voltage R.F. power to high voltage D.C. power by means of a cascaded rectifier system driven in parallel from an R.F. oscillator.

The rectifier tubes which are connected in series between ground and the high voltage terminal, are positioned in two columns on opposite sides of the acceleration tube. The beam tube and the rectifiers are enclosed by a set of arcuate corona shields which are hollow metal tubes formed into a semicircular shape. These corona shields perform the dual function of suppressing sparks and corona discharges from the rectifier terminals and providing a large surface capacitance for coupling the radio frequency power to the rectifier tubes. The assembled high voltage elements, the beam tube, the rectifiers and the corona shields are positioned between a pair of large semi-cylindrical electrodes which form the tuning capacitance of an LC resonant circuit. The entire apparatus is enclosed in a grounded pressure vessel. The resonant inductance is toroidal in shape. It is mounted inside the pressure vessel at one end and is connected in parallel with the tuning electrodes. The vessel is filled with sulphur hexafluoride gas at high pressure to prevent sparking and corona discharge from the corona shields to the resonant electrodes.

The following characteristics are applicable to the SREL Dynamitron:

*Beam Energy:

Continuously adjustable over the range .5 - 3 MeV.

*Beam Current Measured at Machine Output:

From 10μa to 10 ma

Beam Size at Machine Output:

90% of total beam within 2 centimeters.

Beam Emergence:

54 inches above floor level.

Scan Mode:

Scanning rate 1 to 75 per second. Area from 8 - 24 inches.

*Notes:

Temporary restrictions have been placed on high voltage operation, limited to 2.5 MeV.

Beam current output is temporarily restricted to 250μa.

BEAM NO. L - 1

EAD-1

SREL LINAC-BEAM INFORMATION

1) Experiment No. - -

Date Nov. 9, 1967

2) Nominal Beam Energy: 4.1 Mev.

3) Area: Linac Room ______ Dynamitron Room ______ CTA X

REMARKS:

Beam Parameter Development Time

4) Main Magnet (Stray Field): N ______ R X AMPS -1850.

5) Peak Beam Current: EBM-1 240 ma. Other:

EBM-2 ----.

EBM-3 ----.

6) Target Current: Peak ----- Average 1×10^{-1} μa.

7) Modulator Power Supply: Voltage 15 KV., Current .2 AMPS.

8) Beam Pulse Width: 4 μS Pulse Rep. Rate: 10 PPS.

9) Injector: Voltage 90 KV., Current 15 μA.

10) Gun: Filament 65 %, First Anode 68 %, Injector Current ______ %.

11) Klystron: Magnet Current, 1 3.8 AMPS., 2 3.6 AMPS., 3 1.4 AMPS.

Vacuum, 0.5 μA.

12) Waveguide: Magnets, 1 5.7 AMPS., 2 3.3 AMPS.

Vacuum, 1 50 μA, 2 100 μA.

13) Buncher Phase 0 %, Buncher Drive 84 %.

14) Frequency 543 GHz., Tetrode Screen Voltage: 360 Volts.

15) Lens: 1 (50)2.3 AMPS., 2 (50)2.3 AMPS.

16) Injector Steering: VERT (37)1.5 AMPS., Polarity +.

HORZ (25) .8 AMPS., Polarity -.

BEAM NO. L - 1

EAD-1

17) Accelerator Steering No. 1: VERT. (70)4.7 AMPS., Polarity ----.
HORZ. (57)3.5 AMPS., Polarity ----.
No. 2: VERT. (30).4 AMPS., Polarity ----.
HORZ. (50).7 AMPS., Polarity ----.

18) Transport Steering:

Station No. 1 ---- AMPS.
Station No. 2 ~~H4.95~~ V5.48 AMPS.
Station No. 3 ------ AMPS.
Station No. 4 ------ AMPS.

19) Electron Beam Transport Magnet Settings:

MAGNET NO.	SHUNT (MV)	CURRENT (AMPS)	POLARITY (N/R)
EM-2	0.38 Dial		N
EQ-1	0.35		N
EQ-2	0.77		N
EQ-3	0.36		N
EQ-4	0.45		N
EQ-5	14.78mv		N
EQ-6	14.82mv		N
EM-5&7	0.40 Dial		N
EM-6	0.49		N

BEAM NO. L - 1 EAD-1

20) Details and/or Comments:

Beam spot size 1 cm diameter of 20 mil aluminum water cooled window.

BEAM NO. D - 1

SREL DYNAMITRON BEAM INFORMATION

1) Experiment No. ND 101 Date Feb. 27, 1968

2) Nominal Beam Energy: 2.0 MeV

Target Current 3×10^{-7} μa/ma

3) Area: Dynamitron Room X CTA ____

REMARKS:

Beam spot ≃ 1.5 cm.

4) Main Magnet (Stray Field): N X R ____ AMP 1850.

5) Oscillator: Filament 7.6 volts.

Grid .52 AMPS.

Anode 4.2 AMPS.

Anode 8.0 KV.

6) Power Supply: Control Tube 20.4 KV.

7) Tank Parameters: Upper RF Voltmeter 85 KV.

Lower RF Voltmeter 85 KV.

Corona Current 1.8 μa.

High Voltage 100 μa.

Beam Tube Divider 248 μa.

Internal Beam Current 157 μa/~~ma~~.

8) Steering Magnets: HORZ .8 AMPS., Polarity R.

VERT .3 AMPS., Polarity R.

Aux. Ext. 1.6 AMPS., Polarity F.

9) Beam Tube Vacuum: Base 5 $\times 10^{-7}$ TORR.

Operating 3.1 $\times 10^{-6}$ TORR.

BEAM NO. D - 1

EAD-2

10) Electron Beam Transport magnet settings:

MAGNET NO.	SHUNT (MV)	CURRENT (AMPS)	POLARITY (N/R)

11) Details and/or Comments:

Experiment set-up at 90 degree port of EM-3.

Window material, 2 mil titanium, air cooled.

BEAM NO. D - 2

EAD-2

SREL DYNAMITRON BEAM INFORMATION

1) Experiment No. ND 102 Date Mar. 4, 1968

2) Nominal Beam Energy: 2.0 MeV

Target Current 8.8×10^{-8} μa/ma

3) Area: Dynamitron Room X CTA ____

REMARKS:

Beam spot ≃ 1.5 cm

4) Main Magnet (Stray Field): N X R ____ AMP 1912.

5) Oscillator: Filament 7.4 volts.

Grid .6 AMPS.

Anode 3.8 AMPS.

Anode 7 KV.

6) Power Supply: Control Tube 20.8 KV.

7) Tank Parameters: Upper RF Voltmeter 85 KV.

Lower RF Voltmeter 85 KV.

Corona Current .4 μa.

High Voltage 104 μa.

Beam Tube Divider 249 μa.

Internal Beam Current 47 μa/ma.

8) Steering Magnets: HORZ .52 AMPS., Polarity R.

VERT .3 AMPS., Polarity R.

Aux. Ext. 1.6 AMPS., Polarity F.

9) Beam Tube Vacuum: Base 5×10^{-7} TORR.

Operating 2×10^{-6} TORR.

BEAM NO. D - 2

EAD-2

10) Electron Beam Transport magnet settings:

MAGNET NO.	SHUNT (MV)	CURRENT (AMPS)	POLARITY (N/R)

11) Details and/or Comments:

experiment set-up at 90 degree port of EM-3

Window material, 2 mil titanium, air cooled.

VI. DATA ACQUISITION SYSTEM

A. General Description

B. Guide to Nuclear Physics Interface Programming Language

C. Data Acquisition Programming - This is a revision of SREL Internal Report COMP-1

D. Description of Utility Programs - This is a revision of SREL Internal Report COMP-2

E. "Users Guide to the Remote Typewriter Support, Version 1" SREL Internal Report COMP-3

USE OF THE SREL DATA ACQUISITION SYSTEM

A. The SREL Data Acquisition System (DAS) is intended for on-line applications involving the various accelerators in the Laboratory. Those desiring to use the system should submit a completed form S/5 "Request for Use of the SREL Data Acquisition System" (sample attached) to the Head, DAS Section, SREL.

B. In order to provide users with the full power of the system, the SREL system will be available on a 24-hour basis to qualified users. The SREL group will supervise operation during the first shift, Monday through Friday. Second and third shift use must be covered by users who have applied for and received status as qualified users. The Head of the DAS Section will give a qualification examination to each prospective user.

C. Requests for use of the SREL Data Acquisition System will be scheduled according to the following priority sequence:

1) On-line user engaged in an experiment

2) On-line user preparing for an experiment which will start within one week

3) General systems work

4) On-line user preparing for an experiment which is more than a week from starting

FORM S/5
Revision 1
July 1, 1968

REQUEST FOR USE OF THE SREL DATA ACQUISITION SYSTEM

(To be Submitted to Head, DAS Section)

1. NAME____________________ DATE____________

   AFFILIATION____________________________

   ____

2. SREL EXPERIMENT NUMBER____________

3. PROJECT

   DESCRIPTION____________________________

   ____

   ____

   LENGTH a) CALENDAR INTERVAL FROM________ TO________

   b) ESTIMATED TIME (HOURS)____________

   DESIRED LOCATION OF INTERFACE. PROTON AREA____ MESON AREA____

4. PREPARATION: a) CALENDAR INTERVAL FROM________ TO________

   b) ESTIMATED TIME (HOURS)____________

   c) STAFF ASSISTANCE REQUIRED. YES____ NO____

5. SIGNATURE OF SPONSOR____________________

6. SREL DIRECTOR APPROVAL________________ DATE________

7. SREL JOB CODE____________

DATA ACQUISITION SYSTEM

I. General

The SREL computer is a 360/44 devoted to on-line, real-time applications. The primary programming language is FORTRAN IV-H and programs are compatible with any other computer using the H level.

The computer is put on-line to experiments thru the Yale-IBM interface. This interface is supported by the Yale-IBM data acquisition language, which appears to the user as an extension of FORTRAN.

II. Physical Characteristics

Presently, the user has at his disposal the interface itself, two 10-bit 25 MHz ADC's, four 15-bit 25 MHz scalers and four monitor registers. All these units are IBM built and directly compatible. Generally speaking, the electronics conform to slow-logic specifications, such as 3 volt logic levels, 100 nanosecond pulse lengths, etc.

Other nuclear physics instrumentation may be interfaced via the monitor registers.

The present facilities also include an input-output typewriter, cathode ray tube display with light pen, and function keyboard. The interface is available to both Phase I and Phase III users.

III. Restrictions

The maximum data rates are experiment dependent. Sustained rates of over 5000 events per second are not effectively supported by this system.

Provisions exist for recording data on magnetic tape in either 9-track or 7-track format. It is the user's responsibility to verify that his home facility can accept tapes generated at SREL; users should check with the SREL DAS group on this matter.

Tapes will be loaned for short times, but will not be given away.

IV. Caveat Emptor

Just as with an ADC, or any other device having a dead time, the DAS system can cause data to be lost. The loss is not in the computer, but at the interface, and will occur when data rates exceed those that can be sustained by the system. The two determing factors are the maximum transfer rates of the interface and its components, and the program written by the user to analyze his data. Consideration should be given to this in the design of experiments.

V. References

The interested user is referred to the following sources of information:

1) 44PS FORTRAN, IBM #C28-6515 - The standard FORTRAN language is described.

2) 360/44 Functional Characteristics, IBM #A22-6875 - The 360/44 is described in some detail. Familiarity with this manual is not prerequisite to use of the computer.

3) Gelernter et al, "An Advanced Computer-Based Nuclear Physics Data Acquisition System", Nucl. Instr. and Meth., 54, 77-90 (1967). This article was written by the Yale/IBM group and describes the system in some detail.

4) Functional Specification, Scientific Interface Control Unit (IBM). This document describes in detail the electronic characteristics of the interface and components. Knowledge of its contents are essential to the system user. Copies may be obtained from the SREL DAS group.

5) Introduction to the SREL On-Line Computer Programming System - This document describes in detail the

programming system characteristics. Knowledge of its contents are prerequisite to any use of the interface. A revision of this document is included as part C of this section.

6) Utility Programs: Descriptions and Instructions - A revision of this document is included as part D of this section.

7) Joel Birnbaum and Martin W. Sachs, "Computers and Nuclear Physics", Physics Today, July 1968, 43-51. This is a survey article covering computer controlled data acquisition. As most of the examples come from the Yale system, it is very useful as an introduction.

SREL USERS' GUIDE TO THE NUCLEAR PHYSICS INTERFACE PROGRAMMING LANGUAGE

Preliminary Operating Version

This version deals only with the interface itself, and not with either the display or the I/O typewriter.

I. Introduction

The user is given a set of FORTRAN-like statements which may be included in his own data acquisition program.

The purpose of these commands is to allow the user to

1. create devices
2. use devices
3. use particular data words,

all within the framework of the FORTRAN language.

II. Devices

The following devices may be created (henceforth, the word "specified" will be used):

1. analyzers
2. gates
3. scalers

Appendix A covers these in detail.

The devices are used via "action" statements, which are covered in Appendix B, and are equivalent to their electronic analog receiving a signal.

III. Variables

It is possible to use the contents of the data words received from the interface, in just the same way as a normal FORTRAN variable would be used.

Appendix C treats this in detail.

IV. Data Flow

Recording data on magnetic tape is accomplished without user intervention except to exercise an option on a control card.

The size of the buffer into which the interface reads its data is also specified on a control card. The following considerations are pertinent to the choice of the buffer size:

1) each component in the interface transfers one-half word to the computer.
2) an ID half-word precedes each event data-string.
3) processing by the user's program does not start until the buffer has been filled, not as each event data-string enters the computer.
4) the programming system needs one additional buffer the same size as the user's buffer.

These considerations, coupled with the limited amount of main memory, the time required to process each event, and the expected data rate should lead to the choice of buffer size.

Appendix D covers the control card options.

Specification Statements

We will follow the plan to 1) verbally describe the device, 2) describe it using the precise notation of PL/I, and 3) show examples of use in a program.

1. Analyzers

Any number of analyzers with variable gain and (as many as five) contiguous discontinuous ranges may be specified. These analyzers may be either half-word (32K) or full-word (2×10^9) in individual channel capacity. They may analyze from one to seven parameters. These devices act as conventional analyzers in that they add (or subtract) one to storage whenever a datum is presented to them.

The analyzer specification statement is

ANALYZER [*4]: analyzer-name(analyzer-spec)[;analyzer-name(analyzer-spec)]...

where
analyzer-name: up to six characters
analyzer-spec: (analyzer-parameter-list) [(analyzer-parameter-list)]...
analyzer-parameter-list: region-specification [,region-specification]...
region-specification: integer-1 [,integer-2, integer-3]
integer-1: integer-constant

Note: integer-1 is the number of bins onto which channels integer-2 through integer-3 are to be mapped. If only integer-1 is specified a one-to-one correspondence is assumed between bins and channels.

We present some examples. These statements would appear before the first executable statement in the user's program.

ANALYZER: ANA1 (1024, 0, 1023); ANA2 (256, 0, 1023); GAMMA (100, 0, 199, 200, 200, 399, 1, 400, 799, 224, 800, 1023); BETA (1024).

This statement specifies the four analyzers ANA1, ANA2, GAMMA and BETA, all four will count to 32K per bin. ANA1 is one-to-one in bins to electronically defined channels. ANA2 is of coarser resolution, one bin per four channels. GAMMA has four distinct ranges, the first is two-to-one, the second is one-to-one, the third puts all counts from channels 400-799 in one bin and the last is one-to-one. BETA is the same as ANA1, and demonstrates an alternative way of describing a one-to-one analyzer.

ANALYZER *4: ALPHA (1024)
This is a full-word one-to-one analyzer.

ANALYZER: TWØP (128, 0, 1023) (32, 0, 1023)
This is a half-word two-parameter analyzer, accepting input from 10-bit ADC's and occupying 2048 words of storage.

ANALYZER: ANA3 (256, 0, 511, 256, 768, 1023)
This is a half-word one-parameter analyzer with two discontinuous ranges. The first 512 channels are mapped onto the first 256 bins, channels 512 through 767 are neglected and channels 768 through 1023 are mapped one-to-one onto bins 257 through 512.

Note: If discontinuous ranges are specified, the data acquisition language creates dummy ranges to fill the specification. The <u>total</u> (actual plus dummy) number of ranges must be $\leq$ five.

The above examples assumed that only ten-bit ADC's were available to the physicist.

2. Gates

Any number of gates may be specified. Each gate may hold up to some number of counts which, when exceeded, causes transfer to a user-specified routine. Each gate may be of up to seven parameters, one window per parameter.

The gate specification statement is

GATE: gate-name [gate-spec] [;gate-name(gate-spec)]...

where

gate-name: up to six characters

gate-spec: ([limit,] statement number / subroutine name)

limit: integer constant <if not specified limit = 2^{31} -1>

window-list: (window-spec) [(window-spec)]...

window-spec: (integer-constant-1, integer-constant-2)

integer-constant-1 specified the lower window limit

integer-constant-2 specifies the upper window limit

Examples:

```
GATE:  BEAMG (1, BEAMQ) (0, 100) (10000, 1000000);
       GATENG (100, ATLAST) (0, 2) (5, 20)
```

The first gate, BEAMG, could be used as a monitor, transferring control to an error subroutine, BEAMQ, when the number of valid events dropped too low (between 0 and 100) and the beam count remained acceptable (between 10000 and 1000000). The second gate, GATENG, might total the events which lie between channels 0 - 2 and 5 - 20 of a two-parameter analyzer, transferring control to the subroutine ATLAST when 100 such events have been accumulated.

3. Scalers

Any number of pre-settable scalers may be specified. The scaler specification statement is

SCALER: scaler-name [scaler-spec] [;scaler-name(scaler-spec)]...

where

scaler-name: up to six characters

scaler-spec: ([limit,] $\left\{\begin{array}{l}\text{statement number}\\ \text{subroutine name}\end{array}\right\}$)

limit: integer-constant < if not specified, limit = $2^{31}-1$ >

examples

SCALER: GAMS; SCALE1 (32768,3); SCALE2 (5,REST)

This statement specified three scalers. The first, GAMS, will count up to 2,147,483,647 and then start over. The second, SCALE1, will count to 32768 and then cause a transfer to statement 3. The last, SCALE2, will count to 5, and transfer control to subroutine REST.

4. General Comment 1

If a device is to be referred to by a subprogram other than the one in which its specification statement appears, a specification statement of abbreviated form must appear. The form is

$$\left\{\begin{array}{c}\text{ANALYZER}\\ \text{SCALER}\\ \text{GATE}\end{array}\right\} : \text{name}$$

An example is

ANALYZER: ANA1

GATE: GATENG

5. General Comment 2

If a scaler or gate uses a subroutine - name in its specification statement, such as

GATE: G1 (1, EXIT) (1,1000)

then the subroutine named must appear in an EXTERNAL statement, vis.,

EXTERNAL EXIT

6. General Comment 3

Specification statements are related to FØRTRAN DATA initialization statements, hence they may not use variable for the values of limits, windows, etc.

Action Statements

These statements are equivalent to executable FØRTRAN statements. They may also appear in the user's data acquisition program.

I. Statements whose analog is the receipt of the data signal by an electronic device.

1. Analyzer

It is possible to add or subtract from storage by using PHA or NPHA, respectively. The form is

[N]PHA: analyzer-name (list) [;analyzer-name (list)]...

where

analyzer-name: the name of a specified analyzer

list: Parameter [,parameter]...

parameter: integer-constant|full-word-integer-variable|arith.expr. denoting which word(s) from the event data stream are used.

Example:

PHA: ANAI (5); GAMMA (SG)

This causes the analyzer ANAI to use the 5th data work in the data-string as its own datum. It also causes analyzer GAMMA to use the data word specified by the current value of the variable SG; there would have to be some other statement in the program giving SG a legitimate value.

PHA: TWØP (3,5)

This causes the two-parameter analyzer TWØP to act on the contents of the 3rd and 5th words of the string.

2. Gate

There are two types of gates, differential and integral.

a. Differential gate

This type of gate acts in a conventional manner. If the values of the parameters specified in the "action" statement all lie within the limits set for them in the "specification" statement, the count of the named gate is incremented by one. Its action statement is of the form

DGATE: argument [;argument]...

where

argument: gate-name (list)

gate-name: the name of a specified gate

list: parameter [,parameter]...

parameter: integer-constant|full-word-integer-variable|arith. expr. denoting which words from the event data stream are used.

Example:

DGATE: BEAMG (1,2); GATENG (6,7). This causes gate BEAMG to use the first two data words, in the input string from the interface, as its data. It causes gate GATENG to scan words 6 and 7 and use them both as its data.

b. Integral Gate

This type of gate acts on an analyzer. The bins of the analyzer falling within the limits indicated in the gate specification statement are totaled and stored in the gate-name location. The form is

IGATE: argument [;argument]...

argument: gate-name (analyzer-name)

gate name: the name of a specified gate

analyzer name: the name of a specified analyzer

Example:

IGATE: IG4 (ANALI)

where previously specified might have been

GATE: IG4 (1000000, FINE) (0, 1023)

The gate IG4 acts to total the number of counts received by ANALI, and transfers control to subroutine FINE when 10^6 counts are totaled.

3. Scaler

The scaler action statement is of the form

SCALE: argument [;argument]...

where

argument: {scaler-name(parameter) | integer-name (parameter) [(limit) exit]}

scaler-name: the name of a specified scaler

integer-name: an integer variable used as an immediate scaler

limit: integer-constant|full-word-integer-variable|arith. expr.

exit: (statement number)|subroutine name[(subroutine parameters)]| (N[O] E[XIT])

parameter: integer-constant|full-word-integer-variable|arith.expr. denoting which words from the event data stream are used

*Note: The NO EXIT option prohibits limit checking

Example:

SCALE: GAMS (5); SCALE2 (1)

This causes the scaler GAMS to increment its contents by the value of the 5th data word. The scaler SCALE2 will use data word 1 as its datum, and will transfer control to subroutine REST when its contents exceed five (see B.1.3).

SCALE: TEMP (4) (DYNAM) (FINE)

This creates a scaler on the run, so to speak, and uses the full-word-integer-variable TEMP as its storage location. The datum is the contents of data word 4, the limit DYNAM is a full-word-integer-variable and when it is exceeded, control is transferred to subroutine FINE.

*Note: This statement is merely a convenience for the user and generates the code:

```
TEMP=TEMP + DATAWD (4)
IF (TEMP.GT.DYNAM) CALL FINE.
```

It is not permissible to use either VALUE or $VALVE with TEMP, in contrast to a scaler specified in a SCALER statement.

General Comment

It is possible, in the action statements, to override an exit given in the specification statement for a gate or scaler. This overriding exit has control for only the single action statement and after its execution the exit reverts to the one given on the specification statement for this device.

The form of the action statement in this case is

$$\left\{\begin{array}{l}\text{IGATE:}\\ \text{DGATE:}\\ \text{SCALE:}\end{array}\right\}\text{argument [exit]}$$

where

argument: see page VI B B 2

exit: (statement number)|subroutine name[(subroutine parameters)]|
(N[O] E[XIT])

*Note 1: The NO EXIT option prohibits limit checking

*Note 2: Subroutines may have parameters specified in the overriding exit but may not have any in the specification statement.

II. Statements that are for general control of the data acquisition process.

1. CLEAR

This is used to initialize all components to zero value. Its form is

CLEAR argument [;argument]...

where

argument: analyzer-name|gate-name|scaler-name

Example:

CLEAR: NAN1; ANAZ; GAMMA; BETA; BEAMG; BEAMQ; GATENG; GAMS;
SCALE1; SCALE2; IG4

This statement sets the contents of all the named (pre-specified) devices to zero.

2. CREATE

This is used as part of the bookkeeping routine. It must be used <u>before</u> any specified device may be mentioned in an action statement.

Its form is identical to that of the CLEAR statement.

3. ENTER EVENT MODE

This statement defines, for the programming system, the logical start of the individual event packages. An example is given in Appendix E.

4. EVENT

This statement has two forms

a. EVENT integer-constant [:comment]

This defines the beginning of a particular event. It should be understood that the event number corresponds to one of the sixteen event-signals on the interface.

If the integer-constant is zero, the i.d. word is ignored and all the buffer unscrambling is the user's responsibility. If the i.d. word is suppressed by putting the I.D. INHIBIT switch in the "inhibit" position, then EVENT 0 must be used, since there simply will be no i.d. word in the data string. This latter technique might be used to process data at the maximum possible bookkeeping.

b. EVENT END [:comment]

This defines the end of a particular event.

Examples are given in Appendix E.

5. BUFFER END

Execution of this statement suspends further processing of the current front end data buffer. The next event to be processed will be from the next buffer. This statement should be given in place of EVENT END when used.

6. EVENT 0

An EVENT 0 routine may be used to gain access to the entire buffer, at which time the user has complete control over and responsibility for management of all data words in the buffer. Within a buffer, DATAWD (0) refers to the first word in the buffer, and DATAWD (N) refers to the N-1st word. The routine is terminated with EVENT END or BUFFER END. If EVENT 0 is present in the user's program, it will be executed prior to the other event routines.

This routine may be of special value to users who are not doing conventional low energy physics experiments. In the case of a spark chamber experiment, the user could inhibit transmission of the i.d. word by means of the interface front panel switch, and deliver his data serially (in words the width of say one or two monitor registers) until it is exhausted. By tagging the start and finish of his data, he would then be able to process it as he wishes, and not be charged with the overhead of all the unnecessary i.d. words.

It should be noted that the programming system is designed to support buffers that contain i.d. words, and that some of its self-checking features will be nullified by use of EVENT 0, putting a greater responsibility on the user.

7. LØC

This is an absolute location routine, the result returned is the absolute location in storage of the argument. It must be specified as

```
INTEGER    LØC
```

The form is

```
LØC (argument)
```

where

argument: variable name

8. EXAMINING THE BIT STRUCTURE OF A WORD

A. GETBIT

This must be specified as

INTEGER GETBIT

Its form is

GETBIT (var, bitl, nbits)

where

var: a full-word REAL, INTEGER or LØGICAL variable

bitl:
nbits: full-word INTEGERS

The variable var is inspected and the nbits bits beginning with bit bitl are right shifted and returned (as a full-word integer) as the result. If bitl and nbits are omitted, they are taken to be 0 and 32, respectively.

Note that the bits of a word are numbered 0 thru 31, from left to right.

B. GETBTI

The use and definitions are exactly those above, except that

var: LOC (argument)

rather than a variable name.

Example:

GETBIT(4192,5,6)

and

GETBTI(LOC[4192],5,6)

both return bits 5 through 10 of the constant 4192 as a decimal integer (since 4192 is the hexadecimal 1060, the value returned is 3, which can be seen by writing 1060 as 0001 0000 0110 0000).

9. PROGRAM SIMULATION OF EVENTS

It is possible for the program to simulate events. This can be used, for example, in order to transform data before doing a PHA, as in a software particle identifier, when it is desired to record the identifier spectrum.

The following statements transmit the location of the simulated event to the data acquisition mechanism:

```
EXTERNAL $POINT
CALL $PUTAT(LOC(ARRAY),$POINT,0)
```

ARRAY is an INTEGER*2 array containing the simulated event data. The PHA routine, for example, will treat the words as channel numbers. For use with PHA, DATAWD, and other routines which normally access the data buffer, the first work of this array is word 0.

For example, if a normal event is used for 2-dimensional pulse height analysis, the statement PHA:ANAL(1,2) is used. If the simulated event contains the two channel numbers, in ARRAY(1) and ARRAY(2), the corresponding PHA statement is PHA:ANAL(0,1).

In PROCESS, SAVE, SAMPLE, and REPLAY, $PUTAT must be called each time the operation is performed, i.e., within each event routine using simulation. In COPY and NODATA, simulation may also be used, and $PUTAT need only be called once.

If, in PROCESS, SAVE, SAMPLE, and REPLAY, an event routine is to return to processing the true event after it has worked with a simulated event, it is necessary to restore the original information at location $POINT. The following procedure should be used:

```
      EXTERNAL $POINT
      INTEGER $GETAT
      ITEMP = $GETAT($POINT,0)
      CALL $PUTAT(LOC(ARRAY),$POINT,0)
      PHA:ANAL(0)
C     USES ARRAY(I) AS A CHANNEL NUMBER
        CALL $PUTAT(ITEMP,$POINT,0)
C     RESTORES THE ORIGINAL EVENT
```

10. JOB TERMINATION

The proper way to terminate a job is to call the routine EØJS (end-of-job-step). The proper form is

```
CALL EØJS (I,J,K)
```

where the user supplies the values of the three integers I, J, K.

I	0 indicates normal job termination 1 indicates abnormal end of job and will cause a dump if one was requested on the job card
J	is an integer from 0 to 255
K	is an integer from 0 to 65535

J and K will be printed out on the console typewriter. They may be used as identification features, say with J to identify a subroutine and K the particular error. Both J and K may be zero.

Variables

Any data word in the input string may be used as a conventional FØRTRAN variable. Certain built-in functions simplify their use. The following functions are all of the full-word-integer type. Arithmetic expressions may appear in their argument lists.

Note that it is necessary to specify the type of a FØRTRAN function. See pp. 94-95 of the FØRTRAN manual.

1. DATAWD

This form is

DATAWD (argument)

where

argument: integer constant|full-word-integer-variable|arith. express.

If the argument has the value i, then the value of the function is the value of the i-th data word in the current event.

Example:

```
VI=5.0*DATAWD (3)/BETASQ + DATAWD (6* I - 7)
```

2. INTMR

Its form is

INTMR (arg-1, arg-2 [,arg-3])

where

arg-1: points to a data word in the current event.

arg-2, arg-3: bits arg-2 thru arg-3 of the referenced data word are converted to an integer and become the value of the function.

$0 \leq$ arg-2 $\leq$ arg-3 ≤ 15, if arg-3 is not stated, it is taken to be 15

Example:

A monitor register produces the 3rd word in the data string of the current event. The user chooses to set into switch 0-5 the number of scalers in an experiment, as a check, and assumes when he writes the program that NSCAL scalers should be present.

```
     If (NSCAL.NE.INTMR (3, 0, 5)) GØ TØ ERRØR
     .
     .
     .
```

3. LØGMR

Its form is

```
     LOGMR (arg-1, arg-2)
```

where

arg-1: points to a data word in the current event

arg-2: integer constant|full-word-integer-variable

Whenever a bit is 1 in arg-2, the corresponding bit in the data word is tested.

If all the bits tested are 0, or if no bits are tested, the value of the function is 0.

If all the bits tested are 1, the value of the function is 1.

If some of the bits tested are 0 and some are 1, the value of the function is -1.

It should be noted that the 360/44 is a hexadecimal machine, counting from 0 thru F. It stores four characters to a word. The safest way to construct the mask, i.e., the bit pattern in arg-2, is to use a DATA statement and hexadecimal form.

Example:

The outputs from three detectors are run, without conversion but directly as on/off signsls, to a monitor register. The MR is the 2nd data word in the string. It is desired to logically connect the three detectors as $AB\bar{C}$ (they are connected to bits 12-14). The detector $\bar{C}$ is electronically connected so that it presents a signal when it is off.

```
     INTEGER Q, LØGMR
     LØGICAL STATUS, GØØD, NØGØØD
     DATA Q/ZE/,GØØD/.TRUE./,NØGØØD/.FALSE.
     .
     .
     .
```

```
STATUS=NØGØØD
If (1.EQ.LØGMR (2,Q)) STATUS=GØØD
.
.
.
```

The integer variable Q has the value hexadecimal E, where E is decimal 14, or binary 1110, which is right justified to be

0000 0000 0000 1110

The logical variable STATUS has the value .TRUE. if $AB\bar{C}$ is true, and the value .FALSE. is $AB\bar{C}$ is not true.

This same task could be done in another way. Suppose the electronic connections of A, B and C are all the same, i.e., $\bar{C}$ is the absence of a signal for C rather than its presence, as was the case above. We could then write:

```
INTEGER   LOGMR, Q1, Q2
LØGICAL STATUS, GØØD, NØGØØD
DATA Q1/ZC/,Q2/72/,GØØD/.TRUE./,NØGØØD/.FALSE./
.
.
.
.
STATUS=NØGØØD
If (1.EQ.LØGMR(2,Q1).AND.0.EQ.LØGMR(2,Q2))    STATUS=GØØD
.
.
.
```

In this case, the masks Q1 and Q2 are

Q1 = 0000 0000 0000 1100

Q2 = 0000 0000 0000 0010

4. VALUE

The form is

$$\text{VALUE}\left(\left\{\begin{array}{l}\text{gate-name}\\ \text{scaler-name}\\ \text{analyzer-name, } x_1\ [,x_2\ldots,x_n]\end{array}\right\}\right)$$

The content is the data in the named device. If only x_1 is specified, it is assumed to specify the x_1^{th} bin in the analyzer. If several x_i's are specified, they must refer to a multiparameter analyzer and will pick out the desired bin in the space defined by the analyzer specification statement.

Example:

The analyzers AN1 and THREEP are specified as

ANALYZER: AN1 (1023); THREEP (5, 10, 50)

We can ask in the problem program for

IC = VALUE (AN1, 17),

which will place in IC the contents of the seventeenth bin of AN1.

We can also ask for

IC = VALUE (THREEP, 3,2,7)

which will place in IC the contents of the bin (3,2,7) in the four-dimensional space of the analyzer.

The value of the contents of a scaler or gate can be obtained by writing

IC = VALUE (GATE5),

etc.

5. $VALUE

This is a pseudo-function that allows the user to change the contents of a device.

The form is

CALL $VALUE (0, expr. name [,$x_1 \ldots x_n$])

where

expr = integer-constant|integer *4-var|arithmetic expression

name = analyzer-name|scaler-name|gate-name

x_i = in the case of an anlyzer, a bin number

Example:

1. A gate's contents are to be set at some calculated value

   ```
   CALL $VALUE (0,4 * I - J, GATE1)
   ```

2. A scaler is to be set

   ```
   IX = SQRT (CØUNTS)
   CALL $VALUE (0, IX, SCALE2)
   ```

Control Card Options

When the user wants to use the interface, the following control card must be included in the job deck:

//name EXEC SETUP[([option-1,][option-2])]

where

name: the name of the user's program

option-1: The type of analysis to be chosen from

1) NØDATA: no data acquisition, i.e., the interface will be ignored (may be used in program checkout)
2) SAVE: take data, analyze, and dump raw data on tape
3) PRØCESS: take data and analyze
4) CØPY: take data, do not analyze, dump raw data on tape
5) SAMPLE: take data, dump raw data on tape, and analyze for as long as it takes to write data on tape
6) REPLAY: data on tape produced in a previous SAVE, CØPY, or SAMPLE run

option-2: the data buffer size and number (the default option is 1024 x 3). The form is:

B@ integer-1 x integer-2

where

integer-1: size of buffer in bytes

integer-2: number of buffers, ≤ 4

SAMPLE

1. //GAMMA EXEC SETUP
   This invokes both default options, PRØCESS and B@1024x3
2. //GAMMA EXEC SETUP (SAMPLE,B@512x3)
   This uses the SAMPLE option, and creates 3 buffers, each 512 bytes long.

Examples of Programs

Problem I

It is desired to do a simple pulse height analysis. Count are to be accumulated up to some (variable) number, and the spectrum is to be dumped on tape.

The hardward configuration is

EVENT I: scaler, ADC
EVENT 16: monitor register.

The scaler in EVENT I is used to enter the time (it is driven by a periodic pulse) at which the spectrum began and stopped accumulation.

The monitor register in EVENT 16 is used to determine the status of the run, namely, started, stopped and the total number of counts allowed per spectrum.

Referring to EVENT 16, the statement

```
LØGMR (I,I).EQ.I
```

causes the mask 0000 0000 0000 000I to be compared to the monitor register bit settings. If the rightmost bit is on, LØGMR (I,I)=I, if it is off, LØGMR (I,I)=0. The former is the "on" condition, the latter is "off".

At the same time, bits I thru 8 are used to assign a value to the number MAXCT, vix.,

```
MAXCT=INTMR (I,I,4) *I0**INTMR(I,5,8).
```

If the monitor register was set to

```
000I  00I0  0000  0000
```

we would have

```
MAXCT=I*I0**2
```

This number, MAXCT, could be computed in the program, say on the basis of data rate, etc.

Stabilization could be accomplished by accumulating a standard spectrum along with the experimental spectrum, and periodically doing numerical shifting and stretching.

The sample program uses the printer for output, but this could easily be changed to writing on tape.

```
C         PROGRAM FOR PROBLEM NO. 1
C         SPECIFICATION STATEMENTS
          ANALYZER*4:MAIN(1024)
          GATE:CHECK(2147483647,1610)(300,700)
          LOGICAL STOP/.TRUE./
          LOGICAL FLAG/.TRUE./
          INTEGER VALUE,DATAWD,C(8),RUNNO/0/,TIME1/0/,TIME2/0/
          INTEGER LOGMR,INTMR
C
    5     FORMAT(1H1,'EXPERIMENT INITIALIZED')
   10     FORMAT(H0,'TOTAL COUNTS EXCEEDS 2**31-1')
   15     FORMAT(1H1/1H0,'RUN NO. ',I10,'     TIME1= ',I10,'        TIME2=',
     1       I10/1H0,'TOTAL COUNTS=',I12, '   TOTAL COUNTS IN WINDOW= ',
     2       I12/)
   20     FORMAT(1X,9I12)
   25     FORMAT(1'--FOLLOWING PRINTOUT GENERATED BY REQUEST IN EVENT 1')


          WRITE(6,5)
C
          CREATE:MAIN CHECK
          CLEAR:MAIN CHECK
C
          ENTER EVENT MODE
C
          EVENT 1
C         SKIP ANY ACTION UNLESS STOP HAS BEEN SET TO .FALSE., THIS ALLOWS
C            THE EXPERIMENTER TO START,STOP,AND PAUSE WHENEVER HE DESIRES
          IF (STOP) GO TO 199
C         DATA WILL NOW BE PROCESSED
          IF (FLAG) GO TO 110
          FLAG=.TRUE.
          TIME1=DATAWD(1)
  110     IC=IC+1
          PHA:MAIN(2)
          DGATE:CHECK(2)
C         SHOULD PRINTOUT TAKE PLACE NOW
          IF (VALUE(CHECK).LT.MAXCT) GO TO 199
C         YES
          TIME2=DATAWD(1)
          WRITE(6,25)
          GO TO 1620
C
  199     EVENT END
C
          EVENT 16
C         THIS TAKES CARE OF PRINTOUT (OR WRITING ON TAPE, ETC.)
C         AND STARTING AND STOPPING
          IF (LOGMR(1,1).EQ.1) GO TO 1605
C         FINISHED TAKING DATA
```

```
      STOP=.TRUE.
      TIME2=DATAWD(2)
      GO TO 1620
C     START TAKING DATA
 1605 STOP=.FALSE.
      MAXCT=INTMR(1,1,4)*10**INTMR(1,5,8)
      TIME1=DATAWD(2)
      GO TO 1699
C     GET TO 1610 BY PUTTING 2**31-1 COUNTS IN GATE CHECK
 1610 WRITE (6,10)
C
 1620 RUNNO=RUNNO+1
      ICW=VALUE(CHECK)
      WRITE(6,15) RUNNO,TIME1,TIME2,IC,ICW
      DO 1650 I=1,128
      J=(I-1)*8
      JO=J+1
      DO 1625 II=1,8
      J=J+1
      C(II)=VALUE(MAIN,J)
 1625 CONTINUE
      WRITE(6,20) JO,C
 1650 CONTINUE
      CLEAR MAIN CHECK
      IF (.NOT.STOP) FLAG=.FALSE.
 1699 EVENT END
C
      END
```

DATA ACQUISITION PROGRAMMING

I INTRODUCTION

II SUPERVISOR

- A. SYSTEM CONTROLLER
- B. RESPONSIBILITIES

III JOB SUPPORT

- A. SOME DEFINITIONS
  1. MODULE
  2. PHASE
- B. JOB SUPPORT PROGRAMS
  1. JOB CONTROL PROCESSOR
  2. FØRTRAN IV COMPILER
  3. ASSEMBLER
  4. LINKAGE EDITOR
  5. UTILITY PROGRAMS
- C. JOB STEPS
  1. DEFINITION OF JOB STEP
  2. EXAMPLE OF JOB STEP
- D. ASSEMBLY, COMPILATION-EDIT-EXECUTE
  1. ACTION OF THE SUPERVISOR
  2. ASSEMBLY AND COMPILATION AS JOB STEPS
  3. EDITING OF A MODULE
  4. PHASE EXECUTION
- E. JOB CONTROL STATEMENTS
  1. JOB STATEMENTS
  2. EXECUTION STATEMENTS
  3. END OF DATA (/*)
  4. END OF JOB (/&)

IV PROCEDURES AND EXAMPLES TO AID EXPERIMENTERS

PROGRAMMING FOR THE SREL 360/44

DATA ACQUISITION SYSTEM

I INTRODUCTION

The following describes the programming system PS44 used with the SREL DAS. Each part of a "programming system" is a program written to do specific jobs. Although these programs may be extremely complex, they are still of the type familiar to all who have used a computer. PS44 is built on this idea, and the FØRTRAN compiler, the Supervisor, etc., are all treated just as the user would treat one of his own programs.

Any of these programs may be given input and may produce output. Data to the compiler is the user's fortran source program, data to the supervisor are control cards and input/output requests; output from the compiler may be used as input to the linkage editor, etc.

The following description of PS44 is written with these facts in mind, and an understanding of this will help experimenters to use the SREL DAS in the most efficient and trouble free manner.

II SUPERVISOR

The supervisor is the system control program; a user program operates under control of the supervisor. The primary purpose of the supervisor is to provide for the orderly and efficient flow of programs through the programming system. Each part of a job must be identified by the programmer and there must be "Data" for each job step. The job support programs are discussed below.

III JOB SUPPORT

A. SOME DEFINITIONS

MODULE: This is a generic term used in place of the overused term "program". A program should be an executable entity, while a module may be a single executable program or a subprogram that must be combined with other modules in order to be executable. A module may be in any form, FØRTRAN, ASSEMBLER, object desk, etc., where there is the possibility of ambiguity the form will be stated.

PHASE: That portion of a program that resides in main storage. The program specifies in linkage editor control statements which modules should be included in a phase. A program may require only one phase, or it may use several.

B. JOB SUPPORT PROGRAMS

1. JOB CONTROL PROCESSOR: Processes job control statements which describe the jobs to be performed and specify the programmer's requirements for each

job. Job control statements are written by the programmer, using the job control language. Job control statements are discussed later in more detail.

2. FØRTRAN IV COMPILER: Translates a source module written in the FØRTRAN IV language into a relocatable module that can be processed into an executable load module by the model 44 linkage editor.

3. ASSEMBLER: Translates a source module written in assembler language into a relocatable module in a form suitable for input into the system's linkage editor.

4. UTILITY PROGRAM: These are used primarily for such tasks as normally performed with card reproducers, interpreters, etc.

5. LINKAGE EDITOR: Its primary purpose is to process modules and incorporate them into phases, i.e., to load a program into the computer so that it may be executed. The use of the linkage editor to perform these functions is controlled by the programmer through job control statements.

C. JOB STEPS

A job step is one step in the processing of a job. Compilation and assembly are examples of job steps. As the name implies, a job step is a specific step needed in order to complete a job. The failure of any one job step may interfere with a following step, e.g., an error in a FØRTRAN program may prevent linkage editing and execution.

D. ASSEMBLY, COMPILATION - EDITING - EXECUTION

The supervisor loads a requested program and calls for the action of the system for compilation or assembly. A program may need more than one job step (more than one execution of the compiler or assembler). In many cases a program consists of a main program and one or more subprograms. In compiling or assembling such a program, separate job steps must be specified for the main program and for each of the subprograms. Each of these job steps create data for the linkage editor in the form of a module.

The supervisor loads the modules into the machine and editing of the modules takes place when the programmer specifies such in the job control cards. (The "execute link edit" statement is the job control statement that would do this). Output from the linkage editor has one or more phases. A phase may be an entire program or it may be part of a multi-phase program. A single job may be structured by the programmer to have several phases; this is of use if the job is so large that it exceeds the available core storage.

The supervisor loads into the computer the phase (s) to be executed. Phase execution is the execution of the user's program, for example, the program written by the FØRTRAN programmer. If the program is a multiphase program, phase execution automatically executes of all the phases in the program. A phase is written in the phase library (an area on the disk) by the linkage editor at the time the phase is produced. The phases are automatically loaded from the disk to the memory for execution.

E. JOB CONTROL STATEMENTS

Any job control card may carry certain options, which will appear in parentheses immediately after the name of the operation, such as FØRTRAN or LNKEDT. These options are covered in detail in the final section of this description.

1. JOB STATEMENT - defines the start of a job. One job statement is required for every job; it must be the first statement in the job deck.

EXAMPLE [1]

```
//ƀJOB
```

2. EXECUTION STATEMENT - requests the execution of a program (compiler, assembler, linkage editor, etc.), therefore, one execute statement is required for each job step within a job.

EXAMPLES

```
//program-nameƀEXECƀBLAST(LINK,MAP)
//program-nameƀEXECƀFØRTRAN(MAP)
//ƀEXECƀLNKEDT(NOKEEP,MAP)
//ƀEXEC
```

3. END OF DATA (/*) - defines the end of particular job steps, that is it defines the end of a program's input data. In this way, it acts to separate job steps such as consecutive compilations; compilation and editing; editing and execution; etc. As you can see, end of data (/*) refers to job step endings. The following is detailed example of the uses of end of data. If a job consists of two compilation job steps, an editing job step, an execution

[1] ƀ will be used to indicate a mandatory space

job step, and finally some input data for the problem program, then the control cards would be

```
//ɃJOB
//program-nameɃFØRTRAN(MAP)
          source statements of main program
/*
//subprogram1-nameɃFØRTRAN(MAP)
          source statements of subprogram
/*
//ɃEXEC
          data, if any[1]
/*
/&
```

[1] if no Data, everything remains the same except Data is omitted.

4. END OF JOB (/&) - Defines the end of a job. This is the last statement to be placed in a program deck.

APPENDIX A

EXAMPLES

The following are examples to aid the experimenter in efficient organization of programs for submission to the SREL DAS.

1.	Fortran Program in Source Form	Page VI C A 1
2.	Module Deck from Source Statements	VI C A 2
3.	Run Module Deck	VI C A 3
4.	Fortran Program with Subroutines	VI C A 4
5.	Source and Module Decks	VI C A 5
6.	Source and Module Decks	VI C A 6
7.	Run Module Decks	VI C A 7
8.	Data Acquisition Language Source Statements	VI C A 8
9.	Remote Typewriter Language Source Statements	VI C A 11
10.	Data Acquisition and Remote Typewriter	VI C A 14
11.	Use of Interface and Remote Typewriter	VI C A 17
	JOB Statement	VI C A 19
	EXEC FORTRAN Statement	VI C A 20
	EXEC LNKEDT Statement	VI C A 21
	INCLUDE Statement	VI C A 22
	PHASE Statement	VI C A 23

1.

OBJECT: to run a program with only a main program, which is in the form of FØRTRAN source statements.

Arrange the cards as follows:

```
//[name]ƀJOBƀ[DUMP],XX¹
//program-nameƀEXECƀFØRTRAN(MAP)

          fortran source statements

/*
//ƀEXECƀLNKEDT(MAP)
/*
//ƀEXEC
          data, if any
/*
/&
```

[1] where name and DUMP are optional, and XX is your user code.

NOTE: The parameter "MAP" in the above control cards requests the printer to display a compiler and a linkage editor map of the problem program. Theses maps are very important when debugging a problem program.

2.

OBJECT: to make a module deck from FØRTRAN source statements.

Arrange the cards as follows:

//[name]ȸJOBȸ[DUMP],XX[1]
//program-nameȸEXECȸFØRTRAN(DECK)

FØRTRAN source statements

/*

/&

The word DECK in the EXEC FORTRAN (DECK) statement commands the machine to punch a module deck.

PROCEDURE 1 - place cards in card reader and push start button

PROCEDURE 2 - the console typewriter will display "FA99A-INT.REQ.00A"

OPERATORS ACTION - The system is ready to punch the module deck. Clear the card reader, place new cards to be punched in the hopper and then push the start button.

PROCEDURE 3 - When the module deck is completed the typewriter will display

FA99A-INT REQ 00A

This message states that intervention is required on the card reader (00A).

OPERATORS ACTION - Clear the card reader of cards still in the card reader.

PROCEDURE 4 - place the card /&(end of job) into the card reader and push the start button.

This action will terminate the job.

[1] where name and DUMP are optional, and XX is your user code

3.

OBJECT: To run a module deck as a job.

Arrange the cards as follows:

```
//[name]ƀJOBƀ[DUMP],XX¹
//ƀEXECƀLNKEDT(MAP)
ƀMØDULEƀmodule-name

        Module deck

ƀPHASEƀphase-name,S
ƀINCLUDEƀmodule-name,L
/*
//ƀEXEC

        data, if program requires it

/*
/&
```

[1] where name and DUMP are optional, and XX is your user code.

NOTE: The letter "S" in the above phase card specifies that the phase have its origin at the first available location in the problem program area.

The letter "L" in the above include cards indicates that the module can be found in his deck as opposed to having the module found in the module library.

4.

OBJECT: To run a program having a main program and one sub-program, all of which are in the form of FØRTRAN source statements; the subprogram here is punched on a BCD keypunch as opposed to an EBCDIC keypunch.

Arrange the cards as follows:

```
//[name]ƀJOBƀ[DUMP],XX¹
//program-nameƀEXECƀFØRTRAN(MAP)
      fortran source statements
/*
//subprogram1-nameƀEXECƀFØRTRAN(BCD,MAP)
      fortran source statements
/*
//ƀEXECƀLNKEDT(MAP)
/*
//ƀEXEC
      data, if any
/*
/&
```

[1] where name and DUMP are optional, and XX is your user code.

5.

OBJECT: To run a program having a main program in FØRTRAN and a subprogram in the form of a module.

Arrange the cards as follows:

```
//[name]ƀJOBƀ[DUMP],XX¹
//program-nameƀEXECƀFORTRAN(MAP)

     fortran source statements

/*
//ƀEXECƀLNKEDT (MAP)
ƀMODULEƀ-module-name

     Module deck

ƀPHASEƀphase-name,S
ƀINCLUDEƀprogram-name,L
ƀINCLUDEƀmodule-name,L
/*
//ƀEXEC

     Data, if any

/*
/&
```

[1] where name and DUMP are optional, and XX is your user code.

6.

OBJECT: To run a program having a main program in FØRTRAN and two subprograms in module form.

Arrange the cards as follows:

```
//[name]bJOBb[DUMP],XX [1]
//program-namebEXECbFØRTRAN(MAP)

     fortran source statements

/*
//bEXECbLNKEDT(MAP)
bMODULEbmodule-name1

     module deck

bMODULEbmodule-name2

     module deck

bPHASEbphase-name,S
bINCLUDEbprogram-name,L
bINCLUDEbmodule-name1,L
bINCLUDEbmodule-name2,L
/*
//bEXEC

     data, if any

/*
/&
```

[1] where name and DUMP are optional, and XX is your user code.

7.

OBJECT: To run a program that consists of four modules.

Arrange the cards as follows:

```
//[name]ƀJOBƀ[DUMP],XX¹

//ƀEXECƀLNKEDT(MAP)

ƀMODULEƀmodule-name1

      module deck

ƀMODULEƀmodule-name2

      module deck

ƀMODULEƀmodule-name3

      module deck

ƀMODULEƀmodule-name4

      module deck

ƀPHASEphasename,S

ƀINCLUDEƀfirst module-name1,L

ƀINCLUDEƀsecond module-name2,L

ƀINCLUDEƀthird module-name3,L

ƀINCLUDEƀfourth module-name4,L

/*

//EXEC

      data, if any

/*

/&
```

[1] where name and DUMP are optional, and XX is your user code.

8.

TITLE: PROPER CONTROL CARDS FOR USE OF INTERFACE PRECOMPILER

OBJECT: To obtain a module deck of a Yale data acquisition program.

```
//bJOBbDUMP,XX
//SYS001bACCESSbYDSH,291='SREL02'
//SYS002bACCESSbTAPE,280=
//SYSLST ACCESS IGN (optional - see Note 1)
//SYSOPT ACCESS IGN (optional - see Note 2)
//bEXECbROOTP

        y
         o
          u
           r

            p
             r
              o
               g
                r
                 a
                  m

/*
//SYSIPTbACCESSbTAPE,280=
//SYSLST ACCESS IGN (optional - see Note 3)
//DALINbEXECbFORTRAN(MAP,DECK)
/*
/&
```

Note 1 - Suppresses listing of your card images on the printer

Note 2 - Suppresses listing of all sixteen events with associated commands

Note 3 - Suppresses listing of executable Fortran coding generated from a data acquisition program translater

OPERATORS ACTION: Place the cards as shown above into the card reader and push the start and end of file buttons. The system will read the first four cards and then display on the console typewritter

FE11A M 280
FE12A READY

This message requests the operator to ready the nine track tape drive. (A description of how to mount a tape and how to place it in the ready state is given on page D 23.) When the nine track tape is in the ready state the operator must depress the ALTN coding and EOB keys on the console typewriter. This action will set the system into an active state of reading the cards again.

During this time a program that resides on disk called ROOTP analyzes each of your cards. Those cards containing regular data acquisition language instructions are processed to produce as tape output, interpretible FORTRAN instructions. All other cards are transferred directly to tape. The tape in question is the nine track tape.

When the above process is completed the console typewriter will display

FE11A M 280
FE12A READY

OPERATORS ACTION: Hit ALTN coding and EOB on the console typewriter. The system will begin compiling the updated program on the nine track tape. When compilation is finished the console typewriter will display

"FA99A INT REQ 00A"

OPERATORS ACTION: The system is ready to punch a module deck. Clear the card reader, place new cards to be punched in the hopper and then push the start and end of file buttons.

When the module deck is completed the typewriter will display

"FA99A INT REQ 00A"

This message states that intervention is required on the card reader (00A).

OPERATORS ACTION: Clear the card reader of any remaining cards still in the card reader. Place the card /& (End of Job) into the card reader and push the start and end of file buttons. This action will terminate the job.

At this point you have created a module deck to be used with proper control cards for direct communication by means of the remote typewriter in connection with your program.

9.

TITLE: PROPER CONTROL CARDS FOR USE OF 2740 (REMOTE TYPEWRITER) PRECOMPILER

OBJECT: To obtain a module deck that represents direct communication with data acquisition program by means of remote typewriter.

```
//ƀJOBƀDUMP,XX
//SYS001ƀACCESSƀYDSH,291='SREL02'
//SYS002ƀACCESSƀTAPE,280=
//SYSLST ACCESS IGN (optional - see Note 1)
//ƀEXECƀSCAN
          y
           o
            u
             r

              p
               r
                o
                 g
                  r
                   a
                    m
/*
//SYSIPTƀACCESSƀTAPE,280=
//SYSLST ACCESS IGN (optional - see Note 2)
//DALINƀEXECƀFORTRAN(MAP,DECK)
/*
/&
```

ƀ will be used to indicate a mandatory space

Note 1 - Suppresses listing of your card images on the printer

Note 2 - Suppresses listing of executable Fortran statements from non-executable typewriter commands

OPERATORS ACTION: Arrange the above cards as shown. Place the cards into the card reader and push the start and end of file buttons. The system will read the first four cards and then display on the console typewriter

FE11A M 280

FE12A READY

This message requests the operator to ready the nine track tape drive. (A description of how to mount a tape and how to place it in the ready state is given on page D 23.) When the nine track tape is in the ready state the operator must depress the ALTN coding and EOB keys on the console typewriter. This action will set the system into an active state of reading the cards again.

During this time a program that resides on disk called scan analyzes each of your cards. Those cards containing regular remote typewriter instructions are processed by scan to produce as tape output, interpretible FORTRAN instructions. All other cards are transferred directly to tape. The tape in question is the nine track tape.

When the above process is completed the console typewriter will display

FE 11A M 280

FE 12A READY

OPERATORS ACTION: Hit ALTN coding and EOB on the console typewriter.

The system will begin compiling the updated program on the nine track tape. When compilation is finished the console typewriter will display

"FA99A INT REQ 00A"

OPERATORS ACTION: The system is ready to punch a module deck. Clear the card reader, place new cards to be punched in the hopper and then push the start and end of file buttons. When the module deck is completed the typewriter will display

"FA99A INT REQ 00A"

This message states that intervention is required on the card reader (00A).

OPERATORS ACTION: Clear the card reader of any remaining cards still in the card reader. Place the card /& (End of Job) into the card reader and push the start and end of file buttons. This action will terminate the job.

At this point you have created a module deck to be used with proper control cards for direct communication by means of the remote typewriter in connection with your program.

10.

TITLE: PROPER CONTROL CARDS FOR USE OF COMBINED REMOTE TYPEWRITER AND INTERFACE PRECOMPILERS

OBJECT: To obtain a module deck that represents a data acquation program using the remote typewriter and interface.

```
//ƀJOB
//SYS001ƀACCESSƀYDSH,291='SREL02'
//SYS002ƀACCESSƀTAPE,280=
//SYSLST ACCESS IGN (optional - see Note 1)
//ƀEXECƀSCAN

          y
           o
            u
             r

              p
               r
                o
                 g
                  r
                   a
                    m
/*
//SYS001ƀACCESSƀYDSH,291='SREL02'
//SYS002ƀACCESSƀTAPE,281=
//SYSIPTƀACCESSƀTAPE,280=
//SYSOPT ACCESS IGN (optional - see Note 3)
//SYSLST ACCESS IGN (optional - see Note 2)
//ƀEXECƀROOTP
//SYSIPTƀACCESSƀTAPE,281=
//SYSLST ACCESS IGN (optional - see Note 4)
//DALINƀEXECƀFORTRAN(MAP,DECK)
/*
/&
```

Note 1 - Suppresses listing of your card images on the printer

Note 2 - Suppresses listing of non-executable Fortran typewriter commands

Note 3 - Suppresses listing of all sixteen events with associated instructions

Note 4 - Suppresses listing of final Fortran coding to be used for program execution

OPERATORS ACTION: Place the cards as shown above into the card reader and push the start and end of file buttons. The system will read the first four cards and then display on the console typewriter

FE11A M 280
FE12A READY

This message requests the operator to ready the nine track tape drive. (A description of how to mount a tape and how to place it in the ready state is given on page D 23.) When the nine track tape drive is in the ready state the operator must depress ALTN coding and EOB keys on the console typewriter. This action will set the system into an active state of reading the cards again.

During this time a program that resides on the disk called SCAN analyzes each card. Cards containing regular remote typewriter instructions are processed by SCAN to produce as tape output, interpretible Fortran instructions. All other cards are transferred directly to tape. The tape in question is the nine track tape.

When the above process is completed the console typewriter will display

"FE11A M 280"
FE12S READY

OPERATORS ACTION: Hit ACTN coding and EOB on the console typewriter. The console typewriter will display

"FE11A M 281"
FE12A READY

OPERATORS ACTION: Ready the tape as described above then hit ALTN coding and EOB on the console typewriter.

During this time a program that resides on the disk called ROOTP analyzes each card image on tape. Card images containing regular data acquisition language instructions are processed by ROOTP to produce as tape output, interpretible Fortran instructions. All other cards are transferred directly onto tape. The tape in question is the seven track tape. At this point the updated program resides on the seven track tape. The console typewriter will now display

"FE11A M 281"

FE12A READY

OPERATORS ACTION: By hitting ALTN coding and EOB on the console typewriter, the system will begin compiling the information that is on the seven track tape. At the completion of the program being compiled the console typewriter will display

"FA99A INT REQ 00A"

This message states that intervention is required on the card reader (00A).

OPERATORS ACTION: The system is ready to punch a module deck. Clear the card reader, place new cards to be punched in the hopper and then push the start and end of file buttons.

When the module deck is completed the typewriter will display

"FA99A INT REQ 00A"

This message states that intervention is required on the card reader (00A).

OPERATORS ACTION: Clear the card reader of any remaining cards still in the card reader. Place the card /& (End of Job) into the card reader and push the start and end of file buttons. This action will terminate the job.

At this point you have created a module deck to be used with proper control cards for direct communication by means of the remote typewriter and interface in connection with your program.

11.

TITLE: <u>PROPER CONTROL CARDS FOR USE OF INTERFACE AND REMOTE TYPEWRITER</u>

```
//ƀJOBƀDUMP,XX
//ƀEXECƀLNKEDT(MAP)
ƀMODULEƀDALIN

        your module deck

ƀPHASEƀTEST,ROOT
ƀINCLUDEƀDALIN,L
ƀINCLUDEBLKCOM,R
ƀPHASEƀDUMMY,+X'1D000'
ƀINCLUDEƀDUMMY,R
/*
//ƀACCESSƀSDSABS
//ƀDELETEƀSDSABS(DUMMY)
//ƀCONDENSEƀSDSABS
/*
//SYS002ƀACCESSƀSDSLOG
//SYS003ƀACCESSƀTAPE,280=    (see Note 1)
//SYS010ƀACCESSƀFRONTEND,180=
//SYS011ƀACCESSƀTPDUMP,280= (see Note 2)
//SYS012ƀACCESSƀSCOPE,005=    )
//SYS013ƀACCESSƀKBOARD,004=  )  Needed if using scope
```

Note 1 - Include for Process Mode only

Note 2 - Include for Save Mode only

```
//SYS014bACCESSbFTABLE,291='SREL02'
//SYS015bACCESSbOVTUNI,291='SREL02'
//SYS000bACCESSbBGNAMLST,291='SREL02' )
//SYS009bACCESSbTEST,020=             ) Needed if using remote typewriter
//TESTbEXECbSETUP(PROCESS)
/*

      y
       o
        u
         r
          d
           a
            t
             a
              i
               f
                a
                 n
                  y
/*
/&
```

OPERATORS ACTION: Place the cards as shown above into the card reader and push the start and end of file buttons. The system will begin reading the cards and if no errors exist it will be possible to begin the experiment.

Note: If your program uses the Fortran 'Common' statement, one of the above control cards must be altered. Notify one of the data acquation staff members for assistance.

Id	Name	Operation	Operand
//	[jobname]	JOB	[DUMP / NODUMP] [,accounting information]

Specification	Reason for Specifying	How to Specify
//	Required	As shown
jobname	To name the job	From one through eight alphameric characters, the first of which must be a letter
JOB	Required	As shown
DUMP	To produce a dump if the program terminates abnormally; the contents of main storage and of the general registers are written on SYSLST	As shown
NODUMP	Default option -- no dump produced	As shown
accounting information	To satisfy any installation requirement	From 1 through 16 alphameric characters, the first of which must be other than a left parenthesis or a blank

Id	Name	Operation	Operand
//	[stepname]	EXEC	FORTRAN[(parameter list)][,(VPSnn)][,accounting information]

Specification	Reason for Specifying	How to Specify
//	Required	As shown
stepname	To name the job step; required to name the module produced by the compiler, unless NOLINK is specified in the parameter list	From one through eight alphameric characters, the first of which must be a letter
EXEC	Required	As shown
FORTRAN	Required	As shown
(parameter list)	To specify compiler options	From one through five parameters (see next chart), separated by commas; the list must be enclosed in parentheses
(VPSnn)	To ensure that the variable precision switch is set to the value nn	One of the following, enclosed in parentheses: VPS14 VPS10 VPS12 VPS08
accounting information	To satisfy any installation requirement	From 1 through 16 alphameric characters, the first of which must be other than a left parenthesis or a blank

Parameters:

[DECK / NODECK] [NOSOURCE / SOURCE] [NOLINK / LINK] [BCD / EBCDIC] [MAP / NOMAP]

Parameter	Reason for Specifying
DECK	To produce a module deck on SYSPCH
NODECK	Default option -- no deck produced
NOSOURCE	To suppress production of a source listing on SYSOPT
SOURCE	Default option -- source listing produced on SYSOPT
NOLINK	To suppress the writing of the module on SYS000, the linkage editor input unit
LINK	Default option -- module written on SYS000
BCD	Required if any source statements are punched in BCDIC
EBCDIC	Default option -- source statements are punched in EBCDIC
MAP	To produce a compiler storage map on SYSLST
NOMAP	Default option -- no compiler storage map produced

Note: Parameters may appear in the parameter list in any order; each parameter is specified as shown.

EXEC Statement (LNKEDT)

Id	Name	Operation	Operand
//	[stepname]	EXEC	LNKEDT[(parameter list)][,accounting information]

Specification	Reason for Specifying	How to Specify
//	Required	As shown
stepname	To name the job step	From one through eight alphameric characters, the first of which must be a letter
EXEC	Required	As shown
LNKEDT	Required	As shown
(parameter list)	To specify linkage editor options	From one through three parameters (see below), separated by commas; the list must be enclosed in parentheses
accounting information	To satisfy any installation requirement	From 1 through 16 alphameric characters, the first of which must be other than a left parenthesis or a blank

Parameters:

[KEEP / NOKEEP] [NOMAP / MAP] [NOAUTO]

Parameter	Reason for Specifying
KEEP	To retain the phase output produced by the linkage editor; required if phase execution is desired subsequent to the job step immediately following the linkage editor job step
NOKEEP	Default option -- phase output is discarded at the end of the job step immediately following the linkage editor job step
NOMAP	To suppress the production of a phase map on SYSLST
MAP	Default option -- phase map produced on SYSLST
NOAUTO	To suppress the automatic linking facility of the linkage editor during this job step

Note: Parameters may appear in the parameter list in any order; each parameter is specified as shown.

INCLUDE Statement

Operation	Operand
INCLUDE	module, {L / R}

Specification	Reason for Specifying	How to Specify
INCLUDE	Required	As shown
module	Required to identify the module that is to be included in the phase	The name of the module as it appears in a MODULE statement or in the name field of an EXEC FORTRAN statement
L	To indicate that the module to be processed can be found on SYS000	As shown
R	To indicate that the module to be processed can be found in the module library	As shown

MODULE Statement

Operation	Operand
MODULE	name

Specification	Reason for Specifying	How to Specify
MODULE	Required	As shown
name	Required; indicates the name of the module	From one through eight alphameric characters, the first of which must be a letter

PHASE Statement

Operation	Operand
PHASE	phasename, { S / * / ROOT / phase } [,NOAUTO]

Specification	Reason for Specifying	How to Specify
PHASE	Required	As shown
phasename	Required to name the phase	From one through eight alphameric characters, the first of which must be alphabetic
S	To specify that the phase have its origin at the first available location in the problem program area	As shown
*	To specify that the phase have its origin at the first available location after the most recently processed phase in the job step; equivalent to the S specification if this is the first PHASE statement in the linkage editor input deck	As shown
ROOT	For multiphase programs only; identifies the phase as a root phase (its origin is the first available location in the problem program area	As shown
phase	To indicate that this phase is to have the same origin as another phase currently in the phase library	The name of the other phase as specified in the linkage editor PHASE statement that named it
NOAUTO	To suppress the automatic linking facility for this phase only	As shown

DESCRIPTION OF UTILITY PROGRAMS

I. GENERAL UTILITY PROGRAMS

1. REPRODUCE DECK
2. CARDS → 9T
3. CARDS → 7T
4. 80/80 LIST
5. 9T → PRINTER
6. 7T → PRINTER
7. 9T → CARDS
8. 7T → CARDS
9. 9T → 7T
10. 7T → 9T
11. TAPE LOAD PROCEDURE

II. SYSTEM UTILITY PROGRAMS

1. VTØC SDSABS
2. VTØC SDSREL
3. DELETE AND CONDENSE
4. LIST I/O
5. TO HAVE A PROGRAM RESIDENT ON THE SYSTEM DISK
6. TAPE OPTIONS
7. SREL 01 AND SREL 02 CONTENTS
8. TO COPY SUBROUTINES FROM SCIENTIFIC SUBROUTINE PACKAGE
9. TAPE PARAMETER (EXT)

The general utility programs described in the following pages handle routine tasks which may become necessary in the course of an experimenters run.

The system utility programs give the user access to the system itself, and will be of help if he encounters system difficulties.

These programs are kept in a box on the card reader and are available to users. A familiarity with the contents of the "utility box" (herein referred to as "Charles' Box") will increase the usefulness of the SREL data acquisition facility to the user.

TITLE: REPRODUCE DECK

OBJECT: TO REPRODUCE A DECK OF CARDS

PROCEDURE: ARRANGE THE CARDS AS FOLLOWS:

```
//REPROɃJOB
//SYS003ɃACCESSɃSDS001, SDSD(WRCHK)='SREL02'
//ɃEXECɃUTILS
ɃCOPY*ɃENDIN='&&',SIZIN=80,SIZOUT=(360,4),PAD=(,10,'6'),        1
               FILL='Ƀ',IGJCL
     DECK
       TO
         BE
           REPRODUCED
&&
/*
//SYS002ɃACCESSɃSDS001,SDSD='SREL02'
//ɃEXECɃUTILS
ɃPUNCHɃENDING='&&',SIZIN=(360,4),SIZOUT=80,TRUNC=(',80),IGJCL
/*
/&
```

OPERATOR ACTION: Place the above cards as shown into the card reader and push the start and end of file buttons. As soon as the system has read up to and including the next to last card, the console typewriter will display:

"FA99A - INT REQ 00A"

This indicates to the operator that the system is ready to punch cards.

OPERATORS ACTION: Remove any cards that have not been fed into the card reader. Push the STOP and the NPRO buttons on the card reader. This action will feed out any remaining cards left in the card reader. Place fresh cards to be punched into the card reader and push the start and end of file buttons.

When the new deck has been punched the console typewriter will display:

"FA99A INT REQ 00A"

OPERATORS ACTION: This message indicates that the system has completed punching cards. Remove any cards that have not been fed into the card reader. As before push the STOP and NPRO buttons. Now place the following card into the card reader and push the start and end of file buttons.

/&

This card will successfully terminate the reproduction of cards and ready the system to accept a new job.

TITLE: CARDS → 9T

OBJECT: TO DUPLICATE CARD IMAGES ONTO THE NINE TRACK TAPE

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (7)

```
//COPYɃJOB
//SYS003ɃACCESSɃDATA,280=
//ɃEXECɃUTILS
ɃCOPY*ɃSIZOUT=80,IGJCL,ENDIN='&&'
        card
         images
          to
           be
            duplicated
             onto
              the
               nine
                track
                 tape
&&
/*
/&
```

OPERATORS ACTION: Place the cards indicated into the card reader and push the start and end of file buttons. The card reader will then begin to read the cards.

When four of the cards have been read the console typewriter will display:

"FE11A M 280"

"FE12A M READY"

This message requests the nine track tape to be mounted and set to a ready state. A description of how to mount and ready a tape is found on page 23.

After the nine track tape has been set in a ready state the operator must depress the ALT Code and EOB keys simultaneously on the console typewriter. This will place the system into an execute mode. The card images will be duplicated on the nine track tape.

After completion of this job the console typewriter will display:

"FA83A INT REQ 00A"

This message means that the duplication process has taken place successfully and that the system is ready for another job.

OPERATORS ACTION: Push the STOP and NPRO buttons on the card reader. At this time any cards remaining in the card reader will be fed out.

TITLE: CARDS → 7T

OBJECT: TO DUPLICATE CARD IMAGES ONTO THE SEVEN TRACK TAPE

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (·7)

```
//COPY⌀JOB
//SYS003⌀ACCESS⌀DATA,281=
//⌀EXEC⌀UTILS
⌀COPY*⌀SIZOUT=80,IGJCL,ENDIN='&&'
      card
       images
        to
         be
          duplicated
             onto
              the
               seven
                track
                 tape
&&
/*
/&
```

OPERATORS ACTION: Place the cards indicated into the card reader and push the start and end of file buttons. The card reader will then begin to read the cards.

When four of the cards have been read the console typewriter will display:

FE11A M 281

FE12A M READY

This message requests the seven track be mounted and set to a ready state. A description of how to mount and ready a tape is found on Page 23.

After the seven track tape has been set in a ready state the operator must depress the ALT Code and EOB Keys simultaneously on the console typewriter. This will place the system into an execute mode. The card images will be duplicated on the seven track tape.

After completion of this job the console typewriter will display:

"FA83A INT REQ 00A"

This message means that the duplication process has taken place successfully and that the system is ready for another job.

OPERATORS ACTION: Push the STOP and NPRO buttons on the card reader. At this time any cards remaining in the card reader will be fed out.

TITLE: 80/80 LIST

OBJECT: TO OBTAIN A LISTING ON THE PRINTER FROM CARDS FED INTO THE CARD READER

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (6)

```
//LIST₿JOB

//₿EXEC₿UTILS

₿PRINT*₿SIZOUT=80,IGJCL,ENDIN='&&',LINES=60,NUM

       card

        images

         to

          be

           listed

              on

               the

                 printer

&&

/*

/&
```

OPERATORS ACTION: Place the above cards into the card reader and push the start and end of file buttons. The system will display on the printer the card images desired.

As soon as the printer has completed the listings of the cards the console typewriter will display:

"FA83A INT REQ 00A"

At this time the listing has been completed and the system is in a wait state for a new job.

OPERATORS ACTION: Push the STOP and NPRO buttons on the card reader. This will clear any cards from the card reader that have not been run out.

TITLE: 9T → PRINTER

OBJECT: TO DUPLICATE CARD IMAGE INFORMATION FROM NINE TRACK TAPE TO THE PRINTER

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (6)

```
//PRINTbJOB
//SYS002bACCESSbDATA,280=
//bEXECbUTILS
bPRINTbSIZIN=80,SIZOUT=80,IGJCL,LINES=60,NUM
/*
/&
```

OPERATORS ACTION: Arrange the above cards as shown. Place the cards into the card reader and push the start and end of file buttons. The system will read the first four cards and then display on the console typewriter:

```
FE11A M 280
FE12A READY
```

This message requests the operator to ready the nine track tape drive. (A description on how to mount a tape and how to place it in the ready state is given on Page 23.

As soon as the nine track tape is in the ready state the operator must depress two keys simultaneously on the console keyboard. They are the ALTN Coding and EOB keys. When these two keys have been depressed the printer will begin duplicating that information that resides on the nine track tape.

When the console typewriter displays:

"FA83A INT REQ 00A"

the system has completed the job and is now awaiting a new job.

OPERATORS ACTION: Push the STOP and NPRO buttons on the card reader. At this time any cards remaining in the card reader will be fed out.

TITLE: 7T → PRINTER

OBJECT: TO DUPLICATE CARD IMAGE INFORMATION FROM THE SEVEN TRACK TAPE TO THE PRINTER

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (6)

```
//PRINTbJOB
//SYS002bACCESSbDATA,2400T7C=
//bEXECbUTILS
bPRINTbSIZIN=80,SIZOUT=80,IGJCL,LINES=60,NUM
/*
/&
```

OPERATORS ACTION: Arrange the above cards as shown. Place the cards into the card reader and push the start and the end of file buttons. The system will read the first four cards and then display on the console typewriter.

FE11A M 281

FE12A READY

This message requests the operator to ready the seven track tape drive. (A description of how to mount a tape and how to place it in the ready state is given on Page 23.

As soon as the seven track tape is in the ready state the operator must depress two keys simultaneously on the console keyboard. They are the ALT Code and EOB keys. When these two keys have been depressed the printer will begin duplicating that information that resides on the seven track tape.

When the console typewriter displays the message:

"FA83A INT REQ 00A"

the system has completed the job and is now awaiting a new one.

OPERATORS ACTION: Push the STOP and NPRO buttons on the card reader. At this time any cards remaining in the card reader will be fed out.

TITLE: 9T → CARDS

OBJECT: TO DUPLICATE CARD IMAGE INFORMATION FROM NINE TRACK TAPE TO CARDS

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (6)

```
//PUNCHɃJOB
//SYS002ɃACCESSɃDATA,280=
//ɃEXECɃUTILS
ɃPUNCHɃSIZIN=80,SIZOUT=80,IGJCL
/*
/&
```

OPERATORS ACTION: Place the above cards into the card reader and push the start and end of file buttons. The card reader will then begin to read the cards. When four of the cards have been read in the console typewriter will display:

FE11A M 280

FE12A READY

This message requests the operator to mount and set the nine track tape into a ready state. This procedure is described on Page 23.

As soon as the tape is ready the operator must hit the ALT CODE and EOB keys on the console keyboard simultaneously. This will cause the typewriter to display:

"FA99A INT REQ 00A"

OPERATORS ACTION: Take any remaining cards from the card reader. Push the STOP and the NPRO buttons on the card reader. This will clear the card reader of all cards. Place a fresh deck of cards into the card reader and push the start and end of file buttons. At this time the card reader will begin punching cards.

When the cards have all been punched the console typewriter will display:

"FA99A INT REQ 00A"

OPERATORS ACTION: Take any remaining cards from the card reader. Push the STOP and the NPRO buttons on the card reader. This will clear the card reader of all cards. Place a fresh deck of cards into the card reader and push the start and end of file buttons. At this time the card reader will begin punching cards.

When the cards have all been punched the console typewriter will display:

"FA99A INT REQ 00A"

OPERATORS ACTION: Remove any cards remaining in the card reader. Push the STOP and NPRO buttons on the card reader as this will clear any cards that are still in the card reader.

Place the sixth card (/&) into the card reader and push the start and end of file buttons. At this time the console typewriter will display:

"FA83A INT REQ 00A"

OPERATORS ACTION: Push the STOP and NPRO buttons on the card reader. At this time any cards remaining in the card reader will be fed out.

The system is now in a ready state for a new job.

TITLE: 7T → CARDS

OBJECT: TO DUPLICATE CARD IMAGE. INFORMATION FROM SEVEN TRACK TAPE TO CARDS

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (6)

```
//PUNCHbJOB
//SYS002bACCESSbDATA,281=
//bEXECbUTILS
bPUNCHbSIZIN=80,SIZOUT=80,IGJCL
/*
/&
```

OPERATORS ACTION: Place the above cards into the card reader and push the start and end of file buttons. The card reader will then begin to read the cards. When four of the cards have been read in,the console typewriter will display:

FE11A M 281

FE12A READY

This message requests the operator to mount and set the seven track tape into a ready state. This procedure is described on Page 23.

As soon as the tape is ready the operator must hit the ALT CODE and EOB keys on the console keyboard simultaneously. This will cause the typewriter to display:

"FA99A INT REQ 00A"

OPERATORS ACTION: Take any remaining cards from the card reader. Push the STOP and the NPRO buttons on the card reader. This will clear the card reader of all cards. Place a fresh deck of cards into the card reader and push the start and end of file buttons. At this time the card reader will begin punching cards.

When the console typewriter displays the message:

"FA99A INT REQ 00A"

the job has been completed.

OPERATORS ACTION: Remove any cards remaining in the card reader. Push the STOP and NPRO buttons on the card reader. This will clear any cards that are still in the card reader.

Place the sixth card (/&) into the card reader and push the start and end of file buttons. At this time the console typewriter will display:

"FA83A INT REQ 00A"

OPERATORS ACTION: Push the STOP and NPRO buttons on the card reader. At this time any cards remaining in the card reader will be fed out.

The system is now in a ready state for a new job.

TITLE: 9T → 7T

OBJECT: TO DUPLICATE CARD IMAGE INFORMATION FROM THE NINE TRACK TAPE TO THE SEVEN TRACK TAPE

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (7)

```
//COPYƀJOB
//SYS002ƀACCESSƀDATA,280=
//SYS003ƀACCESSƀTAPE,2400T7C(800,Ø,NT,C)=
//ƀEXECƀUTILS
ƀCOPYƀSIZIN=80,SIZOUT=80,IGJCL
/*
/&
```

OPERATORS ACTION: Place these cards into the card reader and push the start and end of file buttons. As soon as the card reader has read five of the cards the console typewriter will display:

"FE11A M 280"

"FE12A READY"

This message requests the nine track tape to be set into a ready state. By looking on Page 23 you can see in detail how to ready the tape.

OPERATORS ACTION: When the tape is in a ready state push the ALT CODE and EOB keys simultaneously on the console typewriter. The console typewriter will now display.

"FE11A M 281"

"FE12A READY"

This message requests the seven track tape to be mounted and to be set into a ready state. Follow the same procedure as you did previously on the nine track tape.

OPERATORS ACTION: When the tape is in a ready state push the ALT CODE and EOB keys simultaneously on the console typewriter. This sets the tapes in a ready state.

At this time the duplication of information from the nine track tape to the seven track tape will take place. As soon as the duplication has been completed the console typewriter will display:

"FA83A INT REQ 00A"

This message means that the system has recognized that a program has completely been duplicated. The system is now waiting for a new job.

OPERATORS ACTION: Push the STOP and NPRO buttons on the card reader; at this time any cards remaining in the card reader will be fed out.

TITLE: 7T → 9T

OBJECT: TO DUPLICATE CARD IMAGE INFORMATION FROM THE SEVEN TRACK TAPE TO THE NINE TRACK TAPE

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (7)

```
//COPY₿JOB

//SYS002₿ACCESS₿TAPE,2400T7C(800,Ø,NT,C)=

//SYS003₿ACCESS₿DATA,280=

//₿EXEC₿UTILS

₿COPY₿SIZIN=80,SIZOUT=80,IGJCL

/*

/&
```

OPERATORS ACTION: Place these cards into the card reader and push the start and end of file buttons. As soon as the card reader has read five of the cards the console typewriter will display:

"FE11A M 281"

"FE12A READY"

This message requests the seven track tape to be set into a ready state. By looking on Page 23 you can see in detail how to ready the tape.

OPERATORS ACTION: Push the ALT CODE and EOB keys simultaneously on the console typewriter. The console typewriter will now display:

"FE11A M 280"

"FE12A READY"

This message requests the nine track tape to be mounted and to be set into a ready state. Follow the same procedures as you did previously on the nine track tape.

OPERATORS ACTION: Push the ALT CODE and EOB keys simultaneously on the console typewriter. This sets the tapes in a ready state.

At this time the duplication of information from the seven track tape to the nine track tape will take place. As soon as the duplication has been completed the console typewriter will display:

"FA83A INT REQ 00A"

This message means that the system has recognized that a program has completely been duplicated. The system is now waiting for a new job.

OPERATORS ACTION: Push the STOP and NPRO buttons on the card reader. At this time any cards remaining in the card reader will be fed out.

Tape Load Procedure — 2401-2404

To load tape, proceed as follows:

1. Open the left hub latch by pulling tab toward you. Mount the reel to be loaded on the left mounting hub. To ensure proper alignment, place the hub of the reel firmly against the stop on the machine mounting hub, and close the hub latch. *Always check to ensure that the hub latch is closed.*

2. Hold the reel release key depressed and rotate the file reel clockwise, unwinding about 4 feet of tape.

3. Place the tape around the left rewind idler (Figures 29 and [illegible]), through the read/write assembly, and around the right rewind idler. Place and hold the end of the tape between the index finger and the hub of the machine reel. Press the reel release key and wind tape on the machine reel clockwise for at least two turns beyond the load point marker. Align the tape carefully on the machine reel to prevent damage to the edge on the first few turns. Use the reel finger hold when winding the tape. Rotating the reel using the cut out area can result in damage to the edge of the tape.

4. Close the reel door, if open.

5. Press the load-rewind key. This closes the power window, loads tape into the vacuum columns, lowers the head assembly, and rewinds tape to load point.

6. Press the start key. This places the tape unit under automatic control and turns on the ready light.

Tape Unload Procedure — 2401-2404

1. If the ready light is on, press the reset key to return the unit to manual control.

2. Press the load rewind key to rewind the tape.

3. When the load point is reached, press the unload key. This raises the head, unloads tape, and lowers the power window.

4. Hold the reel release key depressed and manually rewind the file reel by turning it counterclockwise with the finger pressed in the finger hold of the tape reel.

5. When the tape is completely rewound, open the hub latch and remove the reel. If resistance is encountered in removing a reel, exert pressure from the rear of the reel with the hands as near the hub as possible. Never rock a reel by grasping it near the outer edge in a way that pinches the edges of the outer turns of the tape.

NOTE: Do not turn power off with the tape unit in a load status, because the head assembly must be up for removal of the tape.

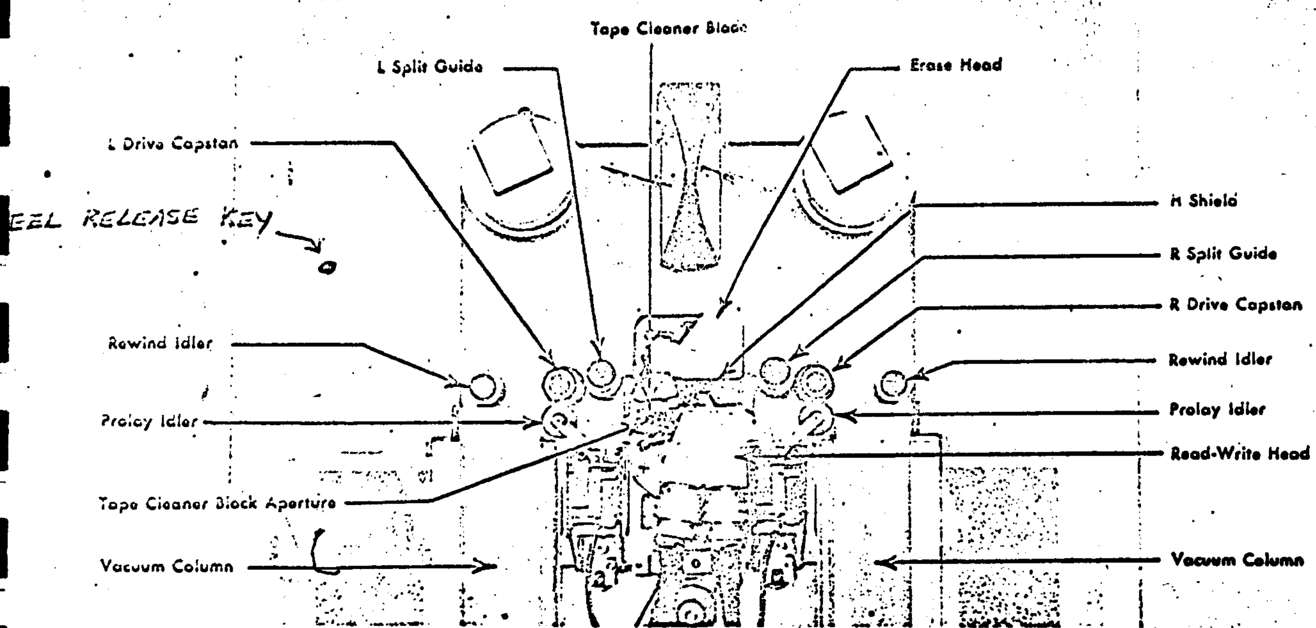


Figure 29. 2401-2404 Tape Transport — Model 1 or 4

TITLE: VTØC SDSABS

OBJECT: TO OBTAIN A LIST OF THE NAMES OF ALL PROGRAMS THAT ARE READY FOR EXECUTION AND ARE FOUND IN THE PHASE LIBRARY

WHAT IS SDSABS: SDSABS contains the phase library. This library consists of programs that are ready for execution. When an exec job control statement names a program to be executed, the system expects to find it in this library. The program cannot be loaded for execution if it is not in this data set or if the system cannot find this data set.

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (6)

```
//VTOCABSbJOB
//SYS002bACCESSbSDSABS,SDSD='SREL01'
//bEXECbUTILS
bPRINTbSIZIN=(720,30),TRUNC=(,10),START=(,120),NUM
/*
/&
```

TITLE: VTØC/SDSREL

OBJECT: TO OBTAIN A LISTING OF SUBROUTINES THAT ARE RESIDENT IN THE MACHINE. A MATHEMATICAL SUBROUTINE (SQUARE ROOT) IS AN EXAMPLE OF ONE SUCH PROGRAM.

WHAT IS SDSREL: The module library contains relocatable program modules (those which have been assembled or compiled) and are available for incorporation into any program.

Such modules as specialized mathematical subroutines are designed for residence in this library. Considerable programming time can often be saved by using this library for permanent storage of various routines and subroutines that are used frequently by one or more installation programs.

These modules are incorporated into a program by the linkage editor. In summary, the module library is a directoried data set, named SDSREL. System unit SYSREL is assigned to it in conjunction with the data set.

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (6)

```
//VTOCREL⊘JOB
//SYS002⊘ACCESS⊘SDSREL,SDSD='SREL01'
//⊘EXEC⊘UTILS
⊘PRINT⊘SIZIN=(360,15),TRUNC=(,10),START-(,180),NUM
/*
/&
```

TITLE: DELETE & CONDENSE

OBJECT: TO DELETE A PHASE NAME THAT HAS BEEN LEFT IN THE PHASE LIBRARY

HOW TO DETERMINE THIS CONDITION: If the console typewriter displays "KA91I" this always means that a program specifies a phase name that duplicates the name of a phase already resident in the Phase Library. Operators action is to remove this name at once.

HOW TO DETERMINE PROGRAM NAME: Place the cards found in "Charles' Box" under the title of VTØC/SDSABS (5 cards) into the card reader and push the start and end of file buttons. This will cause a listing of names in the phase library to appear on the printer. Check this listing with your program and see if your program name is on the listing. When you find it follow the next procedure.

Take the cards marked delete and condense and arrange them as follows:

```
//ɃJOB
//ɃACCESSɃSDSABS,SAME=SYSAB1
//ɃDELETEɃSDSABS(MAIN)***
//ɃCONDENSEɃSDSABS
/&
```

*** Place your program name in place of the word main. If more than one name must be deleted, a series of DELETE cards may be included, one name per card.

Place these cards into the card reader and push the start and end of file buttons. This will cause a successful termination of the delete and condense job.

NOTE: The way one can obtain a KA91I message is to have the system confused on how to complete the job. In contrast, proper termination is via a call exit or stop command in a FORTRAN program, /* or /& command in an ASSEMBLER program and lastly, typing in "cancel" on the console typewriter.

TITLE: LIST I/Ø

OBJECT: TO OBTAIN A LISTING OF CURRENT SYMBOLIC UNIT ASSIGNMENTS

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (3)

```
//LISTIØ̸bJOB
//̸bLISTIØ
/&
```

OPERATORS ACTION: Place the above three cards into the card reader and push the start and end of file buttons. Immediately thereafter the console typewriter and the printer will display symbolic unit names, their current channels and unit addresses, their volume identification serial numbers of the volumes it is assigned to, and the names of the data sets to which the symbolic unit is assigned.

Below is an example of the list I/Ø

SYSAB1	290	SDSABS	SREL01
SYSAB2	290	SDSABS	SREL01
SYSREL	290	SDSREL	SREL01
SYSLOG	01F	SDSLOG	
SYSRDR	00A	SDSRDR	
SYSIPT	00A	SDSIPT	
SYSLST	00B	SDSLST	
SYSOPT	00B	SDSOPT	
SYSPCH	00A	SDSPCH	
SYSPSD	290	SDSPSD	SREL01
SYSUAS	290	SDSUAS	SREL02
SYS000	291	SDS000	SREL02
SYS001	291	SDS001	SREL02

OBJECT: TO HAVE A PROGRAM RESIDENT OF THE SYSTEM DISK

PURPOSE: This enables an experimenter to use only a few control cards to execute the program. This procedure offers speed and convenience to an experimenter as compared to having to load all his program cards into the card reader each time he plans to execute the program.

COMMENT: An experimenter must present to the Data Acquisition Services staff a copy of his working program in object form complete with control cards that can be kept in a users' program library. This will insure the experimenter that in case a system disk has to be erased and reconstructed, his program would be placed back on the disk.

HOW TO ACCOMPLISH STORAGE ON THE SYSTEM DISK: If you are interested in such a procedure, please contact the Data Acquisition Services staff for more information.

Tape Options:

For tape units of device type code 2400T7: $\begin{bmatrix}200\\556\\\underline{800}\end{bmatrix} \begin{bmatrix}E\\\underline{O}\end{bmatrix} \begin{bmatrix}T\\\underline{NT}\end{bmatrix}$

For tape units of device type code 2400T7C: $\begin{bmatrix}200\\556\\\underline{800}\end{bmatrix} \begin{bmatrix}E\\\underline{O}\end{bmatrix} \begin{bmatrix}T\\\underline{NT}\end{bmatrix} \begin{bmatrix}NC\\\underline{C}\end{bmatrix}$

For tape units of device type code 2400D: $\begin{bmatrix}\underline{800}\\1600\end{bmatrix}$

Option	Meaning
200	To indicate a tape density of 200 bpi
556	To indicate a tape density of 556 bpi
800	Default option; indicates a tape density of 800 bpi
1600	To indicate a tape density of 1600 bpi
E	To indicate even parity; should not be specified unless NC is specified
O	Default option; indicates odd parity
T	To indicate that the translate feature is to be used; should not be specified unless NC is specified
NT	Default option; indicates that the translate feature is not to be used
NC	To indicate that the convert feature is not to be used; required if either E or T is specified
C	Default option; indicates that the convert feature is to be used

Note: Options may appear in the option list in any order; each option is specified as shown.

Example:

```
//SYS003 ALLOC NEWDATA,2400T7C(556)=FRESH
```

The statement causes an IBM 2400 Magnetic Tape Unit with a 7-track read/write head and the convert feature to be used for the data set named NEWDATA. The tape density is 556 bytes per inch; default options indicate odd parity, the nonuse of the translate feature, and the use of the convert feature. The data set is assigned to a fresh tape volume and associated with symbolic unit SYS003 (corresponding to data set reference number 3).

THE TWO DISK SYSTEM:

SREL01; the lower disk, contains the following data sets:

SDSIPL - initial program load routines for system use only

SDSABS - phase library; a directoried data set that contains all programs that are to be executed under system control. SDSABS is also used by the system's linkage editor.

SDSREL - The module library containing the Fortran Mathematical and service routines and the dump routines. For example, the square root, trigonometric, exponential, and absolute value functions are included in the module library. This is also the data set in which a user might wish to include any general utility routines or routines from the Scientific Subroutine Package.

SDSUAS - Job control table, used by the job control processor for storing I/O unit assignment information.

SDSPSD - Pseudo directory, used by the language processors and the linkage editor program.

VTOC - Volume table of contents; essentially a collection of labels, one for each data set on the disk. Each label contains such information as the data set name and the location of the data set on the volume. VTOC also contains one or more labels that manage space on the volume by keeping track of the extent of available space. A deck is provided in the computer room for obtaining a listing of the volume table of contents.

USER - A despensible formatted data set which is available to users. If the user wishes to delete USER and name his own area, it can be done. USER contains 272 360-byte blocks.

SREL02; the upper disk, contains the following data sets:

FINAL - A data set used by VARC written 2740 support routines.

FTABLE -the keyboard functions for the Yale Monitor

OVTUNI -the halfword analyzer overflow table for the Yale Monitor.

BGNAMLST-data set used by the SREL remote typewriter, $NL2740

TEMP

SDS000 - the language processors write their output modules in this data set when assemblying or compiling a program that is to be linkage edited later in the same job.

SDS001 - A system work data set.

The user has 592 360-byte blocks available for his use.

OBJECT: How to obtain subroutines from the scientific subroutine package tape.

Arrange the cards as follows:

```
//bJOBb[DUMP],XX
//SYS002bACCESSbTAPE,280=
//SYS003bACCESSbCARD,00A=
//SSPbEXECbASSEMBLE(UPDATE1,NODECK)
                         SKPTObbbXXXXXXXX1
/*                                            YYYYYYYY2
/&
```

OPERATORS ACTION - Mount the scientific subroutine package tape on the nine track tape drive. Place the cards as shown above into the card reader and push the start and end of file buttons. The system will read the first four cards and then display on the console typewriter

FE11A M 280

FE12A READY

OPERATORS ACTION - Hit ALTN coding and EOB on the console typewriter. The system will begin searching the tape for the subroutine in question. When the subroutine has been found the console typewriter will display

'FA99A INT REQ 00A'

OPERATORS ACTION - The system is ready to punch cards. Clear the card reader, place new cards to be punched in the hopper and then push the start and end of file buttons. When the deck is completed the console typewriter will display

'FA99A INT REQ 00A'

OPERATORS ACTION - Clear the card reader of any remaining cards still in the card reader. Place the card /& (End of Job) into the card reader and push the start and end of file buttons. This action will terminate the job.

[1] Where XXXXXXXX is the serial field of the first card in the desired subroutine to be copied.

[2] Where YYYYYYYY is the serial field of the last card in the desired subroutine to be copied. This serial field must start in column 73.

NOTE: The last card punched of the requested deck must be disregarded.

TITLE: TAPE PARAMETER (EXT)

PURPOSE: This parameter relieves the experimenter of having to write a special routine to continue data accumulation to a tape that already has data on it.

An example of the use of this parameter is:

//SYS002ƀACCESSƀTAPE,280=,EXT

USE: The first time a data acquisition program attempts to write to the tape at address 280, the tape will advance to the first end of file mark. Then backspace one record and then place the pending information on the tape. Any additional writing to the tape will continue where the tape is positioned at this time (see note below).

NOTE: This control parameter should only be used if data is already on tape.

USERS GUIDE TO THE REMOTE TYPEWRITER SUPPORT VERSION I

I. General

The remote typewriter is an input/output device that is part of the SREL on-line computer user's station. The support for this device appears as an extension of FØRTRAN.

The user is given a set of FØRTRAN - line statements which may be included anywhere in his own program. These statements may be written in either of two forms, one the normal CALL type of FØRTRAN, the other in the style of the YALE/IBM data acquisition statements.

The purpose of these commands is to allow the user to

1. input and output variables
2. output messages
3. wait for some period of time
4. branch to locations in his program

II. Conversational, Fail-Soft Nature

The support of this device causes messages to be displayed which guide the user in the use of the system.

In case the typewriter appears too garrulous, the user may shift to shorter messages by typing WHØA& whenever he has the attention of the typewriter (this is explained below). If the messages are too enigmatic, he may type HELP&, and longer messages will be output to him.

Tolerance to incorrect input is built into the system and diagnostic messages are printed at appropriate times. Since the typewriter is to be used with an experiment, every attempt has been made to make the system fail-soft, so that user errors (even accidentally turning off the typewriter) do not cause termination of the program.

III. Basis for Input/Output

The NAMELIST feature of FØRTRAN IV-H is relied upon to support input and output. In this way, any variable in the program may be referenced without any need for formatting. As explained further in section V, the user effects I/O by creating NAMELIST's and referencing them in the typewriter support statements.

IV. Use of the typewriter

Several conventions must be followed in using the typewriter.

1. Attention is given to the user when the BID key is pressed.
2. A line is properly terminated upon typing &, and pressing the RETURN key, and then the EOT key.
3. Input is more-or-less free form, allowing the user to make a variety of typing errors, control being returned to the user with an appropriate message.
4. Any line may be canceled by typing # in the line. The typewriter responds by printing LINE DELETED. TRY AGAIN PLEASE.

V. The Commands

A. Message

This causes a message to appear on the typewriter. The message may be up to 128 characters; no carriage control characters are recognized.

1. The form is

CALL $MESSAGE	(message-list)
MESSAGE:	name

where

message-list: the actual message
name: defined below

2. A supplementary form is

$$\left[\begin{array}{l}\text{\$MESSAGE name=} \\ \text{MESSAGE name:}\end{array}\right] \quad \text{(message-list)}$$

where

name: up to six alphanumeric characters

A maximum of ten "names" may appear in any one subprogram; name definitions must occur before the name is used.

EXAMPLES

1. MESSAGE: (HERE I AM)

   this would print HERE I AM on the typewriter.

2. $MESSAGE 1= (PRINTØUT STARTED)
   $MESSAGE ABLE= (PRINTØUT FINISHED)
   MESSAGE: 1
   .
   .
   .
   MESSAGE: ABLE
   CALL $MESSAGE (SECTIØN 1 ØVER)

   this would cause three messages to be printed:

   PRINTØUT STARTED
   PRINTØUT FINISHED
   SECTIØN 1 ØVER

B. WAIT AND BRANCH

This allows the user to wait for some length of time, and to branch to various numbered executable statements in his program.

The form is:

```
[CALL $WAIT]
[WAIT:     ]   (ref-name, ref-no.,[,st.no-1[...,st.-no.
                                                  -12]])
```

where

ref-name: up to six alphanumerics

ref-no.: up to four alphanumerics

st-no.-i: the number of an executable statement in the user's program.

The recommended use for ref-name and ref-no. are:

ref-name: subprogram name

ref-no: a reference number

EXAMPLE

1. CALL $WAIT (EV12,5)

This does not allow any branching. The following message would be printed:

WAITING IN EV12, AT 5, PUSH BID KEY AND MAKE ONE OF THE FOLLOWING RESPONSES 1) TYPE WAIT X, WHERE X= DELAY IN MINUTES. 2) TYPE GØ 0 (ZERO) TO PROCEED TØ NEXT EXECUTABLE INSTRUCTION.

If the user's response was

WAIT 30 (or a variation such as WAIT FOR 30 MINUTES)

a waiting period of 30 minutes would be initiated. This period may be interrupted at any time by pushing the BID key. At this time or at the end of the requested delay, the typewriter displays END TIMEØUT. REFER ABØVE FØR RESPØNSE.

2. WAIT: (EV12,5,100,150,750,999)

The message of example 1 would appear, plus the message

TYPE GØ N, WHERE N IS ØNE ØF THE FØLLØWING STATEMENT NUMBERS 100, 150, 750, 999

The user response

GØ 999 (or a variation such as GØ TØ STATEMENT 999)

would cause transfer to statement 999.

Incorrect input, such as GO TO 432, results in the typewriter printing STATEMENT NØ. NØT IN LIST. TRY AGAIN.

C. INPUT

The user may change the value of any variable in his program. This is done via SETNØW, which is of the form

$$\begin{bmatrix} \text{CALL \$SETNØW} \\ \text{SETNØW:} \end{bmatrix} \quad \text{(ref-name, ref-no., namelist-1 [...namelist-6])}$$

where

$\begin{bmatrix} \text{ref. name:} \\ \text{ref. no.:} \end{bmatrix}$ as in $WAIT

namelist-i: a NAMELIST name already created by the user

EXAMPLE

1. NAMELIST /ALPHA/A,B,I,T

   .

   .

   .

   CALL $SETNOW (MAIN,7,ALPHA)

The following message would be printed:

INPUT REQUIRED IN MAIN, AT STATEMENT NØ. 7 FOR ALPHA
FOR ALPHA PRESS BID KEY AND TYPE 1 TØ INPUT THE NAME,
2 TØ SKIP ALL NAMES
NØ RESPØNSE, SKIP THE NAME

A user response of 1 would result in the following message being displayed:

PUSH BID KEY AND BEGIN TYPING DATA WITHIN 15 SECØNDS AFTER BELL RINGS

The input data takes the form discussed in the 44 FORTRAN manual, except that the NAMELIST name is not required. For instance, the user's response in this example might be:

```
A = 5, T(3) = 4.9 $END
```

assuming that T was an array.

Input may be several lines, in which case only the final line is terminated by $END. After each line the typewriter responds

```
LINE RECEIVED. MØRE EXPECTED
```

and after the last line, it prints

```
INPUT RECEIVED.
```

Incorrect input, such as a mispelled variable name, results in the message

```
FOR ALPHA, PRESS. . .
```

being printed out again.

EXAMPLE

```
2.  NAMELIST /ALPHA/A,B,I,T,/BETA/Q,R,S
    .
    .
    .
    SETNOW:  (MAIN,7,ALPHA,BETA)
```

The course of events would be as in example 1. except that a second round would be entered starting with

```
FOR BETA, PRESS BID KEY . . .
```

D. OUTPUT

1. The user may view the value of any variable in his program. This is done via VIEWNØW, which is of the form:

```
⎡CALL $VIEWNØW⎤
⎢             ⎥  (ref-name, ref-no., namelist-1[,...namelist-6])
⎣VIEWNØW:     ⎦
```

Names have the same meaning as in $SETNØW.

EXAMPLE

1. NAMELIST/ALPHA/A,B,I,T

.

.

.

CALL $VIEWNØW (MAIN,3,ALPHA)

The following message would be printed:

OUTPUT AVAILABLE IN MAIN, AT STATEMENT NO. 3 FOR ALPHA
FOR ALPHA, PRESS BID KEY AND TYPE 1 TO SKIP
NAME, 2 TO SKIP ALL NAMES. NO RESPONSE, OUTPUT THE NAME

Output will be in the standard NAMELIST format, as described in the 44 FORTRAN manual.

2. The user may unconditionally output the value of any variable in his program without the give-and-take involved in VIEWNØW. The form is:

```
⎡CALL $WRITENØW⎤
⎢              ⎥  (namelist-1[,...namelist-6])
⎣WRITENØW:     ⎦
```

EXAMPLE

NAMELIST /ALPHA/A,B,I,T

.

.

.

CALL $WRITENØW(ALPHA)

This would produce the output of variables A,B,I and T in standard NAMELIST form.

E. General Note On Input and Output

If no user action is taken after the $SETNØW message, it will be assumed that no input is desired, and the next executable statement will be processed.

If no user action is taken after the $VIEWNØW message, it will be assumed that output is desired, and all the NAMELIST variables will be printed out.

In order to give the user time to react, the typewriter idles for about one minute before its no-response option action, a user response of typing 0ꝗ will shortcut this waiting time. In case the user presses the BID key and then decides that, after all, he does want the no-response option, he need only type 0ꝗ.

APPENDIX A

SUMMARY OF COMMANDS

A. Output

1. Messages

i

CALL $MESSAGE	(message-list)
MESSAGE:	name

where

Message-list: up to 128 alphanumerics
name: defined below

ii

$MESSAGE name=	(message-list)
MESSAGE name:	

name: up to six alphanumerics

2. Variables

i

CALL $VIEWNØW	(ref-name, ref-no., namelist-1[,...namelist-6])
VIEWNØW:	

ref-name: a reference name, up to six alphanumerics
ref-no.: a reference number, up to four digits
namelist-i: a NAMELIST name previously created by the user

ii

CALL $WRITENØW	(namelist-1[,...namelist-6])
WRITENOW:	

B. Input

CALL $SETNØW	(ref-name, ref-no., namelist-1[,...namelist-6])
SETNØW:	

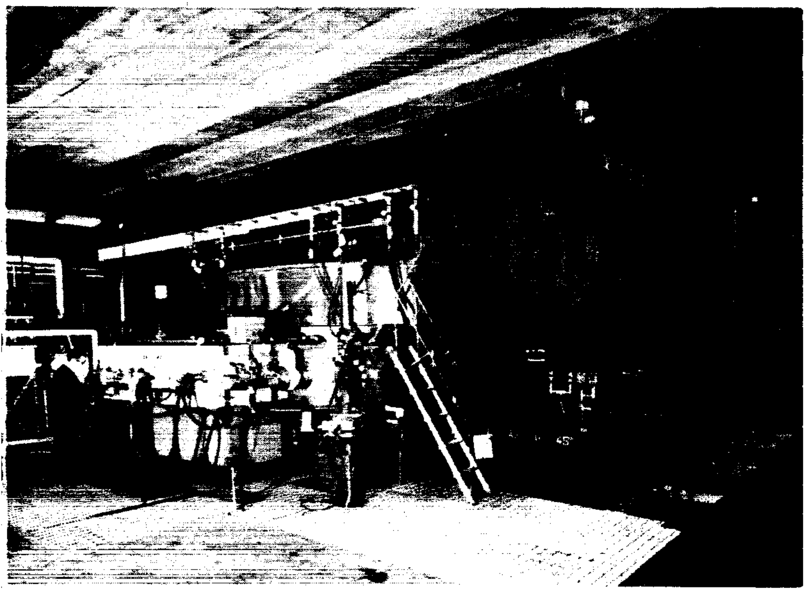
See above for definitions

C. Wait and Branch

$\left[\begin{array}{l}\text{CALL \$WAIT}\\ \text{WAIT:}\end{array}\right]$ (ref-name, ref-no.[,st-no.-1[,...st-no.-12]])

$\left[\begin{array}{l}\text{ref-name:}\\ \text{ref-no.:}\end{array}\right]$ see above

st-no.-i: the statement number of an executable statement in the user's program.

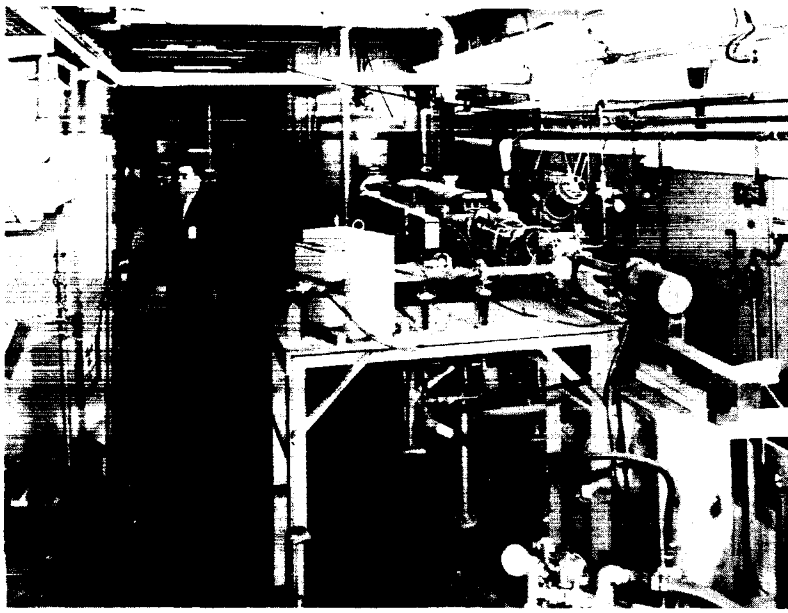


Synchrocyclotron

Primary Extracted Beams:
600 and 300 MeV protons
Secondary Beams:
Pions and muons to 400 MeV
Internal Beam Current:
Approximately 1 microampere
Extraction Efficiency:
Approximately 5 percent
Magnetic Field Strength:
19 kilogauss
R.F. System Operating Frequency:
16 to 29 megacycles
Modulation Frequency:
55 pulses per second
Beam Area:
Variable from 1 cm^2 to 1000 cm^2

Linear Electron Accelerator

Energy Range: 3 to 10 MeV electrons
Average Beam Current:
Adjustable from less than 1 microampere to 0.5 milliampere
Repetition Rate:
Continuously variable from single pulse to 720 pulses per second
Pulse Width:
10 to 100 nanoseconds in steps and continuously variable from 0.1 to 6.0 microseconds
Beam Area:
Variable from 1 cm^2 to 1000 cm^2



Potential Drop Accelerator

Energy Range:
0.5 to 3 MeV electrons
Beam Current:
Variable from 0–10 milliamperes
Beam Area:
Variable from 1 cm^2 to 1000 cm^2