SPACE

RADIATION EFFECTS

LABORATORY

Operated by

THE COLLEGE OF WILLIAM AND MARY IN VIRGINIA

For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SREL - USERS HANDBOOK

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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

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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 1 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:
**EXPERIMENT SUMMARY SHEET**

**SPACE RADIATION EFFECTS LABORATORY**

**DATE RECEIVED AT SREL**

**EXPERIMENT TITLE**

**PRINCIPAL INVESTIGATOR(S)**

**ORGANIZATION(S)**

**Address**

**Telephone**

**EXPERIMENT NUMBER**

**FOR SCHEDULING PERIOD**

**CHOICE # SHIFTS PRIME OR PARASITE DATES REQUESTED ROOM OR BEAM AREA BEAM AND POLARITY**

<table>
<thead>
<tr>
<th>1st</th>
<th># SHIFTS</th>
<th>PRIME OR PARASITE</th>
<th>DATES REQUESTED</th>
<th>ROOM OR BEAM AREA</th>
<th>BEAM AND POLARITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

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.
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)
   345-274 (Control Room)
   345-288 (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 C Y C L O T R O N

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 $\dot{p}$ 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

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

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

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

where

$$m = m_0 (1 - \beta^2)^{-1/2}$$ \hspace{1cm} (2)

and

$$\beta = \frac{v}{c}$$

is the ratio of the particle velocity $v$ to the velocity of light $c$.

(1) then becomes

$$\frac{d}{dt} (m\vec{v}) = e\vec{E} + e (\vec{V} \times \vec{B}).$$ \hspace{1cm} (3)

To resolve (3) into component-form we adopt a system of cylindrical coordinates $r, \theta, z$ 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
\[
\frac{d}{dt} (mr) - mr \dot{\theta}^2 = eE_r + er \dot{\theta} P_z - ez B_\theta,
\] (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
\[ \dot{\theta} = -eB_z/m = \omega, \] say. (5)
Hence the particle moves with constant angular velocity about the centre of the machine. When now an alternating electric field \( E_\theta \) of the same frequency \( \omega \) 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 T/m \(^2\) then the orbital frequency of a singly charged particle is
\[ f_c = \frac{\omega e z \times 10^4 B_z}{2\pi m} \text{ Mc/s}. \]

For protons of rest-mass energy 938 MeV and kinetic energy \( E \) this becomes
\[ f_c = \frac{14.300 B_z}{938 + E} \text{ Mc/s}. \]
The negative sign in (5) indicates that positively charged particles rotate clockwise about a field for which \( B_z \) is positive.

Also from (5)
\[ mr \dot{\theta} = mv \theta = p_\theta = -erB_z, \] (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 \((B_z = \text{constant})\) and non-relativistic motion \((m = m_0)\) an alternating electric field of a single frequency
\[
\omega_o = -\frac{eB_z}{m_0}
\] (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 \(f_0\) at time \(t_0\) to \(f_1\) at \(t_1\), when the bunch of ions reaches the maximum radius. The duration of the acceleration \(t_1 - t_0\) 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.
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

$$ (E + m_0)^2 = p^2 + m_0^2. \tag{8} $$

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

$$ E = m_0 \left[ \frac{eBzr}{m_0} \frac{2}{1 - \frac{1}{1 - 1}} \right]. \tag{9} $$

For $B_z$ in Webers per square metre, $r$ in metres and $m_0$ 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

\[ \frac{E}{m_0} = \sqrt{\frac{300B_z r^2}{m_0} + 1 - 1} \]  

(11)

In the SC the induction \( B_z = 1.83 \text{ W/m}^2 \) at \( r = 2.24 \text{ m} \), when the magnet excitation is 1900 A. For these values formula (10) yields \( p = 1225 \text{ MeV/c} \) and formula (11), with \( m_0 = 938 \text{ MeV} \), gives \( E = 602 \text{ MeV} \).

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

\[ \omega = eB_z \left(1 - \beta^2\right)^{1/2}/m_0, \]  

(12)

or, with (8)

\[ \omega = \frac{eB_z}{E + m_0}. \]  

(12')

For the case of a uniform magnetic field the frequency swing required to attain a kinetic energy \( E \) is therefore

\[ f_o/f(E) = \omega_o/\omega(E) = E/m_0 + 1 \]  

(13)

For 602 MeV protons this yields \( f_o/f(602) = 1.65 \). In the SC at 1900 A magnet excitation the initial radiofrequency is \( f_o = 29.8 \text{ Mc/s} \) and \( f (602 \text{ MeV}) = 17.0 \text{ Mc/s} \). 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 synchrocyclotron 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

$$\frac{B_z(r)}{B_z(r_0)} = \left(\frac{r_0}{r}\right)^n.$$  \hspace{1cm} (14)

Hence

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

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 plane is to be deflected towards it, then the field must have a radial component $B_r$ in the plane of symmetry. We write this as

$$B_r(r,z) = B_r(r,0) + \frac{\partial B_r}{\partial z} z + \ldots = \frac{\partial B_r}{\partial z} z + \ldots,$$

the first term vanishing by symmetry. But

$$\frac{\partial B_r}{\partial z} = \frac{\partial B_z}{\partial r}. \tag{17}$$

Hence the radial component is

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

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

$$\frac{d}{dt}(m \ddot{z}) = e\dot{r}B_\theta - e\dot{\theta}B_r = m \dddot{z}. \tag{19}$$

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

$$m \dddot{z} = - e\omega_c B_z n = \omega_c^2 n z \tag{19}$$
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

\[ f_z = f_c n \]  \hspace{1cm} (20)

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

**Radial Motion**

This is again given by (4). With \( E_r = B_0 = 0 \), and making the same approximations as in the previous paragraph this becomes

\[ m\ddot{r} - mr\dot{\rho}^2 = er\dot{\rho} B_z \]  \hspace{1cm} (21)

Putting

\[ B_z (r) = B_z (r_0) \left( 1 - \frac{r - r_0}{r_0} \right) \]

and introducing

\[ \rho = \frac{r - r_0}{r_0}, \quad \ddot{\rho} = \frac{\ddot{r}}{r_0} \]

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

\[ f_r = f_0 \sqrt{1 - n} \]  \hspace{1cm} (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

\[
\nu_z = \frac{f_z}{f_c} = \sqrt{\frac{n}{1-n}} \quad \nu_r = \frac{f_r}{f_c} = \sqrt{1 - n} \quad (23)
\]

The values of \( \nu_z \) and \( \nu_r \) give respectively the number of axial and radial oscillations per turn. The two parameters are subject to the condition

\[
\nu_r^2 + \nu_z^2 = 1 \quad (24)
\]

In the synchro-cyclotron a basic condition of stability is that both \( \nu_r \) and \( \nu_z \) are real and therefore

\[
0 < n < 1. \quad (25)
\]

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 \( v_r \) or \( v_z \) 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 \( v_z \) against \( v_r \) (see Fig. 6).

According to (24) the working locus of a weak focusing machine on the \( v_r v_z \) 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 \( v_z = 1/2 \) and \( v_r = 1/2 \) are lines parallel to the axes. The "coupling resonances"

\[
p v_r - q v_z = 0 \quad p, q = 1, 2, \ldots
\]

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

\[
v_r - 2v_z = 0 \quad \text{or} \quad n = 0.2
\]
at 
\[ \nu_T - \nu_Z = 0 \text{ or } n = 0.5 \]

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 \( \nu_T = 0.89 \). 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 \( \phi_a \) when the voltage across the gap is rising and at \( \phi_b \) when it is falling (see 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 \( \phi_a \) 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 $\phi_b$. 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 $\phi_0$. 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 synchrocyclotron the ions carry out "phase oscillations" around $\phi_0$. Their frequency for small amplitudes is

$$\omega_\phi = \omega_c \left( \frac{\text{KeV} \cos \phi_0}{2\pi (m_o + \epsilon)} \right)^{1/2}$$

(27)

where $\omega_c$ is given by (5) and

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

(28)

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

For $E \ll m_o$ (27) becomes

$$\omega_\phi / \omega_0 = \left( \frac{\text{KeV} m \cos \phi_0}{2\pi m_o} \right)^{1/2}$$

KeV $m / m_o$ is of order $10^{-6}$; hence $\omega_\phi / \omega_0 \ll 1$ and the particles perform several hundred turns during the course of a single period of phase oscillation.
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 $\phi_{\min}$ with respect to a given $\phi_o$ (see Fig. 8). $\phi_{\min}$ in turn determines $\phi_{\max}$. 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° towards the end of the cycle. Fig. 8 also illustrates that the range of stable oscillation depends on $\phi_o$; it vanishes as $\phi_o$ 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.
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 synchrocyclotron 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

   $$\Delta E \left( \frac{1}{E + m_0} \right) = \Delta \phi \left( \frac{eV_m \cos \phi_0}{2\pi K(E + m_0)} \right)^{1/2}$$

   where $K$ is given by (28).

3. The energy spread leads to a radial spread

   $$\frac{\Delta r}{r} = \frac{\Delta \phi}{(1 - n)\beta^2} \left( \frac{eV_m \cos \phi_0}{2\pi U} \right)^{1/2}$$

   During a phase oscillation cycle a particle therefore varies both its
azimuthal and radial position with respect to the equilibrium particle. With $eV_m \cos \phi_o = 10 \text{ keV}$ we find $\Delta E \approx 2 \text{ MeV}$ and $\Delta r \approx 5 \text{ mm}$ 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

$$\frac{dr}{dt} = -\frac{r}{f_0(n + (1 - n) \beta^2)} \frac{df_c}{dt}$$

(31)

where $f_0$ is the cyclotron frequency, $r$ the radius of the equilibrium orbit and $\beta c$ the velocity of the ions. $df_c/dt$ is given by the frequency programme.

The data listed in section B 7 for $r = 224 \text{ cm}$ and a field excitation of 1.9 kA show $n = 0.094$ and $f_c = 16.89 \text{ Mc/s}$. At this frequency $df_c/dt = 1.33 \times 10^9 \text{ cycles/s}^2$, giving a radial velocity of about $2.65 \times 10^4 \text{ cm/s}$ or a radial gain per turn of $1.6 \times 10^{-3} \text{ cm}$. 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 $2.6 \times 10^4$ cm/sec the entire cloud traverses the target in about 200 $\mu$sec.

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.


III SREL CYCLOTRON BEAMS

1. Beam Transport Identification Code

2. Beam Descriptions

## Beam Transport Identification

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

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:

<table>
<thead>
<tr>
<th>Power Supply</th>
<th>Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.S. #1 thru #6:</td>
<td>6 amps/MV</td>
</tr>
<tr>
<td>P.S. #7 thru #9:</td>
<td>4 amps/MV</td>
</tr>
<tr>
<td>P.S. #10 thru #12:</td>
<td>5 amps/MV</td>
</tr>
<tr>
<td>P.S. #13 thru #20:</td>
<td>3 amps/MV</td>
</tr>
</tbody>
</table>
## SUMMARY OF CYCLOTRON BEAM DESCRIPTIONS

<table>
<thead>
<tr>
<th>Beam No.</th>
<th>Description</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM-1</td>
<td>200 MeV/c $\pi^-$ - Vibrating Target</td>
<td>Maximum</td>
</tr>
<tr>
<td>CM-2</td>
<td>&quot; $\pi^+$ &quot;</td>
<td>Maximum</td>
</tr>
<tr>
<td>CM-3</td>
<td>&quot; $\pi^+$ &quot;</td>
<td>Maximum</td>
</tr>
<tr>
<td>CM-4</td>
<td>200 MeV/c $\pi^-$ - Harp Target</td>
<td>Maximum</td>
</tr>
<tr>
<td>CM-5</td>
<td>176 MeV/c $\pi^+$ - Harp Target</td>
<td>Maximum</td>
</tr>
<tr>
<td>CM-6</td>
<td>165 MeV/c $\pi^+$ - Internal Target (replaces beam CM-5)</td>
<td>Maximum</td>
</tr>
<tr>
<td>CM-7</td>
<td>Backwards (100 MeV/c) $\mu^-$ from Muon Channel</td>
<td>Maximum</td>
</tr>
<tr>
<td>CP-1</td>
<td>600 MeV proton</td>
<td>Low</td>
</tr>
<tr>
<td>CP-2</td>
<td>&quot;</td>
<td>Maximum</td>
</tr>
<tr>
<td>CP-3</td>
<td>500 MeV proton</td>
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<tr>
<td>CP-4</td>
<td>400 MeV proton</td>
<td>Maximum</td>
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<tr>
<td>CP-5A</td>
<td>600 MeV - Calibration Beam - Proton</td>
<td>Very Low</td>
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<tr>
<td>CP-5B</td>
<td>500 MeV - Calibration Beam - Proton</td>
<td>Very Low</td>
</tr>
<tr>
<td>CP-5C</td>
<td>400 MeV - Calibration Beam - Proton</td>
<td>Very Low</td>
</tr>
<tr>
<td>CP-5D</td>
<td>300 MeV - Calibration Beam - Proton</td>
<td>Very Low</td>
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<tr>
<td>CP-5E</td>
<td>320 MeV - Calibration Beam - Proton</td>
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<tr>
<td>CP-5F</td>
<td>200 MeV - Calibration Beam - Proton</td>
<td>Very Low</td>
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<tr>
<td>CP-5G - 5P</td>
<td>159, 105, 79, 74, 64, 54, 48, 41, 35 MeV - Calibration Beam - Proton</td>
<td>Very Low</td>
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<tr>
<td>CP-6</td>
<td>129 MeV Protons - degraded from 300 MeV</td>
<td>Maximum</td>
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<tr>
<td>CP-7</td>
<td>600 MeV protons - POLARIZED</td>
<td>Maximum</td>
</tr>
<tr>
<td>CP-8</td>
<td>300 MeV protons with 300 MeV Platter</td>
<td>Maximum</td>
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### Beam No. \[\text{Blank}\]

#### Beam Dynamics Measurement Information

1. **Beam No.**: Blank
2. **Date**: 10/01/67
3. **Signed**: [Signature]

#### Beam Characteristics

| Particles | Proton | \( \text{?} \) | \( \text{?} \) | Neutron | Other
|-----------|--------|----------------|----------------|---------|---

#### Nominal Beam Energy

- **Nominal Beam Energy**: 100 MeV

#### Beam Line

- **Area**: On
- **Pitcher**: 600
- **Aux. X**: Blank

#### Degrador

- **BD-1**: Blank
- **BD-2**: Blank
- **Copper**: Blank
- **Lenses**: Blank
- **Regenerator Position**: Blank

#### Main Magnet

- **Main Magnet**: \( X \), \( R \)
- **Shunt**: Blank

#### Diverter

- **Elements**: Blank

#### Internal Beam Intensity

- **On Monitor**: Blank
- **On TO Flip**: Blank

#### External Beam Intensity

- **On Monitor**: Blank

#### Proton Transport Magnet Settings

| Magnet No. | Power Supply No. | Shunt (mV) | Current (Amps) | Polarity (N or R)
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</tr>
</tbody>
</table>
II. Internal Target Information

Target active diameter ___________ in.avarage current __________ amp.

Number of targets __________ tail length __________ in.

Description of target __________ Location __________

II. Bending and Focusing Magnet Information (For Proton Beams)

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>10' M</th>
<th>12' M</th>
<th>18' M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position</td>
<td>14&quot;</td>
<td>11 5/8&quot;</td>
<td>13 1 5/8&quot;</td>
</tr>
<tr>
<td>Bending Angle</td>
<td>120°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current (Amp)</td>
<td>160</td>
<td>136</td>
<td>127</td>
</tr>
<tr>
<td>Polarity</td>
<td>X</td>
<td>E</td>
<td>E</td>
</tr>
</tbody>
</table>

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

When bending magnets indicate field B or H, for apertures indicate vertically focusing (V) or horizontally focusing (H) for the beam being used.

II. Beam Details

a. Central Momentum 200 MeV/c Peak Intensity: 200,000/sec (12/sec rate with 5" x 5" counters)

Width of Magnet Curver: __________

b. Defining Apertures in Chopping (Position, Size)

Data

c. Range Information

Scaling Down Material: __________

Stopping Material: __________

Stopping Material: __________

Stopper Dimension: __________

Range Data:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Range</td>
<td>30 cm</td>
</tr>
<tr>
<td>Maximum Stopping Rate</td>
<td>50 cm/hr</td>
</tr>
<tr>
<td>Energy Scales</td>
<td></td>
</tr>
</tbody>
</table>
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:
<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mV)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tbody>
</table>
11. Internal Target Information

Radius Meter Reading 1.56  Radius 87.2  Inches
Azimuth Meter Reading 5.21  Azimuth 2° W  Inches

Description of Target

Vibrating Beryllium Target

Amplitude = .32 mA  Bias = 0.6

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

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>0.25X</th>
<th>0.29X</th>
<th>X 3X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position*</td>
<td>In Quad</td>
<td>Out Quad</td>
<td>Bender</td>
</tr>
<tr>
<td>Bending Angle</td>
<td></td>
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</tr>
<tr>
<td>Current (Amp)</td>
<td>130</td>
<td>100</td>
<td>152</td>
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<tr>
<td>Polarity**</td>
<td>P</td>
<td>D</td>
<td>Y</td>
</tr>
<tr>
<td>Height</td>
<td>2.80</td>
<td>2.20</td>
<td>2.975</td>
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</tbody>
</table>

*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/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. 6"x6" 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:

<table>
<thead>
<tr>
<th>Particle</th>
<th>Peak Range</th>
<th>Polyethylene</th>
<th>5 3/4&quot;</th>
<th>10&quot;</th>
</tr>
</thead>
</table>

* In addition to the listed range there was 2" of H2O and 1 gm/cm² of stainless steel in the beam.
### Beam No. BX - 3

**General Operating Sheet Information**

1. **Exp. No.** 13,105  
   **Date:** 10/2/67  
   **Signed:** T. Vitten

2. **Particle:** Proton  
   **Nominal Beam Energy:** 100 Mev  
   **Beam:** $^1$H

3. **Area:** GMR, PXA, NIX, Plotter 500, 600 X, Aux.

4. **Degrador:** BD-1, BD-2, Copper; **Inches:** Regenerator Position: **Full Out**

5. **Main Magnet:** X, R, Shunt

6. **Divertor:** 3, 2.5 amp on shunt; 17.5 amp on meter

7. **Internal Beam Intensity:** __ on Monitor __ mv on TC Flip

8. **External Beam Intensity:** __ on Monitor __ on Monitor __ on Monitor __ on Monitor __

9. **Proton Transport Magnet Settings**

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tbody>
</table>
11. Internal Target Information
Radius Meter Reading 1.93
Azimuth Meter Reading 5.35

Description of Target: Vibrating Beryllium Target

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

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>0.23X</th>
<th>0.29X</th>
<th>X.8X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position (%)</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Bending Angle</td>
<td>60°</td>
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<tr>
<td>Current (Amp)</td>
<td>130</td>
<td>100</td>
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<tr>
<td>Polarity **</td>
<td>+</td>
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</table>

Halopot 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/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: CH₂
   Stopping Material: Aluminium
   Stopper Dimensions: 0.25"

Range Data:

<table>
<thead>
<tr>
<th>Particle</th>
<th>π</th>
<th>μ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Range</td>
<td>11.25&quot;</td>
<td>16&quot; CH₂</td>
</tr>
<tr>
<td>FWHM</td>
<td>7&quot;</td>
<td>10 Mev =2.50&quot;</td>
</tr>
<tr>
<td>Maximum Stopping Rate</td>
<td>2.5 K/sec 400/sec</td>
<td></td>
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</tbody>
</table>
13. Beam Details Continued

c. Other characteristics - beam profile if known (give position at which measured); whether parallel, 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^-____, 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; Regenerator Position____

6. Main Magnet: N____, R____, 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

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>
11. Internal Target Information

Radius Meter Reading: 1.18
Radius: 86.1 inches

Azimuth Meter Reading: 5.70
Azimuth: 1°

Description of Target: Harp with Be Blocks

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

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>M8x</th>
<th>Q28x</th>
<th>Q29x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position*</td>
<td>normal</td>
<td>normal</td>
<td>normal</td>
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<tr>
<td>Bending Angle</td>
<td></td>
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<tr>
<td>Current (Amp)</td>
<td>150</td>
<td>140</td>
<td>100</td>
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<tr>
<td>Polarity**</td>
<td>F</td>
<td>D</td>
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</tbody>
</table>

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 200MeV/C

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

Width of Magnet Curve: %

b. Defining Apertures in Shielding (Position, Size)

c. Range Information

Slowing Down Material: CH₂

Stopping Material: Na, CH₂

Stopper Dimensions: 6" X 6"

Range Data:

<table>
<thead>
<tr>
<th>Particle</th>
<th>π⁻</th>
<th>μ⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Range</td>
<td>7&quot;</td>
<td>11 1/2&quot;</td>
</tr>
<tr>
<td>FWHM</td>
<td>2 1/2&quot;</td>
<td>3&quot;</td>
</tr>
<tr>
<td>Maximum Stopping Rate</td>
<td>20/gm-sec</td>
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</tbody>
</table>

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 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.

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⁺, π⁻, Neutron, Other


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

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

6. Main Magnet: N493 V, R, Shunt 72.70 mv

7. Diverter: 4.14 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 ___, ___ on Monitor ___, ___ on Monitor ___, 30K/sec. max. 4" x 8" scin.

10. Proton Transport Magnet Settings

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
</thead>
<tbody>
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11. Internal Target Information

<table>
<thead>
<tr>
<th>Radius Meter Reading</th>
<th>Radius 37.5 Inches</th>
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<tr>
<td>1.2</td>
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<table>
<thead>
<tr>
<th>Azimuth Meter Reading</th>
<th>Azimuth 0°</th>
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</thead>
<tbody>
<tr>
<td>3.55</td>
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</table>

Description of Target: X-ray

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

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>Q23X</th>
<th>Q29X</th>
<th>X8X</th>
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<table>
<thead>
<tr>
<th>Position**</th>
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<table>
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<th>Bending Angle</th>
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<thead>
<tr>
<th>Current (Amp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 100 400</td>
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</table>

<table>
<thead>
<tr>
<th>Polarity**</th>
</tr>
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<tbody>
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</tbody>
</table>

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

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

13. Beam Details 176mev/c

a. Central Momentum: 398/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:

<table>
<thead>
<tr>
<th>Particle</th>
<th>π⁺</th>
</tr>
</thead>
</table>
| Peak Range (Al. equiv.) | 27.4 gm/cm²
| FWHM (Al. equiv.) | 0.5" (-15MeV)
| Maximum Stopping Rate |   |
13. Beam Details Continued

c. 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.

15. Comments:
SREL CYCLOTRON-BEAM INFORMATION

2. Particle: Proton, \( \pi^+ \), \( \pi^- \), 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, R, Shunt \( \frac{7}{3.3} \) mv
7. Diverter: \( \frac{7}{17.31} \) amp on shunt; \( \frac{25}{25} \) amp on meter
8. Internal Beam Intensity: on Monitor, 7.6 mv, on TC Flip #3 (0.3 \( \mu \)a/mv)
9. External Beam Intensity: on Monitor, on Monitor, on Monitor, on Monitor
10. Proton Transport Magnet Settings

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M6</td>
<td>2</td>
<td>17.66</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>3</td>
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<tr>
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<td></td>
</tr>
</tbody>
</table>
11. Internal Target Information

Radius Meter Reading: 85 inches
Azimuth Meter Reading: 3.5° inches
Description of Target: Vibrating target

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

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>Q in</th>
<th>Q out</th>
<th>M6</th>
<th>π-Bender (M8X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position*</td>
<td>Normal radius in the center line of channel</td>
<td>60°</td>
<td>45°</td>
<td></td>
</tr>
<tr>
<td>Bending Angle</td>
<td>60 amp</td>
<td>60 amp</td>
<td>17.65 mv</td>
<td>300 amp</td>
</tr>
<tr>
<td>Current (Amp)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polarity**</td>
<td>VF</td>
<td>VD</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

*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 S2 see next page)
   Slowing Down Material: Copper
   Stopping Material: 1/2" Scintillator
   Stopper Dimensions: 8 X 8 (S2 counter, see page 3)

Range Data:

<table>
<thead>
<tr>
<th>Particle</th>
<th>π⁺</th>
<th>μ⁺</th>
<th>e⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Range</td>
<td>1 1/8&quot;</td>
<td>1 7/8&quot;</td>
<td></td>
</tr>
<tr>
<td>FWHM</td>
<td>≈1/4&quot;</td>
<td>1/4&quot;</td>
<td></td>
</tr>
<tr>
<td>Maximum Stopping Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Intensity: π⁺: μ⁺: e⁺ = 1:0.5 : 0.17
Eπ = 83 Mev
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.

\[\text{Beam size } \pm S'' \]

\[\text{Beam Size} \]

RATES:

\[S_1C = 100^k/\text{sec} \]
\[S_1C S_2 = 50^k/\text{sec} \]
\[C_2S_1 = 8'' \times 8'' \]
\[S_2 = 6'' \times 6'' \]

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


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 Inch; Regenerater Position Full Out

6. Main Magnet: N, R, Shunt 73.48 mv

7. Diverter: +1990 μA on shunt; +30 amperes on meter

8. Internal Beam Intensity: ___ on Monitor, 6.8 mv. on TC Flip #3 (3 μA/mu)


10. Proton Transport Magnet Settings

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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</tbody>
</table>
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)

<table>
<thead>
<tr>
<th>Position*</th>
<th>Channel</th>
<th>A</th>
<th>B</th>
<th>Bend</th>
</tr>
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<tbody>
<tr>
<td>Bending Angle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current (Amp)</td>
<td>1500</td>
<td>950</td>
<td>1275</td>
<td>2.20 on dial</td>
</tr>
</tbody>
</table>

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

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

13. Beam Details 100 Mev/c

a. Central Momentum: 7 __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: CH₂

Stopping Material: ZnO

Stopper Dimensions: 9" X 9"

Range Data:

<table>
<thead>
<tr>
<th>Particle</th>
<th>µ</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Peak Range</td>
<td>≈4&quot;CH₂</td>
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</tr>
<tr>
<td>FWHM</td>
<td>1 1/2&quot; CH₂</td>
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</tr>
<tr>
<td>Maximum Stopping Rate</td>
<td>≈150/gm-sec</td>
<td></td>
</tr>
</tbody>
</table>
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 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
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<tbody>
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<td>2.26</td>
<td>53.90</td>
<td>6.04</td>
<td>0.23</td>
<td>81.18</td>
<td>91.18</td>
<td>0.23</td>
<td>91.18</td>
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<td>68.52</td>
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<td>68.05</td>
<td>68.05</td>
<td>0.20</td>
<td>68.05</td>
</tr>
</tbody>
</table>

**Polarity (N or R)**

- N
- R
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

\[ E = 594.8 \pm 1.5 \text{ MeV} \]  (measured on similar beam in combined target area)

\[ \Delta E \text{ (FWHM)} = 8.5 \text{ MeV} \]

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:
**SREL CYCLOTRON-BEAM INFORMATION**

1. Expd No.: NC 107        Date: 10/19/67        Signed: J. Cline

2. Particle: Proton X, H\(^+\), H\(^-\), Neutron, Other

3. Nominal Beam Energy: 600 Mev - Full Intensity

4. Area: CTA, FTA X, NM; Platter 500, 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. Divertor: \(\frac{1}{2}\) amp on shunt; amp on meter

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

9. External Beam Intensity: \(5 \times 10^{-6}\) on Monitor 1, \(3.2 \times 10^{5}\) on Monitor 5, ____ on Monitor, ____ on Monitor, ____ on Monitor. (Cf. item 13)

10. Proton Transport Magnet Settings

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2/M3</td>
<td>1</td>
<td>43.67</td>
<td>262</td>
<td>N</td>
</tr>
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<td>M 5</td>
<td>2</td>
<td>50.07</td>
<td>300</td>
<td>N</td>
</tr>
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<td>M 7</td>
<td>3</td>
<td>50.85</td>
<td>305</td>
<td>N</td>
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<td>01A/02A</td>
<td>4</td>
<td>27.02</td>
<td>162</td>
<td>N</td>
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<td>Q 17</td>
<td>5</td>
<td>31.28</td>
<td>186</td>
<td>N</td>
</tr>
<tr>
<td>Q 3</td>
<td>6</td>
<td>23.32</td>
<td>140</td>
<td>N</td>
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<tr>
<td>Q 02/04</td>
<td>7</td>
<td>35.85</td>
<td>143</td>
<td>N</td>
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<tr>
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<td>56.24</td>
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<td>Q 01/016</td>
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<td>45.80</td>
<td>185</td>
<td>N</td>
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<td>Q 1</td>
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<td>35.93</td>
<td>180</td>
<td>N</td>
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<tr>
<td>Q 19</td>
<td>11</td>
<td>66.81</td>
<td>345</td>
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<td>Q 20</td>
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<td>59.29</td>
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<td>14</td>
<td>53.66</td>
<td>162</td>
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<td>O 21</td>
<td>15</td>
<td>74.84</td>
<td>222</td>
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<td>O 23</td>
<td>16</td>
<td>58.41</td>
<td>174</td>
<td>N</td>
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<tr>
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<td>K 1</td>
<td>20</td>
<td>2.25</td>
<td>6</td>
<td>N</td>
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</table>
II. Internal Target Information

<table>
<thead>
<tr>
<th>Radius Meter Reading</th>
<th>Radius</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azimuth Meter Reading</td>
<td>Azimuth</td>
<td>Inches</td>
</tr>
<tr>
<td>Description of Target</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>Position*</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending Angle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current (Amp)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polarity**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* 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.

III. Beam Details

a. Central Momentum: ___________ Peak Intensity: $(1.75 - 2) \times 10^9$ protons/sec

b. Defining Apertures in Shielding (Position, Size)

<table>
<thead>
<tr>
<th>Range Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slowing Down Material:</td>
</tr>
<tr>
<td>Stopping Material:</td>
</tr>
<tr>
<td>Stopper Dimensions:</td>
</tr>
<tr>
<td>Range Date:</td>
</tr>
</tbody>
</table>

| Particle | Peak Range | FWHM | Maximum Stopping Rate |
13. Beam Details Continued

4. Other characteristics - beam profile if known (give position at which measured); whether parallel, 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

SCEL CYCLOTRON-BEAM INFORMATION

1. Exp. 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: CIA, PTA X, NM; Platter 500, 600 X, Aux.

5. Degrader: BD-1, BD-2, Copper 2.5 inches; Regenerator Position IN

6. Main Magnet: N, R, Shunt 73.48 mV

7. Diverter: amp on shunt; amp on meter

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

9. External Beam Intensity: 7.8 x 10⁵ on Monitor

10. Proton Transport Magnet Settings

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
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<tr>
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<td>X 7</td>
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<td>43.24</td>
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<td>CIA/02A</td>
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<td>017</td>
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<td>50.20</td>
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<td>N</td>
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This page includes all presently available information on beam CP - 3
Beam No. 02-4

SRL CYCLOTRON-BEAM INFORMATION

1. Exp. No. NO. 137  Date 10/20/37  Signed J. Cline

2. Particle: Proton X, H+, H-, Neutron X, Other X

3. Nominal Beam Energy: 400 Mev

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

5. Degrader: BD-1 X, BD-2 X, Copper 8.75 inches; Regenerator Position IN

6. Main Magnet: N X, R X, Shunt 73.3 mv

7. Slitter: X amp on shunt; X amp on meter

8. Internal Beam Intensity: 8x10^-6 on Monitor_1, ___. mv. on TC Flip

9. External Beam Intensity: ___. on Monitor___, ___. on Monitor___, ___. on Monitor___, ___. on Monitor___

10. Proton Transport Magnet Settings

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
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</table>

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.

**Beam No. CP-5A**

### SREL CYCLOTRON-BEAM INFORMATION

1. **Expt. No.** NC-105  
   **Date** 1/8/68  
   **Signed** R.J. Kurz

2. **Particle:** Proton _, N^+ _, N^- _, 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; Regenerator Position Full In

6. **Main Magnet:** N X __, R __, Shunt 74.00mv

7. **Diverter:** + 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 ___.

### Proton Transport Magnet Settings

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
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</thead>
<tbody>
<tr>
<td>M2/M3</td>
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<td>43.68</td>
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<td>N</td>
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<td>M7</td>
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<td>35.92</td>
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<td>M1</td>
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<td>2.27</td>
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11. Internal Target Information

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<tr>
<th>Parameter</th>
<th>Radius in.</th>
<th>Azimuth in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of Target</td>
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<td></td>
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</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>Position</th>
<th>Bending Angle</th>
<th>Current (Amp)</th>
<th>Polarity**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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

13. Beam Details

a. Central Beam: 585 MeV Peak Intensity: 3000 sec. in 1/2" diam. @ 4.0 x 10^-9 A.

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:

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<th>Particle</th>
<th>p^+</th>
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<tr>
<td>Maximum Stopping Rate</td>
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</table>
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.

NOTE: The following information was obtained for beam CP-SE, 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 set up with currents from previous 600 MeV beams. Beam spot at BM2 was ± 1" horiz. 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* Position Hörz. Magnification Vert. Mag. Dispersion (2X/4X/p) BC2 - .57 - .48 224.7 inches TARGET + .27 + .99 -105.9 inches

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

Calculated properties of beam system after BD1
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; Regenerator Position
   +87 dial on No. 1 wedge
6. Main Magnet: N X, R74.00, Shunt mv see 600 MeV
7. Diverter: 9.15amp on shunt; --- amp on meter
8. Internal Beam Intensity: ____ on Monitor, ____ mv. on TC Flip
9. External Beam Intensity: See 600 MeV on Monitor, ____ on Monitor,
   ____ on Monitor, ____ on Monitor
10. Proton Transport Magnet Settings See Beam CP-5A for magnets up to BD1

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
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<tr>
<td>M2/M3</td>
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12. Bending and Focussing Magnet Information (For Meson Beams)

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>Position*</th>
<th>Bending Angle</th>
<th>Current (Amp)</th>
<th>Polarity**</th>
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*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: 510 MeV

<table>
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<tr>
<th>Energy</th>
<th>Peak Intensity: 100/sec in 1/2&quot; diam. @5.6x10^-9 A</th>
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b. Width of Magnet Curve: 14 MeV

c. Defining Apertures in Shielding (Position, Size)

See Beam CP-5A

c. Range Information: Integral

<table>
<thead>
<tr>
<th>Slowing Down Material: Copper</th>
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<td>Stopping Material:</td>
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<tr>
<td>Stopper Dimensions:</td>
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Range Data:

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<th>Particle</th>
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<tbody>
<tr>
<td>Peak Range</td>
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<tr>
<td>FWHM</td>
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<tr>
<td>Maximum Stopping Rate</td>
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</tr>
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</table>

For beam profile and experimental set-up, see beam CP-5A.
Beam No. CP-5C

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC105  Date 1/8/68  Signed R.J. Kurz
2. Particle: Proton, π⁰, 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; Regenerator Position
   +58 Dial No. 1 wedge
6. Main Magnet: N X, R; Shunt 74.00 mv 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
10. Proton Transport Magnet Settings See Beam CP-5A for magnets up to BD1

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
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<tr>
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</table>
11. Internal Target Information
   Radius Meter Reading Radius inches
   Azimuth Meter Reading Azimuth inches
   Description of Target

12. Bending and Focusing Magnet Information (For Meson Beams)
   
<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>Position*</th>
<th>Bending Angle</th>
<th>Current (Amp)</th>
<th>Polarity**</th>
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</tr>
</tbody>
</table>

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

13. Beam Details
   a. Central Maximum: 415 MeV Peak Intensity: 2000/sec in 1/2" diam @ 3.0x10^-8A.
      Width of Steep 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.
Beam No. **CP-5D**

**SREL CYCLOTRON-BEAM INFORMATION**

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

2. Particle:  
   Proton **X**, **H**+, **H**-, Neutron **N**, Other _

3. Nominal Beam Energy:  
   **300**

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

5. Degrader:  
   BD-1 **X**, BD-2 **X**, Copper 5.75 Inches; Regenerator Position **X**

6. Main Magnet:  
   N **X**, R **X**, 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, _on Monitor, _on Monitor, See Beam CP-5A

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

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M6</td>
<td>2</td>
<td>33.07</td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>M7</td>
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<td>Q17</td>
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<td>Q18</td>
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<td>14.20</td>
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<td>Q26</td>
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</table>
Beam No. CP-5D

11. Internal Target Information

<table>
<thead>
<tr>
<th>Radius Meter Reading</th>
<th>Radius</th>
<th>inches</th>
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<tbody>
<tr>
<td>Azimuth Meter Reading</td>
<td>Azimuth</td>
<td>inches</td>
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<tr>
<td>Description of Target</td>
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</table>

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

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>Position*</th>
<th>Bending Angle</th>
<th>Current (Amp)</th>
<th>Polarity**</th>
</tr>
</thead>
</table>

*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: 315 MeV Peak Intensity: 600/sec in 1/2"diam. @ 5.0x10^-8A. Width of Magnet Curve: 20 MeV

b. Defining Apertures In Shielding (Position, Size)

See Beam CP-5A

c. Range Information: Integral

<table>
<thead>
<tr>
<th>Slowing Down Material: Copper</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Stopping Material:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Stopper Dimensions:</th>
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Range Data:

<table>
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<tr>
<th>Particle</th>
<th>p</th>
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<tbody>
<tr>
<td>Peak Range</td>
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<td>FWHM</td>
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<tr>
<td>Maximum Stopping Rate</td>
<td>-</td>
</tr>
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</table>

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

5. Degrader: BD-1 X, BD-2 , Copper 0 Inches; Regenerator Position

6. Main Magnet: N X, R , Shunt 68.70mv

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

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


10. Proton Transport Magnet Settings

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
</thead>
<tbody>
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<td>M2/M3</td>
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<td>33.60</td>
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<td>N</td>
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<td>M6</td>
<td>2</td>
<td>33.25</td>
<td></td>
<td>N</td>
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<td>M7</td>
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<td>33.25</td>
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<td>N</td>
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<td>9.61</td>
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<td>N</td>
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<td>M1</td>
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Beam No. CP-5E

11. Internal Target Information

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<th>Radius Meter Reading</th>
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<th>Inches</th>
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<td>Azimuth Meter Reading</td>
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<td>Inches</td>
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<td>Description of Target</td>
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12. Bending and Focussing Magnet Information (For Meson Beams)

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>Position*</th>
<th>Bending Angle</th>
<th>Current (Amp)</th>
<th>Polarity**</th>
</tr>
</thead>
</table>

*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: 320 MeV  
   Peak Intensity: See below  
   Width of Magnet 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:

<table>
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Intensity Information:

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<th>BM3</th>
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<tr>
<td>(protons/sec)</td>
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<td>amps</td>
<td>amps</td>
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<td>3.0x10^-6</td>
<td>1.8x10^-6</td>
<td>2.4x10^-8</td>
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MAXIMUM

For Beam profile and experimental set-up, see Beam CP-5A.
SREL CYCLOTRON-BEAM INFORMATION

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

2. Particle: Proton X, II+ II- Neutron, Other

3. Nominal Beam Energy: 200 MeV

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

5. Degrader: BD-1, BD-2, Copper 2.0 inches; Regenerator Position

6. Main Magnet: N X, R, Shunt mv +41 Dial on No. 1 wedge See 320 MeV

7. Diverter: +15 amp on shunt; ___ amp on meter

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


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

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
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<td>M7</td>
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Beam No. CP-5F

11. Internal Target Information

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<tr>
<th>Radius Meter Reading</th>
<th>Radius inches</th>
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<tbody>
<tr>
<td>Azimuth Meter Reading</td>
<td>Azimuth inches</td>
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<td>Description of Target</td>
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</table>

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

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>Position*</th>
<th>Bending Angle</th>
<th>Current (Amp)</th>
<th>Polarity**</th>
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</tr>
</tbody>
</table>

*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: 204 MeV
   Peak Intensity: See Below
   Width of Magnet 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:

<table>
<thead>
<tr>
<th>Particle</th>
<th>Peak Range</th>
<th>FWHM</th>
<th>Maximum Stopping Rate</th>
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<tbody>
<tr>
<td></td>
<td>1.70&quot;</td>
<td>.06&quot;</td>
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Intensity Information:

<table>
<thead>
<tr>
<th>in 1/2&quot; diam. (protons/sec)</th>
<th>in 2&quot; diam (protons/sec)</th>
<th>BM1 (amps)</th>
<th>BM2 (amps)</th>
<th>BM3 (amps)</th>
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</thead>
<tbody>
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<td>35</td>
<td>500</td>
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<td>1.1x10^-9</td>
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<td>450</td>
<td>3300</td>
<td>1.1x10^-6</td>
<td>6.4x10^-7</td>
<td>1.1x10^-9</td>
</tr>
<tr>
<td>MAXIMUM -&gt; 1300</td>
<td>7600</td>
<td>2.9x10^-6</td>
<td>1.9x10^-6</td>
<td>3.5x10^-9</td>
</tr>
</tbody>
</table>

For beam profile and experimental set-up, see Beam CP-5A.
Beam No. CP-5G through CP-5P

**SNEL CYCLOTRON-BEAM INFORMATION**

1. Expt. No. NC-105  
   Date 1/8/68  
   Signed R.J. Kurz

2. Particle: Proton X, H⁺, H⁻, 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; Regenerator Position


   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 ciai 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.

\[ \text{Cu absorber} \]

\[ \text{Ein} \]

\[ \text{Eout} \]

\[ 2''\text{ diam} \times 1/8''\text{ thick} \]

\[ \text{Pilot B Scintillator with 2 mils of Al foil on each side} \]

\[ 3''\text{ diam} \times 1/8''\text{ thick} \]

\[ \text{Pilot B Scintillator with 2 mils of Al foil on each side} \]

\[ \text{Eout resolution was estimated by replacing Cu absorber and 3'' diam counter by a 1'' thick CsI scintillator and measuring the pulse-height-spectrum of the protons stopping in this crystal.} \]
### Table of Beam Data

<table>
<thead>
<tr>
<th>BEAM NO.</th>
<th>Ein (MeV)</th>
<th>Eout (MeV)</th>
<th>Eout FWHM (%)</th>
<th>BD1 (in.+dial)</th>
<th>M6,7 (Mv)</th>
<th>Q17 (Mv)</th>
<th>Q18 (Mv)</th>
<th>Q25 (Mv)</th>
<th>Q26 (Mv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP-5G</td>
<td>158.4</td>
<td>155.0</td>
<td>-</td>
<td>2.50+52</td>
<td>22.50</td>
<td>5.77</td>
<td>10.16</td>
<td>31.26</td>
<td>31.33</td>
</tr>
<tr>
<td>CP-5A</td>
<td>105.4</td>
<td>102.0</td>
<td>-</td>
<td>3.25+46</td>
<td>18.40</td>
<td>4.44</td>
<td>7.81</td>
<td>24.03</td>
<td>24.08</td>
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<tr>
<td>CP-5I</td>
<td>79.0</td>
<td>74.0</td>
<td>47</td>
<td>3.50+44</td>
<td>15.90</td>
<td>4.0</td>
<td>6.8</td>
<td>21.0</td>
<td>21.0</td>
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<tr>
<td>CP-5J</td>
<td>74.0</td>
<td>68.0</td>
<td>-</td>
<td>3.50+50</td>
<td>15.35</td>
<td>&quot;</td>
<td>&quot;</td>
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<td>CP-5L</td>
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<td>57.2</td>
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<td>-</td>
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<td>3.50+64</td>
<td>12.55</td>
<td>&quot;</td>
<td>&quot;</td>
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<tr>
<td>Collimators same as on 600 Beam</td>
<td></td>
<td></td>
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<tr>
<td>CP-5O</td>
<td>40.6</td>
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<td>-</td>
<td>3.50+64</td>
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<td>CP-5P</td>
<td>34.5</td>
<td>20.5</td>
<td>20</td>
<td>3.50+74</td>
<td>10.92</td>
<td>2.56</td>
<td>4.8</td>
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<td>13.85</td>
</tr>
</tbody>
</table>

Maximum intensities in a 2" diam decrease with energy from 7500/sec at 155 MeV to 5/sec at 20.5 MeV.
# SREL CYCLOTRON-BEAM INFORMATION

1. **Expt. No.:** 1C-111  
   **Date:** 11-14-67  
   **Signed:** S. Cleary

2. **Particle:** Proton $\pi^+$, $\pi^-$, Neutron, Other

3. **Nominal Beam Energy:** 300 Mev-degraded to 129 Mev

4. **Area:** CTA $X$, PTA $N$, NM; Platter 300 $X$, 600 $Y$, Aux.

5. **Degrader:** BD-1 $X$, BD-2 $Y$, Copper 3 inches; Regenerator Position

6. **Main Magnet:** N $X$, R $Y$, Shunt 67.8 mv

7. **Diverter:** $\pm 20.60$ amp on shunt; $\pm 31$ amp on meter

8. **Internal Beam Intensity:** on Monitor $\pm$ mv. on TC Flip

9. **External Beam Intensity:** $24 \times 10^{-6}$ on Monitor $BM1$, on Monitor $BM2$, on Monitor $BM3$, on Monitor $BM4$.

10. **Proton Transport Magnet Settings**

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mv)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2/M3</td>
<td>1</td>
<td>33.22</td>
<td>195</td>
<td>N</td>
</tr>
<tr>
<td>M4</td>
<td>2</td>
<td>20.14</td>
<td>120</td>
<td>N</td>
</tr>
<tr>
<td>M5</td>
<td>3</td>
<td>20.05</td>
<td>120</td>
<td>N</td>
</tr>
<tr>
<td>Q1A/Q2A</td>
<td>4</td>
<td>10.6</td>
<td>64</td>
<td>N</td>
</tr>
<tr>
<td>Q5</td>
<td>5</td>
<td>24.65</td>
<td>148</td>
<td>N</td>
</tr>
<tr>
<td>Q8</td>
<td>6</td>
<td>20.53</td>
<td>123</td>
<td>N</td>
</tr>
<tr>
<td>Q2/Q3</td>
<td>7</td>
<td>21.22</td>
<td>85</td>
<td>N</td>
</tr>
<tr>
<td>Q6/Q10</td>
<td>8</td>
<td>25.09</td>
<td>100</td>
<td>N</td>
</tr>
<tr>
<td>N.A.</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1</td>
<td>10</td>
<td>24.55</td>
<td>123</td>
<td>N</td>
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<tr>
<td>Q7</td>
<td>11</td>
<td>16.2</td>
<td>81</td>
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<td>Q9</td>
<td>12</td>
<td>7.23</td>
<td>35</td>
<td>N</td>
</tr>
<tr>
<td>N.A.</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N.A.</td>
<td>14</td>
<td></td>
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<td></td>
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<tr>
<td>Q4</td>
<td>15</td>
<td>26.49</td>
<td>78</td>
<td>N</td>
</tr>
<tr>
<td>Q11</td>
<td>16</td>
<td>19.53</td>
<td>58</td>
<td>N</td>
</tr>
<tr>
<td>Q12</td>
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<td>Q14</td>
<td>19</td>
<td>23.94</td>
<td>72</td>
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<tr>
<td>M1</td>
<td>20</td>
<td>9.02</td>
<td>27</td>
<td>N</td>
</tr>
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</table>
11. Internal Target Information
   
   Radius Meter Reading
   Azimuth Meter Reading
   Description of Target

12. Bending and Focussing Magnet Information (For Meson Beams)
   
<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>Position*</th>
<th>Bending Angle</th>
<th>Current (Amp)</th>
<th>Polarity**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   *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: 129 Mev Peak Intensity: $1.7 \times 10^7$ p+/cm²/sec
      Width of Magnet Curve: %
   b. Defining Apertures in Shielding (Position, Size)
   c. Range information
      Slowing Down Material: polystyrene
      Stoppering Material: H₂O
      Stopper Dimensions: 
      Range Data:
      
      | Particle | Peak Range | FWHM | Maximum Stopping Rate |
      |----------|------------|------|-----------------------|
      |          | 12.2 cm    | 15.5 mm |                        |
      |          |            |      |                       |

      Peak Range: 12.2 cm in H₂O
      FWHM: 15.5 mm horizontal
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.

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.

![Diagram]

15. Comments:

(1) Position of Polystyrene degrader (0 to 4.5"")
(2) Position of beam profile measurement with semiconductor diode.
Beam No. CP7

SREL CYCLOTRON-BEAM INFORMATION

1. Expt. No. NC 106  
Date 2-1-68  
Signed E. Boschitz

2. Particle: Proton\( \oplus \), \( \pi^+ \), \( \pi^- \), Neutron \(_\oplus\), Other \(_\oplus\)

3. Nominal Beam Energy: 600 MeV  
Polarized

4. Area: CTA \(_\oplus\), PTA \(_\oplus\), NM \(_\oplus\); Platter 300 \(_\oplus\), 600 \(_\oplus\), Aux. \(_\oplus\) See Page 3

5. Degrader: BD-1 \(_\oplus\), BD-2 \(_\oplus\), Copper \(_\oplus\) inches; Regenerator Position \(_\oplus\)

6. Main Magnet: N \(_\oplus\), R \(_\oplus\), Shunt 74.0 mV

7. Diverter: \(_\oplus\) on shunt; \(+26\) amp on meter

8. Internal Beam Intensity: \(_\oplus\) on Monitor, \(2.2\) mV on TC Flip .297 mA/mV

9. External Beam Intensity: \(8.2 \times 10^{-9}\) on Monitor \(_1\), \(5 \times 10^{-10}\) on Monitor \(_5\), \(_\oplus\) on Monitor \(_\oplus\), \(_\oplus\) on Monitor

10. Proton Transport Magnet Settings

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mV)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2/M3</td>
<td>1</td>
<td>43.28</td>
<td>258</td>
<td>N</td>
</tr>
<tr>
<td>M6</td>
<td>2</td>
<td>48.00</td>
<td>292</td>
<td>N</td>
</tr>
<tr>
<td>M7</td>
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<td>46.90</td>
<td>282</td>
<td>N</td>
</tr>
<tr>
<td>Q1A/Q2A</td>
<td>4</td>
<td>26.00</td>
<td>150</td>
<td>N</td>
</tr>
<tr>
<td>Q17</td>
<td>5</td>
<td>30.18</td>
<td>182</td>
<td>N</td>
</tr>
<tr>
<td>Q3</td>
<td>6</td>
<td>22.44</td>
<td>137</td>
<td>N</td>
</tr>
<tr>
<td>Q2/Q4</td>
<td>7</td>
<td>34.55</td>
<td>145</td>
<td>N</td>
</tr>
<tr>
<td>Q18/Q22</td>
<td>8</td>
<td>53.97</td>
<td>212</td>
<td>N</td>
</tr>
<tr>
<td>Q15/Q16</td>
<td>9</td>
<td>47.86</td>
<td>190</td>
<td>N</td>
</tr>
<tr>
<td>Q1</td>
<td>10</td>
<td>35.89</td>
<td>160</td>
<td>N</td>
</tr>
<tr>
<td>Q19</td>
<td>11</td>
<td>66.44</td>
<td>330</td>
<td>N</td>
</tr>
<tr>
<td>Q20</td>
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<td>Q6</td>
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<td>Q23</td>
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<td>M1</td>
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<td>0</td>
<td>N</td>
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</table>
Beam No. CP7

11. Internal Target Information

<table>
<thead>
<tr>
<th>Radius Meter Reading</th>
<th>1.65</th>
<th>Radius Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azimuth Meter Reading</td>
<td>1.90</td>
<td>Azimuth Measurement</td>
</tr>
<tr>
<td>Description of Target</td>
<td>.75&quot; x 2&quot; x 4&quot; Graphite Block</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Magnets Used</th>
<th>Position*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending Angle</td>
<td>Current (Amp)</td>
</tr>
<tr>
<td>Polarity**</td>
<td></td>
</tr>
</tbody>
</table>

*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

<table>
<thead>
<tr>
<th>ENERGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Central: 545 Peak Intensity: 5 X 10^7 protons/sec</td>
</tr>
<tr>
<td>Width of Magnet Curve: _____</td>
</tr>
<tr>
<td>b. Defining Apertures in Shielding (Position, Size)</td>
</tr>
<tr>
<td>2&quot; thick, 1/2&quot; wide copper collimator</td>
</tr>
<tr>
<td>upstream from Q15/Q16</td>
</tr>
<tr>
<td>c. Range Information</td>
</tr>
<tr>
<td>Slowing Down Material:</td>
</tr>
<tr>
<td>Stopping Material:</td>
</tr>
<tr>
<td>Stopper Dimensions:</td>
</tr>
<tr>
<td>Range Data:</td>
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<tr>
<td>Particle</td>
</tr>
<tr>
<td>Peak Range</td>
</tr>
<tr>
<td>FWHM</td>
</tr>
<tr>
<td>Maximum Stopping Rate</td>
</tr>
</tbody>
</table>
The beam was polarized by using a carbon block inside the cyclotron at a radius of 37.2 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.
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; Regenerator 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)
   2.75 X 10⁻⁶  1.4 X 10⁻⁶

9. External Beam Intensity: ___ on Monitor 1, ___ on Monitor 2,
   1.8 X 10⁻⁶ on Monitor 3, ___ on Monitor 5, ___ on Monitor ___
   1.9 X 10⁻⁶

10. Proton Transport Magnet Settings

<table>
<thead>
<tr>
<th>Magnet No.</th>
<th>Power Supply No.</th>
<th>Shunt (mV)</th>
<th>Current (Amperes)</th>
<th>Polarity (N or R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2/M3</td>
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<td>33.29</td>
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<td>N</td>
</tr>
<tr>
<td>M6</td>
<td>2</td>
<td>34.54</td>
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<td>N</td>
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<td>M7</td>
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</tr>
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<td>Q3A/Q2A</td>
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<td>Q17</td>
<td>5</td>
<td>15.54</td>
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<td>Q3</td>
<td>6</td>
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<td>N</td>
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<td>Q15/Q16</td>
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<td>Q26</td>
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<td>M1</td>
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<td>9.35</td>
<td></td>
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</table>
II. Internal Target Information

Radius Meter Reading
Radius

Azimuth Meter Reading
Azimuth

Description of Target

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

Magnet 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:

<table>
<thead>
<tr>
<th>Particle</th>
<th>Peak Range</th>
<th>FWHM</th>
<th>Maximum Stopping Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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.

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 $1.9 \times 10^{-6}$, the intensity at BM-2 is measured as $1.4 \times 10^{-6}$. The discrepancy is apparently caused by saturation in the BM-2 Ion Chamber.
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 Cl₂ (p, pn) Cl¹ activation. The Faraday cup used corresponds to SREL Dwg. No. KO 31-126-2. Polyethylene foils of 7.36 mg/cm² thickness were activated and placed in a 0.51 dia. Aluminum pill box. The pill box was placed 5.75 inches from a 3x3 NaI crystal and the annihilation radiation counted. The counting efficiency was determined by counting a calibrated Na²² source in the same geometry.

The first experimental set up was as follows. The extracted 600 MeV beam passed through the beam transport system, BX5 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 microvoltmeter. The charge collected by BX5 was integrated on an Elco electrometer. The Argon pressure in the BX5 ion chamber was 14 psi. Typical measured values are given in Table 1.

<table>
<thead>
<tr>
<th>RUN NO.</th>
<th>BX5 CHARGE (Coulombs)</th>
<th>FARADAY CUP CHARGE (Coulombs)</th>
<th>ACTIVATION (Protons/sec)</th>
<th>3M5</th>
<th>FARADAY CUP (Protons/sec)</th>
<th>FARADAY CUP Activation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.57x10⁻³</td>
<td>1.92x10⁻⁵</td>
<td>1.75x10¹¹</td>
<td>134</td>
<td>2.0x10¹¹</td>
<td>1.14</td>
</tr>
<tr>
<td>2</td>
<td>6.6 x10⁻⁴</td>
<td>2.5x10⁻⁶</td>
<td>2.71x10¹⁰</td>
<td>264</td>
<td>2.6x10¹⁰</td>
<td>0.96</td>
</tr>
<tr>
<td>3</td>
<td>1.31x10⁻⁴</td>
<td>3.19x10⁻⁷</td>
<td>3.22x10⁹</td>
<td>410</td>
<td>3.3x10⁹</td>
<td>1.02</td>
</tr>
<tr>
<td>4</td>
<td>2.61x10⁻⁵</td>
<td>5.4x10⁻⁸</td>
<td>5.05x10⁸</td>
<td>483</td>
<td>5.6x10⁸</td>
<td>1.11</td>
</tr>
<tr>
<td>5</td>
<td>6.36x10⁻⁶</td>
<td>1.29x10⁻⁸</td>
<td>1.25x10⁸</td>
<td>493</td>
<td>1.34x10⁸</td>
<td>1.07</td>
</tr>
</tbody>
</table>

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 intensity is about 2x10¹³ protons/sec. Comparison of the charge collected on BX5 with the Faraday Cup in Column 5 indicates a nonlinear behavior of the ion chamber for beam intensities greater than ~10⁹ protons/sec. The ratio BX5/Faraday Cup is represented in Figure 1, and a calibration curve for BX5 is given in Figure 2.

The ratio BX5/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 keV proton beam passed through the BX4 ion chamber, the remaining beam transport system and into the Combined Target Area where it traversed BX4, an activation foil and was collected by the Faraday Cup. An Elcor electrometer was used to measure the current collected by BX4, a Hewlett Packard 425 micro volt-amp meter read the current collected by BX4 and a Keithley 602 electrometer registered the Faraday Cup current. The Argon pressure in the ion chamber was 14 psig 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>
<thead>
<tr>
<th>BX4 (amps)</th>
<th>BX4 (amps)</th>
<th>FARADAY CUP (amps)</th>
<th>BX4 Faraday Cup</th>
<th>BX4 Faraday Cup</th>
<th>Faraday Cup (protons/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0x10^-7</td>
<td>1.5x10^-7</td>
<td>4.6x10^-6</td>
<td>417</td>
<td>375</td>
<td>2.88x10^6</td>
</tr>
<tr>
<td>5.0x10^-7</td>
<td>3.8x10^-7</td>
<td>1.3x10^-6</td>
<td>355</td>
<td>292</td>
<td>7.8x10^6</td>
</tr>
<tr>
<td>1.0x10^-6</td>
<td>7.0x10^-7</td>
<td>2.6x10^-9</td>
<td>270</td>
<td>200</td>
<td>1.56x10^6</td>
</tr>
<tr>
<td>2.25x10^-6</td>
<td>1.2x10^-6</td>
<td>6.0x10^-9</td>
<td>375</td>
<td>200</td>
<td>3.6x10^6</td>
</tr>
<tr>
<td>9.6x10^-8</td>
<td>9.2x10^-8</td>
<td>2.2x10^-10</td>
<td>436</td>
<td>418</td>
<td>1.32x10^9</td>
</tr>
<tr>
<td>4.8x10^-8</td>
<td>4.8x10^-8</td>
<td>1.1x10^-10</td>
<td>436</td>
<td>435</td>
<td>6.6x10^6</td>
</tr>
<tr>
<td>2.0x10^-8</td>
<td>2.1x10^-8</td>
<td>4.6x10^-11</td>
<td>417</td>
<td>433</td>
<td>2.88x10^6</td>
</tr>
<tr>
<td>4.15x10^-8</td>
<td>4.0x10^-9</td>
<td>9.0x10^-12</td>
<td>460</td>
<td>445</td>
<td>5.4x10^7</td>
</tr>
<tr>
<td>1.0x10^-8</td>
<td>1.0x10^-8</td>
<td>2.3x10^-11</td>
<td>434</td>
<td>434</td>
<td>1.56x10^8</td>
</tr>
<tr>
<td>1.7x10^-9</td>
<td>1.68x10^-9</td>
<td>4.0x10^-12</td>
<td>425</td>
<td>420</td>
<td>2.4x10^7</td>
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<tr>
<td>9.0x10^-10</td>
<td>9.0x10^-10</td>
<td>2.0x10^-12</td>
<td>430</td>
<td>430</td>
<td>1.2x10^7</td>
</tr>
<tr>
<td>4.55x10^-10</td>
<td>4.6x10^-10</td>
<td>1.0x10^-12</td>
<td>455</td>
<td>460</td>
<td>6.0x10^6</td>
</tr>
<tr>
<td>8.2x10^-7</td>
<td>3.25x10^-5</td>
<td>2.5x10^-8</td>
<td>330</td>
<td>130</td>
<td>1.38x10^11</td>
</tr>
</tbody>
</table>

Again the nonlinearity of the ion chambers is evident for beam intensities greater than about 10^6 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 BX4 is given in Figure 4. Additional curves for BX2 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 BX2, the remaining beam transport system through BX4 and was collected by the Faraday Cup in the Combined Target Area. The Faraday Cup current was read by a Keithly 602 electrometer, BX2 by a Hewlett Packard 425 and BX4 by an Elcor electrometer. The measured currents are represented in Table III.

<table>
<thead>
<tr>
<th>BX2 (amps)</th>
<th>BX4 (amps)</th>
<th>Faraday Cup (amp)</th>
<th>BX2 Faraday Cup</th>
<th>BX4 Faraday Cup</th>
<th>Faraday Cup Protons/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1x10^-6</td>
<td>1.0x10^-6</td>
<td>3.2x10^-9</td>
<td>342</td>
<td>313</td>
<td>1.92x10^10</td>
</tr>
</tbody>
</table>

It appears that the nominal maximum beam intensity for the 300 MeV beam is about 2x10^10 protons/sec. For this beam intensity the current readings of BX2 and BX4 agree well with readings taken at 600 MeV taking into account the change in dE/dx from 600 to 300 MeV.
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 H18x36-KW300
PACIFIC ELECTRIC MOTOR CO.

POWER AND WATER CONNECTIONS
(COVERED) TYPICAL THIS SIDE

CUTAWAY VIEW-POLE TIP
BENDING MAGNET
H18 x36 - KW300

MAGNETIC FIELD, KILOGAUSS

CURRENT, AMPERES

500
450
400
350
300
250
200
150
100
FIELD MEASUREMENT POINTS FOR TABLES ON THE FOLLOWING PAGES ARE SHOWN BELOW:

```

A    H    O

B    I    P

C    J    Q

D    K    R

E    L    S

F    M    T

G    N    U
```

POLE
BENDING MAGNET
H18x36-KW300

TEST DATA  CURRENT : 250 AMPERES

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<th>12&quot;</th>
<th>14&quot;</th>
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<tbody>
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<td>5.9</td>
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<td>B</td>
<td>7.45</td>
<td>5.85</td>
<td>5.2</td>
</tr>
<tr>
<td>C</td>
<td>7.55</td>
<td>5.85</td>
<td>5.25</td>
</tr>
<tr>
<td>D</td>
<td>7.45</td>
<td>5.85</td>
<td>5.2</td>
</tr>
<tr>
<td>E</td>
<td>5.6</td>
<td>4.85</td>
<td>4.1</td>
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<tr>
<td>F</td>
<td>1.4</td>
<td>1.33</td>
<td>1.28</td>
</tr>
<tr>
<td>G</td>
<td>.39</td>
<td>.3</td>
<td>.4</td>
</tr>
<tr>
<td>H</td>
<td>6.95</td>
<td>4.9</td>
<td>4.25</td>
</tr>
<tr>
<td>I</td>
<td>8.25</td>
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<td>5.2</td>
</tr>
<tr>
<td>K</td>
<td>8.1</td>
<td>6.1</td>
<td>5.1</td>
</tr>
<tr>
<td>L</td>
<td>6.35</td>
<td>4.9</td>
<td>4.1</td>
</tr>
<tr>
<td>M</td>
<td>1.65</td>
<td>1.55</td>
<td>1.37</td>
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<td>.44</td>
<td>.45</td>
<td>.4</td>
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<tr>
<td>O</td>
<td>6.</td>
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<td>4.15</td>
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<td>P</td>
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<td>Q</td>
<td>7.45</td>
<td>5.85</td>
<td>5.3</td>
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<td>R</td>
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<td>S</td>
<td>5.67</td>
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<td>4.</td>
</tr>
<tr>
<td>T</td>
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<tr>
<td>U</td>
<td>.39</td>
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<td>.33</td>
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### TEST DATA

**CURRENT: 500 AMPERES**

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<th>AIR GAP 12&quot;</th>
<th>AIR GAP 14&quot;</th>
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</tr>
<tr>
<td>B</td>
<td>14.</td>
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</tr>
<tr>
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<td>10.25</td>
</tr>
<tr>
<td>D</td>
<td>13.56</td>
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<td>E</td>
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</tr>
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<td>8.</td>
<td>6.8</td>
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<td>I</td>
<td>15.9</td>
<td>12.1</td>
<td>10.3</td>
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<tr>
<td>J</td>
<td>16.</td>
<td>12.1</td>
<td>10.35</td>
</tr>
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<td>12.1</td>
<td>10.3</td>
</tr>
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<td>9.3</td>
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<td>M</td>
<td>3.</td>
<td>3.</td>
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<td>.85</td>
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<td>10.5</td>
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<td>14.</td>
<td>11.4</td>
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<td>14.2</td>
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<tr>
<td>U</td>
<td>.7</td>
<td>.75</td>
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</tbody>
</table>
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-18x36-10
SPECTROMAGNETIC

POWER AND WATER CONNECTIONS (COVERED) TYPICAL THIS SIDE

CUTAWAY VIEW-POLE TIP

POLE TIP
18 13/16" w x 36" LG

91

57

48

8 36

2 1/2

1 1/2

20

18 13/16

47

57

9" NOM
BENDING MAGNET
H-18x36-10 - kW175
MAGNETIZATION CURVE
SPECTROMAGNETIC

MAGNETIC FIELD, KILOGAUSS

CURRENT, AMPERES
BENDING MAGNET
H-18 x 36-10 - KW 175

NMR PLOT AT 50 % FIELD

\[ \text{SCALE: } \frac{1}{8}" = 1" \]

A = 8955  \quad E = 8977  \quad I = 8964

B = 8964  \quad F = 8964  \quad J = 8964

C = 8977  \quad G = 8955  \quad K = 8955

D = 8973  \quad H = 8955

ALL READINGS ARE IN GAUSS
BENDING MAGNET
H-18 x 36-10 - KW 175

FRINGE FIELD MEASUREMENTS
WITH RAWSON PROBE

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<tr>
<th>PROBE PATH</th>
<th>LEAD END</th>
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<tr>
<td>POLE OUTLINE</td>
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<thead>
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<tbody>
<tr>
<td>-Y</td>
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| 18" |
| 36" |

### AT MAXIMUM FIELD

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### AT 50% FIELD

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<tr>
<td>21.5</td>
<td>303</td>
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</table>
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 5-9972A

POWER AND WATER CONNECTIONS TYPICAL THIS SIDE

CUTAWAY VIEW-POLE TIP
H₂₀x₂₀ – KV175
MAGNETIZATION CURVE
SERIAL NUMBER S-9972A

MAGNETIC FIELD, KILOGAUSS

CURRENT, AMPERES

9" AIR GAP
12" AIR GAP
H 20 x 20 — KW 175
TEST DATA
SERIAL NUMBER S-9972A

AIR GAP 9"
ALL READINGS IN KILOGAUSS

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**H2Ox20 - KW 175**

**TEST DATA**

**SERIAL NUMBER S-9972A**

**AIR GAP 12"**

**ALL READINGS IN KILOGAUSS**

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IV SREL EQUIPMENT POOL

A. Rules for the Use of the Equipment Pool
B. Fast Counting Equipment (≥ 100 MHz)
C. Slow Counting Equipment (≤ 50 MHz)
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
### APPROVAL FOR REMOVAL OF PROPERTY FROM SPACE RADIATION EFFECTS LABORATORY

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<tr>
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<td>4. Manufacturer</td>
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<td>7. Date to be Returned:</td>
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<td>8. Purpose of Removal:</td>
<td>9. Condition (Include notation of any</td>
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<td>10. SREL Experiment No.</td>
<td>11. Destination of Equipment:</td>
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<td>12. Remarks:</td>
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<td>13. Remover</td>
<td>14. Approval of D/SREL or his Delegate:</td>
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<td></td>
<td>Signature Date</td>
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<td></td>
<td>Affiliation</td>
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<td>( ) Other (Explain in detail in Blank 10)</td>
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</table>

---

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.
### Fast Counting Equipment

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<td>Extenders</td>
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<tr>
<td></td>
<td>103</td>
<td>And/Or</td>
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<td>Prescaler</td>
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<td>TC-907B</td>
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<td>&quot;</td>
<td>TC-908</td>
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<td>&quot;</td>
<td>TC-200</td>
<td>Linear Amplifier</td>
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<td>&quot;</td>
<td>TC-250A</td>
<td>Biased Amplifier and Stretcher</td>
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<td>&quot;</td>
<td>TC-800</td>
<td>Precision Pulser</td>
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<td>TC-135</td>
<td>FET Preamp</td>
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<td>TC-930</td>
<td>Power Supply</td>
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<tr>
<td>Tomlinson</td>
<td>2000AEC</td>
<td>Beam Current Integrator</td>
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D. Scintillation and Solid State Counters

<table>
<thead>
<tr>
<th>Mfr.</th>
<th>Model</th>
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<tr>
<td>Amperex</td>
<td>56 AVP</td>
<td>PM Tubes</td>
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<tr>
<td></td>
<td>58 AVP</td>
<td>PM Tubes</td>
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<td>Ortec</td>
<td>216</td>
<td>Shield for 56 AVP</td>
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<td>217</td>
<td>Shield for 58 AVP</td>
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<td></td>
<td>269</td>
<td>PM Tube Base</td>
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<td>Harshaw</td>
<td>12S12</td>
<td>3&quot; x 3&quot; NaI Xtal</td>
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<td>20MB1S/A</td>
<td>5&quot; x 4&quot; NaI Xtal</td>
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<td>Ortec</td>
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<td>150-150</td>
<td>Si(Li) Detector</td>
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<td>Princeton</td>
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<td>Ge(Li) Detector</td>
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<td>Gamma-Tech</td>
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<td>Linde</td>
<td>LD-10</td>
<td>Liquid N\textsubscript{2} Dewar</td>
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<td>Solid State R</td>
<td>100SBTM-500</td>
<td>Surface Barrier Transmission</td>
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<td>Radiations</td>
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<td>Mount Detector</td>
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E. Pulse-Height Analyzers and Readout Equipment

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

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

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<th>Mfr.</th>
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<tr>
<td>EGG</td>
<td>1T 100</td>
<td>Inverting Transformer</td>
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<td>Ad-YU</td>
<td>10T 9B 1</td>
<td>Lumped Delay, 93Ω, 2 μsec</td>
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<td>10T 5B 1</td>
<td>&quot; &quot; , 50Ω, 2 μsec</td>
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<td>10T 9A 1</td>
<td>&quot; &quot; , 93Ω, 1 μsec</td>
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<tr>
<td></td>
<td>10T 5A 1</td>
<td>&quot; &quot; , 50Ω, 1 μsec</td>
<td>5</td>
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<tr>
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<td>10T 5D 21</td>
<td>&quot; &quot; , 93Ω, 0.5 μsec</td>
<td>5</td>
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<td>10T 5D 01</td>
<td>&quot; &quot; , 50Ω, 0.5 μsec</td>
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<td>10T 9C 21</td>
<td>&quot; &quot; , 93Ω, 0.3 μsec</td>
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<td>10T 5C 01</td>
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<td>5</td>
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<tr>
<td></td>
<td>10T 9A 21</td>
<td>&quot; &quot; , 93Ω, 0.15 μsec</td>
<td>5</td>
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<td>10T 5A 11</td>
<td>&quot; &quot; , 50Ω, 0.15 μsec</td>
<td>5</td>
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<tr>
<td>Lecroy</td>
<td>A 101</td>
<td>Variable 50Ω Attenuators</td>
<td>10</td>
</tr>
</tbody>
</table>
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.
DYNAAtITRON

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 SRHEL 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.
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 X 10^-1 μA
7) Modulator Power Supply: Voltage 15 KV., Current 0.2 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) 0.8 AMPS., Polarity -.
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 V5.48 AMPS.
   Station No. 3 _______ AMPS.
   Station No. 4 _______ AMPS.

19) Electron Beam Transport Magnet Settings:

<table>
<thead>
<tr>
<th>MAGNET NO.</th>
<th>SHUNT (MV)</th>
<th>CURRENT (AMPS)</th>
<th>POLARITY (N/R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM-2</td>
<td>0.38 Dial</td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>EQ-1</td>
<td>0.35</td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>EQ-2</td>
<td>0.77</td>
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<td>N</td>
</tr>
<tr>
<td>EQ-3</td>
<td>0.36</td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>EQ-4</td>
<td>0.45</td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>EQ-5</td>
<td>14.78mv</td>
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<td>N</td>
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<tr>
<td>EQ-6</td>
<td>14.82mv</td>
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<td>N</td>
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<td>EM-5&amp;7</td>
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<tr>
<td>EM-6</td>
<td>0.49</td>
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<td>N</td>
</tr>
<tr>
<td>EM-7</td>
<td></td>
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<td>N</td>
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</tbody>
</table>
BEAM NO. 1 - 1

20) Details and/or Comments:

Beam spot size 1 cm diameter of 20 mil aluminum water cooled window.
SREL DYNAMITRON BEAM INFORMATION

1) Experiment No. ND 101
2) Nominal Beam Energy: 2.0 MeV
   Target Current 3 x 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.
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 x 10^-7 TORR.
   Operating 3.1 x 10^-6 TORR.

Date Feb. 27, 1968
10) Electron Beam Transport magnet settings:

<table>
<thead>
<tr>
<th>MAGNET NO.</th>
<th>SHUNT (MV)</th>
<th>CURRENT (AMPS)</th>
<th>POLARITY (N/R)</th>
</tr>
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<tbody>
<tr>
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</table>

11) Details and/or Comments:

Experiment set-up at 90 degree port of EM-3.
Window material, 2 mil titanium, air cooled.
### SREL DYNAMITRON BEAM INFORMATION

1) **Experiment No.** 102  
2) **Nominal Beam Energy:** 2.0 MeV  
   **Target Current:** $8.8 \times 10^{-8}$ $\mu$A/ma  
3) **Area:** Dynamitron Room $X$ CTA  
   **REMARKS:**  
   Beam spot $\approx 1.5$ 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 $\mu$A.  
   **High Voltage:** 104 $\mu$A.  
   **Beam Tube Divider:** 249 $\mu$A.  
   **Internal Beam Current:** 47 $\mu$A/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:** $5 \times 10^{-7}$ TORR.  
   **Operating:** $2 \times 10^{-6}$ TORR.

---

**Date:** Mar. 4, 1968
10) Electron Beam Transport magnet settings:

<table>
<thead>
<tr>
<th>MAGNET NO.</th>
<th>SHUNT (MV)</th>
<th>CURRENT (AMPS)</th>
<th>POLARITY (N/R)</th>
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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

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
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

1. 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 determining 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 x 10⁹) 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)]...

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: ANAL (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 ANAL, 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: TWOP (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 total (actual plus dummy) number of ranges must be < 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

statement number
gate-spec: ([limit,] 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 (I, 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,] \{statement number\})

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

\[
\begin{align*}
&\text{ANALYZER} \\
&\text{SCALER} \\
&\text{GATE}
\end{align*}
\]

An example is

ANALYZER: ANAl
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, viz.,

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.
Appendix B

Action Statements

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

1. 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

\[ \texttt{[N]} \texttt{PHA: analyzer-name (list) [; analyzer-name (list)]} ... \]

where

- analyzer-name: the name of a specified analyzer
- list: Parameter \[,\, \text{parameter}\] ...
- parameter: integer-constant|full-word-integer-variable\,\text{arith.expr.}

denoting which word(s) from the event data stream are used.

Example:

\texttt{PHA: ANAl (5); GAMMA (SG)}

This causes the analyzer ANAl 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.

\texttt{PHA: TWOP (3,5)}

This causes the two-parameter analyzer TWOP 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

\[ \text{DGATE: argument } [; \text{argument}]... \]

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:

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

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

\[ \text{IGATE: argument } [; \text{argument}]... \]

argument: gate-name (analyzer-name)
- gate name: the name of a specified gate
- analyzer name: the name of a specified analyzer

Example:

\[ \text{IGATE: IG4 (ANALI)} \]

where previously specified might have been

\[ \text{GATE: IG4 (1000000, FINE) (0, 1023)} \]

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

\[
\begin{align*}
&\text{IGATE:} \\
&\text{DGATE:} \text{argument [exit]} \\
&\text{SCALE:} \\
\end{align*}
\]

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
   \[
   \text{CLEAR argument [;argument]}...
   \]
   where
   - argument: analyzer-name|gate-name|scanner-name

   Example:
   \[
   \text{CLEAR: NANI; ANAZ; GAMMA; BETA; BEAMG; BEAMQ; GATENG; GAMS; SCALEI; SCALE2; IG4}
   \]
   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 before 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, **DATA(0)** refers to the first word in the buffer, and **DATA(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. **LOC**

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

```
INTEGER  LOC
```

The form is

```
LOC (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 LOGICAL variable

bitl: full-word INTEGERS

nbits:

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. GETBITI

The use and definitions are exactly those above, except that

var: LOC (argument)

rather than a variable name.

Example:

GETBIT(4192,5,6)

and

GETBITI(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,"")

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(I,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 $\text{POINT}$. The following procedure should be used:

```plaintext
EXTERNAL $\text{POINT}$
INTEGER $\text{GETAT}$
ITEMP = $\text{GETAT}(\text{POINT}, 0)$
CALL $\text{PUTAT}(\text{LOC(ARRAY)}, \text{POINT}, 0)$
PHA:ANAL(0)

C USES ARRAY(1) AS A CHANNEL NUMBER
   CALL $\text{PUTAT}(\text{ITEMP}, \text{POINT}, 0)$
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

```plaintext
CALL EØJS (I, J, K)
```

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

- $I = 0$ indicates normal job termination
- $I = 1$ 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

   \[
   \text{DATAWD} \ (\text{argument})
   \]

   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:
   \[
   \text{VI}=5.0\times\text{DATAWD} \ (3)/\text{BETASQ} + \text{DATAWD} \ (6* \ i - 7)
   \]

2. **INTMR**

   Its form is

   \[
   \text{INTMR} \ (\text{arg-1}, \text{arg-2} [,\text{arg-3}])
   \]

   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.
   \[0 \leq \text{arg-2} \leq \text{arg-3} \leq 15\], 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.

\[
\text{If (NSCAL.NE.INTMR (3, 0, 5)) GO TO ERROR}
\]

3. \textsc{logmr}

Its form is

\[
\text{LOGMR (arg-1, arg-2)}
\]

where

- \text{arg-1: points to a data word in the current event}
- \text{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 \textsc{DATA} statement and hexadecimal form.

Example:

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

\[
\begin{align*}
\text{INTEGER Q, LOGMR} \\
\text{LOGICAL STATUS, GOOD, NOGOOD} \\
\text{DATA Q/ZE/,GOOD/.TRUE./,NOGOOD/.FALSE.}
\end{align*}
\]
The integer variable \( Q \) has the value hexadecimal \( E \), where \( E \) is decimal 14, or binary 1110, which is right justified to be

\[
\begin{array}{llllll}
0 & 0 & 0 & 0 & 0 & 0 \\
\end{array}
\]

The logical variable \( \text{STATUS} \) has the value \( \text{.TRUE.} \) if \( \overline{ABC} \) is true, and the value \( \text{.FALSE.} \) is \( \overline{ABC} \) 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., \( \overline{C} \) 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
LOGICAL STATUS, GOOD, NOGOOD
DATA Q1/ZC/, Q2/72/, GOOD/, .TRUE./, NOGOOD/, .FALSE./
```

The form is

```
VALUE ( { gate-name scaler-name analyzer-name, \( x_1, x_2 \ldots, x_n \} )
```
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

\[
\text{ANALYZER: AN1 (1023); THREEP (5, 10, 50)}
\]

We can ask in the problem program for

\[ IC = \text{VALUE (AN1, 17)}, \]

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

We can also ask for

\[ IC = \text{VALUE (THREEP, 3,2,7)} \]

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

\[ IC = \text{VALUE (GATE5)}, \]

etc.

5. \$VALUE

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

The form is

\[
\text{CALL \$VALUE (0, expr. name [,x_1...x_n])}
\]

where

- \( \text{expr} \) = integer-constant\text{|integer *4-var\text{|arithmetic expression}
- \( \text{name} \) = analyzer-name\text{|scaler-name\text{|gate-name}
- \( x_i \) = in the case of an analyzer, 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 (COUNTS)
   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) NODATA: 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) PROCESS: take data and analyze
4) COPY: 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, COPY, 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, PROCESS 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 1

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 hardware configuration is

EVENT 1: scaler, ADC
EVENT 16: monitor register.

The scaler in EVENT 1 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

\[ \text{LGMR} (1,1) . \text{EQ}.1 \]

causes the mask 0000 0000 0000 0001 to be compared to the monitor register bit settings. If the rightmost bit is on, \( \text{LGMR} (1,1) = 1 \), if it is off, \( \text{LGMR} (1,1) = 0 \). The former is the "on" condition, the latter is "off".

At the same time, bits 1 thru 8 are used to assign a value to the number MAXCT, viz.,

\[ \text{MAXCT} = \text{INTMR} (1,1,4) \times 10^{\text{INTMR}(1,5,8)} \]

If the monitor register was set to

0001 0010 0000 0000

we would have

\[ \text{MAXCT} = 1 \times 10^{2} \]

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.
PROGRAM FOR PROBLEM NO. 1

SPECIFICATION STATEMENTS

ANALYZER*4: MAIN(1024)
GATE: CHECK(2147483647, 1610)(300, 700)
LOGICAL STOP/.TRUE./
LOGICAL FLAG/.TRUE./
INTEGER VALUE, DATAWD, C(8), RUNNO/O/, TIME1/0/, TIME2/0/
INTEGER LOGMR, INTMR

FORMAT(IHI, 'EXPERIMENT INITIALIZED')
FORMAT(HO, 'TOTAL COUNTS EXCEEDS 2**31-1')
FORMAT(IHI/IHO, 'RUN NO. ',110,' TIME1=',110,' TIME2=',
    110/IHO, 'TOTAL COUNTS=',112,' TOTAL COUNTS IN WINDOW=',
    112/)
FORMAT(I, 9112)
FORMAT(I, --FOLLOWING PRINTOUT GENERATED BY REQUEST IN EVENT 1')

WRITE(6, 5)
CREATE: MAIN CHECK
CLEAR: MAIN CHECK

ENTER EVENT MODE

EVENT 1

SKIP ANY ACTION UNLESS STOP HAS BEEN SET TO .FALSE., THIS ALLOWS
THE EXPERIMENTER TO START, STOP, AND PAUSE WHENEVER HE DESIRES

IF (STOP) GO TO 199
DATA WILL NOW BE PROCESSED
IF (FLAG) GO TO 110
FLAG=.TRUE.
TIME1=DATAWD(1)
IC=IC+1
PHA: MAIN(2)
DGATE: CHECK(2)
SHOULD PRINTOUT TAKE PLACE NOW
IF (VALUE(CHECK).LT.MAXCT) GO TO 199
YES
TIME2=DATAWD(1)
WRITE(6, 25)
GO TO 1620

EVENT END

EVENT 16

THIS TAKES CARE OF PRINTOUT (OR WRITING ON TAPE, ETC.)
AND STARTING AND STOPPING
IF (LOGMR(1,1).EQ.1) GO TO 1605
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 11=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

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        3. END OF DATA (/*)
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IV  PROCEDURES AND EXAMPLES TO AID EXPERIMENTERS
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 FORTRAN 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, FORTRAN, 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 FORTRAN 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 FORTRAN 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

// JOB

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-name EXEC BLAST(LINK,MAP)
//program-name EXEC FORTRAN(MAP)
// EXEC LNKEDT(NOKEEP,MAP)
// EXEC

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 */ 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

```
// JOB
// program-name FORTRAN(MAP)
source statements of main program
/*
// subprogram1-name FORTRAN(MAP)
source statements of subprogram
*/
// EXEC
data, if any
/*
&
```

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*  
2. *Module Deck from Source Statements*  
3. *Run Module Deck*  
4. *Fortran Program with Subroutines*  
5. *Source and Module Decks*  
6. *Source and Module Decks*  
7. *Run Module Decks*  
8. *Data Acquisition Language Source Statements*  
9. *Remote Typewriter Language Source Statements*  
10. *Data Acquisition and Remote Typewriter*  
11. *Use of Interface and Remote Typewriter*  

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1.

OBJECT: to run a program with only a main program, which

is in the form of FORTRAN source statements.

Arrange the cards as follows:

// [name] JOB DUMP, XX

// program-name EXEC FORTRAN (MAP)

fortran source statements

/*

// EXEC LNKEDT (MAP)

*/

// EXEC

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 FORTRAN source statements.

Arrange the cards as follows:

// [name]_JOB_[DUMP],XX
// program-name EXEC FORTRAN(Deck)

FORTRAN 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

PROCEDURE 4 - place the card /X(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
OBJECT: To run a module deck as a job.

Arrange the cards as follows:

```
//\[name]\$JOB\$[DUMP],XX
//\$EXEC\$LNKEDT(MAP)
\$MODULE\$module-name
```

Module deck

```
\$PHASE\$phase-name,S
\$INCLUDE\$module-name,L
/*
//\$EXEC

  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.
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]_JOB_[DUMP],XX

// program-name EXEC FØRTRAN (MAP)

fortran source statements

/*

// subprogram1-name EXEC FØRTRAN (BCD, MAP)

fortran source statements

*/

// EXEC LNKEDT (MAP)

/*

// EXEC

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 FORTRAN
and a subprogram in the form of a module.

Arrange the cards as follows:

// [name] $JOB$ [DUMP], XX
// [program-name] $EXEC$ FORTRAN (MAP)

Fortran source statements

/*

// $EXEC$ LNKEDT (MAP)

$MODULE$ module-name

Module deck

$PHASE$ phase-name, S

$INCLUDE$ program-name, L

$INCLUDE$ module-name, L

/*

// $EXEC$

Data, if any

/*

&

where name and DUMP are optional, and XX is your user code.
6.

OBJECT: To run a program having a main program in FORTRAN
and two subprograms in module form.

Arrange the cards as follows:

1
//[name]_JOB_[DUMP],XX
//program-name_EXEC_FORTRAN(MAP)

fortran source statements

/*
//EXEC_LNKEDT(MAP)
MODULE module-name1

module deck
MODULE module-name2

module deck
PHASE phase-name, S
INCLUDE program-name,L
INCLUDE module-name1,L
INCLUDE module-name2,L
/*
//EXEC

data, if any

/*
/ &

1 where name and DUMP are optional, and XX is your user code.
OBJECT: To run a program that consists of four modules.

Arrange the cards as follows:

```
/^[name]$/JOB$/[DUMP],XX

//EXEC$/LNKEDT (MAP)

\$MODULE\$module-name1
    module deck

\$MODULE\$module-name2
    module deck

\$MODULE\$module-name3
    module deck

\$MODULE\$module-name4
    module deck

\$PHASE$/phasename,S

\$INCLUDE$/first module-name1,L

\$INCLUDE$/second module-name2,L

\$INCLUDE$/third module-name3,L

\$INCLUDE$/fourth module-name4,L

/*

//EXEC

data, if any

/*

/\n
1 where name and DUMP are optional, and XX is your user code.
TITLE: PROPER CONTROL CARDS FOR USE OF INTERFACE PRECOMPILER

OBJECT: To obtain a module deck of a Yale data acquisition program.

//\%JOB\%DUMP,XX
//SYS001\%ACCESS\%YDISH,291='SREL02'
//SYS002\%ACCESS\%TAPE,280=
//SYSLST ACCESS IGN (optional - see Note 1)
//SYSOPT ACCESS IGN (optional - see Note 2)
//\%EXEC\%ROOTP

# your program

/*
//SYSIPT\%ACCESS\%TAPE,280=
//SYSLST ACCESS IGN (optional - see Note 3)
//DALIN\%EXEC\%FORTRAN(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 translator
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 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, interpretable 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 /6 (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.
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 type-writer.

//WJOB=DUMP,XX
//SYS001=ACCESS=YDSH,291='SREL02'
//SYS002=ACCESS=TAPE,280=
//SYSLST ACCESS IGN (optional - see Note 1)
//EXEC=SCAN

Your
program

/*
//SYSIPT=ACCESS=TAPE,280=
//SYSLST ACCESS IGN (optional - see Note 2)
//DALIN=EXEC=FORTRAN(MAP,DECK)
/*
*/

# 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

\[
\text{FE11A M 280}
\]
\[
\text{FE12A READY}
\]

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, interpretable 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

\[
\text{FE 11A M 280}
\]
\[
\text{FE 12A READY}
\]

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 /8 (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.
TITLE: PROPER CONTROL CARDS FOR USE OF COMBINED REMOTE TYPEWRITER
AND INTERFACE PRECOMPILERS

OBJECT: To obtain a module deck that represents a data acquisition
program using the remote typewriter and interface.

// JOB
// SYS001 ACCESS YDSH,291='SREL02'
// SYS002 ACCESS TAPE,280=
// SYSLST ACCESS IGN (optional - see Note 1)
// EXEC SCAN

your program

/*
// SYS001 ACCESS YDSH,291='SREL02'
// SYS002 ACCESS TAPE,281=
// SYSIPT ACCESS TAPE,280=
// SYSOPT ACCESS IGN (optional - see Note 3)
// SYSLST ACCESS IGN (optional - see Note 2)
// EXEC ROOTP
// SYSIPT ACCESS TAPE,281=
// SYSLST ACCESS IGN (optional - see Note 4)
// DALIN EXEC FORTRAN (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, interpretable 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, interpretable 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 pro-
gram 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.
TITLE:  PROPER CONTROL CARDS FOR USE OF INTERFACE AND REMOTE TYPEWRITER

//JOB=DUMP,XX
//EXEC=LINKEDT(MAP)
MODULE=DALIN

module deck

PHASE=TEST,ROOT
#include=DALIN,L
#include=BLKCOM,R
#include=DUMMY,"X'1D000'
#include=DUMMY,R

cluded

#include=SDFSABS
#include=DELETE=SDFSABS(DUMMY)
#include=CONDENSE=SDFSABS

/*
#include=SDFSABS
#include=SDFSABS
#include=SDFSABS

 SYS002=ACCESS=SDFSABS
 SYS003=ACCESS=TAPE,280= (see Note 1)
 SYS010=ACCESS=FRONTEND,180=
 SYS011=ACCESS=TBDUMP,280= (see Note 2)
 SYS012=ACCESS=TAPE,280= (see Note 2)
 SYS013=ACCESS=KBOARD,004= ) Needed if using scope

Note 1 - Include for Process Mode only
Note 2 - Include for Save Mode only
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 acquisition staff members for assistance.
### Job Statement

<table>
<thead>
<tr>
<th>Specification</th>
<th>Reason for Specifying</th>
<th>How to Specify</th>
</tr>
</thead>
<tbody>
<tr>
<td>// [jobname]</td>
<td>Required</td>
<td>As shown</td>
</tr>
<tr>
<td>Jobname</td>
<td>To name the job</td>
<td>From one through eight alphameric characters, the first of which must be a letter</td>
</tr>
<tr>
<td>JOB</td>
<td>Required</td>
<td>As shown</td>
</tr>
<tr>
<td>DUMP</td>
<td>To produce a dump if the program terminates abnormally; the contents of main storage and of the general registers are written on SYSLST</td>
<td>As shown</td>
</tr>
<tr>
<td>NODUMP</td>
<td>Default option -- no dump produced</td>
<td>As shown</td>
</tr>
<tr>
<td>accounting</td>
<td>To satisfy any installation requirement</td>
<td>From 1 through 16 alphameric characters, the first of which must be other than a left parenthesis or a blank</td>
</tr>
<tr>
<td>Specification</td>
<td>Reason for Specifying</td>
<td>How to Specify</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>//</td>
<td>Required</td>
<td>as shown</td>
</tr>
<tr>
<td>stepname</td>
<td>To find the job step; required to name the module produced by the compiler unless NOCLASS is specified in the parameter list</td>
<td>From one through eight alphanumeric characters, the first of which must be a letter</td>
</tr>
<tr>
<td>zxc</td>
<td>Required</td>
<td>as shown</td>
</tr>
<tr>
<td>MSTM</td>
<td>Required</td>
<td>as shown</td>
</tr>
<tr>
<td>(parameter list)</td>
<td>To specify compiler options</td>
<td>From one through five parameters (see next chart), separated by commas; the list must be enclosed in parentheses</td>
</tr>
<tr>
<td>VSCNM</td>
<td>To ensure that the variable precision switch is set to the value in</td>
<td>One of the following, enclosed in parentheses: VPP, VPP, VPP</td>
</tr>
<tr>
<td>accounting information</td>
<td>To satisfy any installation requirement</td>
<td>From 1 through 15 alphanumeric characters, the first of which must be other than a left parenthesis or a blank</td>
</tr>
</tbody>
</table>

**Parameters:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reason for Specifying</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBCN</td>
<td>To produce a module deck on SYSPRINT</td>
</tr>
<tr>
<td>NOCLASS</td>
<td>Default option -- no deck produced</td>
</tr>
<tr>
<td>NOCLASS</td>
<td>Co. suppress production of a source listing on SYSPRINT</td>
</tr>
<tr>
<td>SOURCE</td>
<td>Default option -- source listing produced on SYSPRINT</td>
</tr>
<tr>
<td>NOCLASS</td>
<td>To suppress the writing of the module on SYSPRINT, the linkage editor input file</td>
</tr>
<tr>
<td>LNK</td>
<td>Default option -- module written on SYSPRINT</td>
</tr>
<tr>
<td>CDP</td>
<td>Required if any source statements are punched in BDP</td>
</tr>
<tr>
<td>ICMR</td>
<td>Default option -- source statements are punched in BDP</td>
</tr>
<tr>
<td>ICMR</td>
<td>To produce a compiler storage map on SYSPRINT</td>
</tr>
<tr>
<td>ICMR</td>
<td>Default option -- no compiler storage map produced</td>
</tr>
</tbody>
</table>

**Note:** Parameters may appear in any order; each parameter is specified as shown.
**Parameters:**

- **KEEP**
- **NOKEEP**
- **NOAUTO**
- **NOXMAP**
- **XMAP**

### 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.

**NOAUTO** | To suppress the automatic linking facility of the linkage editor during this job step.

**NOXMAP** | To suppress the production of a phase map on SYSLST.

**XMAP** | Default option -- phase map produced on SYSLST.

Note: Parameters may appear in the parameter list in any order; each parameter is specified as shown.
### INCLUDE Statement

**Operation**

| INCLUDE module, {L}. {R} |

**Specification** | **Reason for Specifying** | **How to Specify** |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>INCLUDE</td>
<td>Required</td>
<td>As shown</td>
</tr>
<tr>
<td>module</td>
<td>Required to identify the module that is to be included in the phase</td>
<td>The name of the module as it appears in a MODULE statement or in the name field of an EXEC FORTRAN statement</td>
</tr>
<tr>
<td>L</td>
<td>To indicate that the module to be processed can be found on SYS000</td>
<td>As shown</td>
</tr>
<tr>
<td>R</td>
<td>To indicate that the module to be processed can be found in the module library</td>
<td>As shown</td>
</tr>
</tbody>
</table>

### MODULE Statement

**Operation**

| MODULE name |

**Specification** | **Reason for Specifying** | **How to Specify** |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MODULE</td>
<td>Required</td>
<td>As shown</td>
</tr>
<tr>
<td>name</td>
<td>Required; indicates the name of the module</td>
<td>From one through eight alphanemic characters, the first of which must be a letter</td>
</tr>
</tbody>
</table>
### PHASE Statement

**Operation**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Operand</th>
</tr>
</thead>
</table>
| PHASE     | phasename, 

- `S`
- `ROOT`
- `phase`

{NOAUTO}

<table>
<thead>
<tr>
<th>Specification</th>
<th>Reason for Specifying</th>
<th>How to Specify</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHASE</td>
<td>Required</td>
<td>As shown</td>
</tr>
<tr>
<td>phasename</td>
<td>Required to name the phase</td>
<td>From one through eight alphabetic characters, the first of which must be alphabetic</td>
</tr>
<tr>
<td><code>S</code></td>
<td>To specify that the phase have its origin at the first available location in the problem program area</td>
<td>As shown</td>
</tr>
<tr>
<td><code>*</code></td>
<td>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</td>
<td>As shown</td>
</tr>
<tr>
<td>ROOT</td>
<td>For multiphase programs only; identifies the phase as a root phase (its origin is the first available location in the problem program area)</td>
<td>As shown</td>
</tr>
<tr>
<td>phase</td>
<td>To indicate that this phase is to have the same origin as another phase currently in the phase library</td>
<td>The name of the other phase as specified in the linkage editor PHASE statement that named it</td>
</tr>
<tr>
<td>NOAUTO</td>
<td>To suppress the automatic linking facility for this phase only</td>
<td>As shown</td>
</tr>
</tbody>
</table>
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. VT0C SDSABS
2. VT0C 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:

//REPRO\$JOB
//SYS003\$ACCESS$SDS001, SDSD(WRCHK)='SRELO2'
//$EXEC\$UTILS
$COPY$ENDIN='&6', SIZIN=80, SIZOUT=(360,4), PAD=(10,6), FILL='6', IGJCL

DECK
TO
BE
REPRODUCED

&6
/*
//SYS002\$ACCESS$SDS001, SDSD='SRELO2'
//$EXEC\$UTILS
$PUNCH$ENDING='&6', SIZIN=(360,4), SIZOUT=80, TRUNC=(1,80), IGJCL
/*
&6

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.

/6

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)

//COPYJOB
//SYS003//ACCESS//DATA,280=
//EXEC//UTILS
COPY//SIZOUT=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)

//COPYJOB
//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 type-writer will display:
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)

//PRINTJOB
//SYS002ACCESSDATA,280=
//EXECUTILS
//PRINTSIZIN=80,SIZOUT=80,IGJCL,LINES=60,NUM
/*
/6

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)

//PRINT\JOB
//SYS002\ACCESS\DATA,2400\T7C=
//\EXEC\UTILS
\PRINT\SIZIN=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)

//PUNCH\JOB
//SYS002\ACCESS\DATA,280=
//EXEC\UTILS
\'PUNCH\SIZIN=80,SIZOUT=80,IGJCL
/*
/4

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 (/6) 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)

//PUNCH\JOB
//SYS002\ACCESS\DATA,281=
//\EXEC\UTILS
\PUNCH\SIZIN=80,SIZOUT=80,IGJCL
/*
/8

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 NPR0 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 NPR0 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)

//COPY%JOB
//SYS002%ACCESS%DATA,280=
//SYS003%ACCESS%TAPE,2400T7C(800,0,NT,C)=
//%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 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\UTILITY
\COPY\SIZIN=80,SIZOUT=80,\IGJCL
/*
/5

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 31), 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 winds 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 26. 2401-2404 Tape Transport — Model 1 or 4*
TITLE: VTJC 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)

//VTOCABS$JOB
//SYS002$ACCESS$SDSABS,SDS='SREL01'
//EXEC$UTILS
$PRINT$SIZIN=(720,30),TRUNC=(,10),START=(,120),NUM
/*
*/
/&)
TITLE: VTVC/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 directoryed 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)

```
//VTVCREL JOB
//SYS002 ACCESS SDSREL,SDSD='SREL01'
//EXEC UTILS
PRINTF SIZIN=(360,15),TRUNC=(,10),START=,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 VTIC/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:

```
//JOB
//ACCESS=SDSABS,SAME=SYSAB1
//DELETE=SDSABS(MAIN)***
//CONDENSE=SDSABS
```

*** 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 type-
writer.
TITLE: LIST I/O

OBJECT: TO OBTAIN A LISTING OF CURRENT SYMBOLIC UNIT ASSIGNMENTS

TOTAL NUMBER OF CARDS NECESSARY FROM CHARLES' BOX: (3)

//LISTI@/JOB
//@LISTI@
/@

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/O

<table>
<thead>
<tr>
<th>Symbolic Unit</th>
<th>Channel</th>
<th>Data Set</th>
<th>Volume Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSAB1</td>
<td>290</td>
<td>SDSABS</td>
<td>SREL01</td>
</tr>
<tr>
<td>SYSAB2</td>
<td>290</td>
<td>SDSABS</td>
<td>SREL01</td>
</tr>
<tr>
<td>SYSREL</td>
<td>290</td>
<td>SDSREL</td>
<td>SREL01</td>
</tr>
<tr>
<td>SYSLOG</td>
<td>01F</td>
<td>SDSLOG</td>
<td></td>
</tr>
<tr>
<td>SYSRDR</td>
<td>00A</td>
<td>SDSRDR</td>
<td></td>
</tr>
<tr>
<td>SYSIPT</td>
<td>00A</td>
<td>SDSIPT</td>
<td></td>
</tr>
<tr>
<td>SYSLST</td>
<td>00B</td>
<td>SDSLST</td>
<td></td>
</tr>
<tr>
<td>SYSOPT</td>
<td>00B</td>
<td>SDSOPT</td>
<td></td>
</tr>
<tr>
<td>SYSPCH</td>
<td>00A</td>
<td>SDSPCH</td>
<td></td>
</tr>
<tr>
<td>SYSPSD</td>
<td>290</td>
<td>SDSPSD</td>
<td>SREL01</td>
</tr>
<tr>
<td>SYSUAS</td>
<td>290</td>
<td>SDSUAS</td>
<td>SREL02</td>
</tr>
<tr>
<td>SYS000</td>
<td>291</td>
<td>SDS000</td>
<td>SREL02</td>
</tr>
<tr>
<td>SYS001</td>
<td>291</td>
<td>SDS001</td>
<td>SREL02</td>
</tr>
</tbody>
</table>
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:

\[
\begin{array}{ll}
200 & [E] \\
556 & [O] \\
800 & [T] \\
\end{array}
\]

For tape units of device type code 2400T7C:

\[
\begin{array}{ll}
200 & [E] \\
556 & [O] \\
800 & [NT] \\
\end{array}
\]

For tape units of device type code 2400D:

\[
\begin{array}{ll}
800 & [1600] \\
\end{array}
\]

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 directoryed 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.

SDPSRD - Pseudo directory, used by the language processors and the

linkage editor program.

VTOC - Volume table of contents; essentially a collection of labels,

each 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 despicable 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 assembling 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:

//JOB[DUMP],XX
//SYS002ACCESS=TAPE,280=
//SYS003ACCESS=CARD,00A=
//SSP EXEC ASSEMBLE(UPDATE1,NODECK)
SKPTO=XXXXXXXXX

/
YYYYYYY
/*

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.

1Where-XXXXXXXXX is the serial field of the first card in the desired subroutine to be copied.

2Where-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:

//SYS002%ACCESS#TAPE,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.
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 FORTRAN.

The user is given a set of FORTRAN - 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 FORTRAN, the other in the style of the YALE/IH 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 \texttt{DA} whenever he has the attention of the typewriter (this is explained below). If the messages are too enigmatic, he may type \texttt{ILP}, 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 FORTRAN 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 BUDD key is pressed.

2. A line is properly terminated upon typing $ and pressing the RETURN key, and then the END 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

```
\$MESSAGE name= \{message-list\}
\$MESSAGE name: 
```

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= (PRINTOUT STARTED)`
   `\$MESSAGE ABLE= (PRINTOUT FINISHED)`
   `MESSAGE: 1`
   
   \`
   \`
   \`
   `MESSAGE: Able`
   `CALL \$MESSAGE (SECTION 1 \$VER)`
   
   this would cause three messages to be printed:
   
   `PRINTOUT STARTED`
   `PRINTOUT FINISHED`
   `SECTION 1 \$VER`

**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:

\[\text{CALL } \$\text{WAIT} \]
\[\text{WAIT: } (\text{ref-name, ref-no., [st.no.-1 [... , st.-no. -12]})\]

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 } \$\text{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 G0 0 (ZERO) TO PROCEED TO 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 TIMEOUT. REFER ABOVE FOR RESPONSE.

2. **WAIT: (EV12,5,100,150,750,999)**

The message of example 1 would appear, plus the message

`TYPE G0 N, WHERE N IS ONE OF THE FOLLOWING STATEMENT NUMBERS 100, 150, 750, 999`
The user response

GO 999 (or a variation such as GO TO STATEMENT 999) would cause transfer to statement 999.

Incorrect input, such as GO TO 432, results in the typewriter printing STATEMENT NO. NOT IN LIST. TRY AGAIN.

C. INPUT

The user may change the value of any variable in his program. This is done via SETNOW, which is of the form

```
CALL $SETNOW
SETNOW: (ref-name, ref-no., namelist-1 [...namelist-6])
```

where

- [ref. name:] as in $WAIT
- [ref. no.]
- 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 NO. 7 FOR ALPHA
FOR ALPHA PRESS B10 KEY AND TYPE 1 TO INPUT THE NAME,
2 TO SKIP ALL NAMES
NO RESPONSE, SKIP THE NAME
```

A user response of 1 would result in the following message being displayed:
PUSH BIU KEY AND BEGIN TYPING DATA WITHIN 15 SECONDS 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:

\[ A = 5, \ T(3) = 4.9 \ \text{END} \]

assuming that T was an array.

Input may be several lines, in which case only the final line is terminated by \text{END}. After each line the typewriter responds \text{LINE RECEIVED}. \text{MORE EXPECTED}

and after the last line, it prints \text{INPUT RECEIVED}.

Incorrect input, such as a mispelled variable name, results in the message

\text{FOR ALPHA, PRESS...}

being printed out again.

EXAMPLE

2. \text{NAMELIST /ALPHA/A,B,I,T,/BETA/Q,R,S}

. . .

\text{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

\text{FOR BETA, PRESS BIU KEY...}
D. OUTPUT

1. The user may view the value of any variable in his program. This is done via VIEWNOW, which is of the form:

\[
\text{CALL } \$\text{VIEWNOW} \quad \text{(ref-name, ref-no., namelist-1[,...namelist-6])}
\]

Names have the same meaning as in $SETNOW$.

EXAMPLE

1. NAMELIST/ALPHA/A,B,I,T
   .
   .
   .
   CALL $\text{VIEWNOW}\ (\text{MAIN},3,\text{ALPHA})$

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 VIEWNOW. The form is:

\[
\text{CALL } \$\text{WRITENOW} \quad \text{(namelist-1[,...namelist-6])}
\]

EXAMPLE

NAMELIST /ALPHA/A,B,I,T
   .
   .
   .
CALL $WRITENOW(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 $SETNOW 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 $VIEWNOW 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 0 will shortcut this waiting time. In case the user presses the 10 key and then decides that, after all, he does want the no-response option, he need only type 0.
APPENDIX A
SUMMARY OF COMMANDS

A. Output

1. Messages

i \[
\text{CALL} \ \\
\text{MESSAGE: } \ \\
\text{name} \\
\] \\
\text{where} \\
\text{message-list: up to 128 alphanumeric} \\
\text{name: defined below}

ii \[
\text{MESSAGE name=} \ \\
\text{(message-list)} \\
\] \\
\text{name: up to six alphanumeric}

2. Variables

i \[
\text{CALL} \ \\
\text{VIEWNOW: } \ \\
\text{(ref-name, ref-no., namelist-1[,...namelist-6])} \\
\] \\
\text{ref-name: a reference name, up to six alphanumeric} \\
\text{ref-no.: a reference number, up to four digits} \\
\text{namelist-i: a NAMELIST name previously created by the user}

ii \[
\text{CALL} \ \\
\text{WIRENOW: } \ \\
\text{(namelist-1[,...namelist-6])} \\
\] \\
\text{b. Input}

\[
\text{CALL} \ \\
\text{SETNOW: } \ \\
\text{(ref-name, ref-no., namelist-1[,...namelist-6])} \\
\] \\
\text{See above for definitions}
C. Wait and Branch

\[
\text{CALL } \$\text{WAIT} \\
\text{WAIT: (ref-name, ref-no.\[,st-no.-1[,\ldots st-no.-12]\])}
\]

- \text{ref-name:} see above
- \text{ref-no.:} see above
- \text{st-no.-i:} the statement number of an executable statement in the user's program.
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$^2$

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$^2$

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$^2$