MPS/Int. CO 61-29
17.10.1961

VISIT TO THE U.S.A.

This report contains in a brief form what I was able to see and discuss during a recent visit (16.9.1961 - 5.10.1961) to :

- Radiation Laboratory (Berkeley)
- Stanford University
- Brookhaven National Laboratories

I have grouped the information according to major items rather than to laboratories. The content is as follows :

PS/2847

1. Operation

1.1 Accelerators - Brookhaven (AGS and Cosmotron)

The functions of the department are :

- running the AGS
- running the Cosmotron
- study of a new machine

The third point is being looked at by very few people. In August, a design Committee set up at the laboratories under the direction of J. Blewett and with the participation of physicists from many American institutions, Harwell and CERN (K. Johnsen) prepared a study for a 300 - 1 000 GeV Accelerator. A report has just appeared together with a possible experimental programme, At the AGS, the overall activity can be subdivided into four main branches.

a) Machine operation

b) Machine improvements

c) New equipment

d) Experimental Assistance

I shall deal more in detail with points a) and d).

1.1.1 Operation

So far, the machine does not run through night, but it is operated 5 days/week from 08.30 hours to 24.00 hours.

The actual detailed schedule is as follows :

08.30 h - 09.00 h - Patrol to clear the Linac Wing and the Inflector region. Preparation for Linac Beam.

09.00 h - 10.00 h - Continuation of patrol to clear out the tunnel. Linac and Inflection setting-up (from Linac Control Centre)

10.00 h - 10.15 h - Spiralling beam obtained by Linac Operator and checked in the M.C.R.

10.15 h - 10.30 h - Preparation for accelerated beam. Radiation safety established in the experimental zone.

10.30 h - 11.00 h - Accelerated beam obtained.
Target Burst obtained.

11.00 h - 23.30 h - Operation according to schedule.

23.30 h - Beam stopped.

23.30 h - 24.00 h - Switching-off procedure.

It is the feeling of the AGS department that, for the time being, 2 out of the 10 shifts should be devoted to measurements and testing of the machine.

The personnel on duty is :

- 1 Duty Engineer in the building
- 2 M.C.R. Operators
- 2 Power House Operators
- 1 Pump room Operator (cooling system)
- 2 Linac Operators
- 2 Floor Operators (experimental lay-out)

Shifts are of eight hours each. Extra help is available in day-time. The Duty Engineer is a graduate (four years of college) and a rather senior person. At present, there are three Duty Engineers and two of them have taken part as designers to the whole construction period, whereas the third one is a new comer.

The Duty Engineer is on call in the building but not necessarily present in the M.C.R.

The M.C.R. operators are well qualified technicians, chosen whenever possible between the ones who took an active part in the design.

According to the qualifications, they can be subdivided into three main classes :

1 - People with about two years of college (an engineer has four years).

2 - Technicians from the armed forces, with about one year technical training on specific subjects.

3 - People having attended a technical high school, instead of a general one as class 1 -.

The preference is given quite definitely to class 1 -, because of their higher knowledge, "absorption" power and versatility.

The operators work always on shifts, but when the machine works well they carry out maintenance and construction work in the laboratories attached to the M.C.R. Few comments about the other operators. The ones for Power are only for the main magnet power supply, no other rotating machine being in existance.

The Linac operators are actually in the Linac Wing but again not necessarily in the control position.

The floor operators carry quite an extended responsibility, going from the beam transport elements and their power supplies (all dry-rectifier type) to the safety (radiation, hydrogen and industrial) all over the place including the ring.

A few words, now, about training of the operators. The designer of a given system or piece of equipment has been made responsible for giving a series of lectures and practical demonstrations to the operating staff. The effort involved has not been however very big since major parts like the R.F. system were covered by 8 - 10 hour courses. Most of the operators'knowledge has been obtained through experience and mutual training, since each operator or duty engineer is very familiar with some specific part(s) of the machine.

1.1.2 Experimental assistance

The activity here is divided into two main branches :

- a) Planning
- b) Operation

The Planning Group, under the direction of Mrs. H. Blewett, takes an active part in the overall planning, beam calculations and gathering of equipment for the various experiments.

It is composed mainly by physicists and gets in contact with the Experimental Groups at a very early stage of any given experiment. A physicist of the Planning Group is assigned as a liaison to the experiment and his job is to constitute the bridge between machine people and experimenters as well as help the latter ones in the actual setting-up of the beam to some extent in the data collection.

In so far as I have seen, this linkman takes also an active part in the preparation of major experimental apparatus, such as the construction and testing of the big spark chamber for the neutrino experiment.

Whenever the experiment has come nearer to the actual setting-up, the details of the layout, the drawings and the overall organisation is passed over to the Apparatus Layout Section which appoints an engineer as linkman.

Finally then, when the experiment is in course, there are two linkmen: one from the Planning Group, who should spend less and less time on it and another one, an engineer from the Apparatus Layout, who looks after the actual realisation of it.

1.2 Bevatron - Berkeley

The machine operates all round the week apart two mornings (Tuesday, Friday) devoted to maintenance and changes of experimental arrangements. Major installations of secondary beams have of course to be carried out during shut-downs.

The operation is carried out on the basis of three shifts per day and each shift (crew) is composed of :

- 1 crew chief
- 2 - 3 operators
- 2 operators in the Control Room for rotating machines.

Such a crew can call at any time upon the help of electrical, electronic and mechanical maintenance people (5 - 7 people). During day-time only, it can be helped by engineers and very qualified technicians generally belonging to the development field. This seems to happen regularly at the starting-up on Tuesday and Friday afternoon.

There are 4 crew chiefs and 18 operators in total, under W. Hartsough. The crew chiefs are in general well qualified technicians who are not obliged to stay in the MCR all the time but are on call in the building. This enables them to participate to development work under the guidance of engineers, so that they do not feel confined to operation. It happens that if a crew chief turns out to be very useful in the development field, he is made free from operation.

It is important to note that it has been tried in the past to have more qualified crew chiefs (e.g. college graduates) but they could not be kept, mainly because the job was not attractive enough.

The qualifications required for the operators are not confined to a given certificate or diplome. Basically, what is asked for is a technical background (not necessarily in engineering) and above all intelligence and good will. Aircraft mechanics prooved very useful. Minimum age : 22 - 23 years The operators divide according to their ability and preference into two categories:

- a) pure operators (70 % operation)
- b) operators taking part to development or constructional work (30 - 40 % operation)

Category b) disposes of small labs and shops near to the M.C.R. so they can actually work also during their shift.

1.3 1 GeV - 60 c.p.s., electron - linear accelerator - Stanford

Because of radiation problems, the machine is now working during the nights (4 p.m. - 8 a.m.) Monday through Friday and then continuously from Friday 4 p.m. to Monday 8 a.m. Saturday night is off with no people present , however.

During operation there is only one operator. In total there are 6 operators, with some electronic background, sharing almost in equal parts operation and maintenance. The overall machine group, responsible also for development and maintenance amounts to about 20 persons. Various very interesting experimental arrangements are connected with the machine as the :

1.3.1 Colliding beams storage rings

500 MeV electrons can be accumulated during 5 - 10 minutes in the rings and then collide. The half-time of the beam is as long as 30 hours, with a vacuum of 10^{-9} - 10^{-10}. This vacuum is obtained by taking the whole double ring vacuum chamber in a special furnace and then make it act as an ion pump by means on electrode at 900 Volt.

Special features are :

a) a ferrite magnet for injection which acts as a 1/usec line.

b) a 25 Mc/s cavity to compensate the 4 keV/turn radiation losses.

c) two nearly hemispherical domes expanding from the vacuum chamber at the colliding point, which will be surrounded by photo-multipliers for interaction observation.

The whole machine is now being finally assembled. Injection studies, with the beam going half-way around, have been carried out.

1.3.2 Two specially shaped magnets for beam analysis, which can move around a vertical axis.

1.4 Overall impression

About operation, the most important remark is that the operators are encouraged to carry out constructional work, maintenance or development during their shifts, since "watching" the machine running and taking action when required is not considered as a full occupation for the entire crew.
Of course, at least one man has always to be present in the M.C.R., or other key positions.

One has to underline that the use of operators for aside work is done not in the spirit of exploiting them (not much work is expected by a man in the middle of the night) but rather with the intention of increasing their interest and overall knowledge as well as make them feel more directly responsible for the machine performance.

This efficient way of utilising the operators allows a somewhat bigger crew which then can cope more easily with complicated situation.

For other more general impression, see report MPS/Int. RF 61-9 by H. Fischer.

2. Personnel security

2.1 AGS

At present, no actual electrical system is in operation, The Ring patrol (four people) closes the doors from the inside, and whenever an entry is allowed, the beam is switched off and an operator (Apparatus Layout) actually accompanies the person(s) to the only entrance, takes name(s) and remains at the door as a watchman.

Detailed plans for a door interlock system exist, however, and are reviewed here briefly.

The main doors will be electrically locked and interlocked. The lock will consists in a solenoid operated bar, controlled by a kew-switch at the door itself. The bar will also make the contact of the microswitch. Emergency handle will provide escape from the inside.

Suspension of lock will be achieved by the simultaneous pushing of a button near the door and of another one on the control desk.

<u>Person(s) will always be accompanied to the door by an operator acting as a watchman</u>.

Simpler doors (like our ventilation room exits) will be only interlocked.

As far as possible, the experimental area will not be closed. In this connection, it is worth mentioning that :

a) the beam level in the new experimental area is about 2 m (target area about 1.5 m)

b) the floor operators stay in the experimental Control Room which dominates the experimental area.

2.2 Cosmotron

It represents an interesting case beacuse of the extracted proton beam.

The beam path is completely shielded as to allow the presence of personnel and counting equipment as near as possible to the beam.

This condition is however hard to obtain and the changes of the experimental set-up require a continuous effort by the Health Physics Group. In fact, three to four members of the Group are always present in the building, carrying out extensive surveys. In term of space, the fraction of the experimental floor taken by the shielding is impressively high (at least 50 %).

2.3 Bevatron

The general philosophy is to leave a good deal of responsibility with the personnel concerned, who can dispose of full information by means of notices and announcements. The discipline seems to be good. There are basically two types of areas :

- Machine Interior with radiation doses as high as 10 rem/40 hours.
- Experimental Areas, with much lower doses.

The first type of area is defined by small climbable barriers which are merely interlocked but not locked. If opened, they switch off R.F. and prevent injection. The normal way to get through is to report to the M.C.R., obtain permission and take a key which does essentially the same action as the microswitch mentioned above.

The experimental areas are defined by means of small pivoting wooden barriers ("saloon" type) and noticed. Physicists and installation people are normally allowed into these areas. Every two hours in day-time a patrol clears out not concerned people. Everybody wears gamma and neutron film badges (even short term visitor like me).

Here again, it has to be noticed that the beams are well above man-height.

Before switching on the machine, clearing patrols and announcements are made.

Actual beam going to be ON is marked by a whistle of increasing frequency. Beam OFF by one of decreasing frequency.

3. Control Centres

3.1 AGS - Arrangement of Control Centres

The most important differences with respect to the CERN PS are :

a) The existence of an Experimental Control Room, looking over the new hall. This room will be manned by the two floor operators (Apparatus Layout) and deal with all experimental arrangements (beam transport, separators, etc..) as well as with Security in the whole AGS area, including the Ring.

b) The non-existence of a separate RF Control Room. Everything has been installed from the start in the M.C.R., including the frequency programme generator.

c) The non-existence of a separate Generator Building for the power supplies of the beam transport elements, since all the supplies are of the dry-rectifier type.

Of course, this activity is transferred to the floor-operators mentioned under 1. above.

For the rest the situation is pretty much the same than in CERN. An additional operator is however required for the Pump Room (cooling system)

From the equipment point of view, one notices a marked simplification of all control circuits and a substantial reduction of their amount.

This implies on one hand fewer intrinsic possibilities but on the other hand a much simpler handling and maintenance.

3.1.1 The M.C.R.

It is still in a rather provisorish state. The total number of racks is 39 plus the console, to perform the functions of our M.C.R., C.B. and Computer Room.

The break-down of number of racks per system is roughly as follows :

i) Linac + Injection - practically nothing for the time being

ii) RF controls + Monitoring including beam control and frequency programme .... 11 Racks

iii) Master Timer and Distribution of signals .... 8 "

iv) Correcting elements .... 5 "

v) PU electrodes .... 3 "

vi) Flags + Targets .... 2 "

vii) Vacuum .... 5 "

viii) Telecommunications .... 5 "

The empty space in the above racks can be evaluated to some 15 - 20 %.

3.2 Bevatron M.C.R. and other control centres

3.2.1 M.C.R. Racks

The racks are of the open type but a row constitutes an enclosure which is air-cooled ; the total number is 37 and from the layout point of view it is possible to establish the following break-down :

a) Control Desk, formed by 7 racks, of the normal type apart the sloping panel and the writing table.

b) Wings of the Control Desk continuing it at both ends, with 6 racks on one side and 4 at the other.

c) The remainder 20, divided into a 12-rack row behind the shoulders of the operators and another one of 8 for patch-panels, etc..

3.2.2 Layout - Controls

It is possible to control partially or completely all machine parts and thw power supplies for the beam transport equipment during operation.

In addition to the M.C.R. one finds :

a) The Power House c.c. from where it is possible to start up and control all rotating machines. Manned by 2 people during operation.

b) The Injection c.c., to start up the Linac. Not manned after the starting-up.

c) The R.F. equipment room, at the centre of the machine, never manned apart in case of failure.

From the view-point of the power supplies for the beam transport, they are divided (see 5.2) into rotating machines and dry-rectifier sets.

The M.C.R. gives permission to feed the beam transport elements for both types and can control remotely the motor-generator sets. The dry=rectifier units seat near to the magnet or quadrupole concerned in the experimental floor itself.

3.2.3 Displays

The oscilloscopic presentation consists of 14 Tektronix double-beam scopes (502 and 535), concentrated in 12 racks. In the desk part, they are installed immediately above the sloping panel.

The functions displayed are :

6 - target-up signals

2 - timing sequences

4 - Linac parameters

2 - Magnet current and voltage

2 - Injection frequency

2 - Beam Radial position

2 - Beam intensity

2 - Radial feedback (closed loop)

6 - Secondary beam counter signals (these are sent to the M.C.R. by the experimenters).

It is interesting to note that the Secondary Beam Counter signals are definitely requested by the operation people as a condition to run the experiment. The signals have to satisfy certain requirements such as :

a) to be linear (no saturation)

b) to show marked target on - off effect (that is to say that when the target is switched off there should be no signal or very different from when it is on).

3.2.4 Power House Control Centre

Two interesting instruments are installed here :

a) a closed loop tape recorder for analogue signals, which can be played back on a scope.

b) a 12-channel oscilloscope looked by a camera triggered by a fault signal.

4. Experimental set-up and equipment

4.1 Spark chamber for the neutrino experiment

A huge spark chamber, composed of two superimposed raw of 1" thick Aluminium plate, is now being assembled.

Photos are available from me.

4.2 Bevatron experimental set-up

Walking around the experimental area, it is possible to observe very complicated counter arrangements which, in the opinion of the experimenters, represent an unavoidable evolution from the simple yield and cross-section measurements typical of the early life of a machine breaking through a new energy range.

For example, experiments with up 80 counters and various spark chambers are not at all unusual. Two or three groups have been putting considerable effort in building spark chambers for almost two years.

Nice cylindrical chambers have been produced, some of them with a hydrogen target inside placed along the axis. This arrangement offers the advantage of having all the traces practically perpendicular to the plates.

Considerable experience has been obtained on basic features such as sensitive time, clearing field, etc..

Fast cameras, with a reset time of 20 msec, are about to be developed and will be used with the chambers.

No effort has been made as yet to collect the information electrically rather than by means of pictures.

Photos taken with cylindrical chambers are available from me.

5. Beam transport (supplies and measurements)

5.1

5.1.1 AGS Beam transport power supplies

No rotating machines exist.

Thirty silicon-rectifier three-phased full-wave sets, with magnetic amplifier regulation, are in operation :

16 sets	175 kW	- 0 - 75 V
8 "	300 kW	- 0 - 125 V
6 "	600 kW	- 0 - 125 V

Sixteen more sets are on order, type 175 and 450 kW.

The stability obtained is better than 1 o/oo for currents between 1/3 I max and I max.

No change of polarity is possible. This is achieved by means of isolating switches at the beam transport element.

The sets are completely air-cooled.

The regulation can operate on voltage, current or magnetic field (Hall plates). Remote control is possible by means of potentiometers (change of reference voltage). Separate terminals at the precision shunt are made available to the experimenters for comparators.

Complete description and circuit diagrams available from me.

5.1.2 Magnetic measurements on Beam transport elements of the AGS

It is worth while noting that the group in charge of the magnetic measurements for the main magnet has been kept and is now fully occupied in carrying out similar measurements on the bending magnets and lenses.

The general principle is that, by knowing the magnetic characteristics with high accuracy, one avoids carrying out wire measurements, which, although more direct, require to be repeated for every experiment with the beam transport in the actual position on the experimental floor.

Furthermore, one can note that the wire measurement is not an exhaustive answer to the setting-up of a particular beam since it cannot include the fringing field of the main magnet.

The procedure adopted for a given class of elements (e.g. all quadrupoles with the same aperture and length) is the following :

a) for one member a complete three-dimensional map of the magnetic field as a function of current is obtained. Aberrations and hysteresis are also carefully considered.

b) for all other members the integral of the field over the length for a certain number of positions and currents is measured. The close mechanical and magnetic tolerances of the series guarantee for the uniformity of the remaining characteristics.

A series of rectangular quadrupoles, Panosfki's type, is not very useful because the maximum specified field cannot be obtained.

Apart particular cases, the classical four-pole ones are considered to be superior.

5.2 Bevatron beam transport power supplies

There at present 26 silicon rectifier units of the following characteristics :

a) 10 units - 150 kW (100 Volt - 1,500 Amp)
3-phased full-wave type with magnetic amplifiers regulators.
Open loop gain of regulation system : approx. 200
Open loop response to a step function : approx. 60 msec
when driven with 100 Watts (50 V - 2 A)

b) 6 dual units - 2 x 49 kW (2 x 70 Volt - 700 Amp)
similar to a).

c) 10 dual units - 2 x 90 kW (2 x 90 Volt - 1,000 Amp).
similar to a).

The total power available in this form is then approximately 4 MW. The units are commercially produced according to Radiation Laboratory specifications. The regulator, however, is produced on a laboratory design for 500 Dollars/piece.

As already mentioned, these supplies are installed on the experimental floor as near as convenient to the beam transport element concerned. They are water cooled. Circuit diagram available from me.

In addition to this type , 12 motor-generator sets of various sizes for a total of few MW, are installed in the Power House.

6. Counting Equipment

6.1 Radiation Laboratory - Counting equipment

Basically the laboratory-wide organisation is splitted in various groups, such as :

6.1.1 Counter Research, concerned with the develepment of new ideas in the field and with the suggestion of novel ways of signal treatment and transmission.

6.1.2 Counter Development, the responsibility of which is to design and produce the first working model of a new unit.

6.1.3 Counter Maintenance and Installation, which maintains the equipment and helps the experimenters in setting up the electronics. It also provides maintenance people round the clock.

It is worth while noting that with the increasing complexity of the experiments, the physicists call more and more upon the help of the third group which has therefore set up recently a section called "Systems", especially in charge of connecting up and getting to work complicated counter arrangements for particular experiments. The third group only amounts to 40 people.

6.2 Signal cable impedance

For long years, the impedance for long connections has been standardised at 125 Ohm. The Counter Research Group developed low-loss cables at this impedance like the styroform and the styroflex, at that time not existing on the market. The so called "BERKELEY" connector was also developed.

For years, however, there has been a constant trend toward lower impedances (e.g. 50 Ohm) much for the same reasons put forward in CERN, such as wider choice of commercial products, better connectors, etc..

Obviously, the higher gain of recent photo-multiplier tubes and ever-increasing use of transistor circuits have helped this tendency.

At present, both 50 and 125 Ohm are used, with pressure coming from the Counting Research to adopt 50 Ohm

7. Ejection

7.1 Brookhaven

At the moment, the ejection scheme under consideration is a Piccioni type extraction making use of an energy loss target followed, $\frac{\lambda}{4}$ downstream, by a Septum magnet inducing a betatron oscillation large enough to permit to a second magnet downstream to extract the beam.

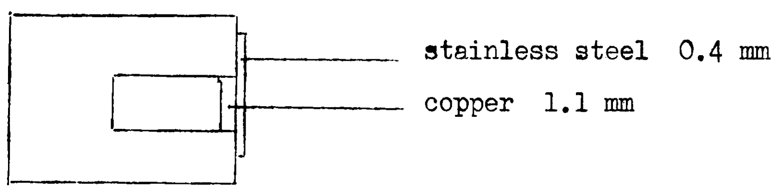
The efficiency is believed to be 10 - 15 %.

The items under design now are essentially the two above-mentioned magnets and the attached hydraulic system. It is believed, however, that the same magnets can be used also for a fast ejection in which case the energy loss target would be replaced by the existing air-core fast beam kicker.

First Magnet

horizontal aperture	:	2.5 cm
vertical "	:	1.0 cm

A 0.6 m model is under construction. The Septum is obtained from a 1.5mm thick copper-clad stainless steel mounted as shown



From previous tests, an useful field inside the aperture of 2 000 gauss should not give more than few gauss at 1 mm outside the Septum.

The final magnet will be formed by laminations of 0.1 mm thickness and will be moved by approximately 8 cm in 0.1 sec.

Second Magnet

Also of the Septum type with an useful horizontal aperture of 5 cm. Copper thickness at the Septum 2.5 cm and external magnetic shielding.

This magnet will have to be moved only by about 2.5 cm.

7.2 Bevatron

The goal is to obtain an external proton beam of as good optical properties as possible. The overall scheme works as follows - a flipped target produces a small but definite energy loss on the primary interacting protons, which after 7/10 turn are again focalised in the vertical plane. At this point the particles find a first C-type bending magnet which was plunged into position toward the end of the cycle (without interference with the beam) and which bends them onto a smaller radius. A quarter of turn downstream, the particles, moved now definitely apart from the centre of the vacuum chamber, find a stronger second bending magnet which brings them toward the outside of the machine another quadrant downstream, where they pass through a thin aluminium window. To reduce the divergences in both planes, the first bending magnet is associated with a Panofski type quadrupole focusing vertically and the second bending magnet with a similar quadrupole for the horizontal plane.

It is important to note that the two-bending-magnet scheme is brought about in order to maintain the Δ E in the target as small as possible and still, of course, be able to extract the beam.

The plunging mechanism, especially for the second bending magnet and associated quadrupole, is a major affair : it moves 3,200 kg at a speed of about 1 m/sec. The tolerances, asked for by the theoreticians, on the position and on the time are very stringent ($\pm$ 0.25 mm and $\pm$ 1 msec respectively) and will very probably not be met.

There is confidence, however, that the system will work all the same. It has to be noted that it is requested to have the magnets to follow the main magnet so that extraction at variable energy will be possible. The pulse length will depend essentially upon the exact energy loss target arrangement as well as upon the part of the cycle chosen.

8. Bevatron development and improvement programme

An important programme, amounting to a total of 9.5 Million Dollars (approximately 40 Million Sw.Fr.), has been initiated and is actively pursued. This amount approaches closely the initial cost of the machine. The aim is to obtain an accelerated beam intensity , 20 - 30 times higher than the present one together with a number of improvements and extension of experimental facilities as to make the Bevatron a very useful nuclear physics tool for the next ten years.

The major items of the project are :

- a) A new Injector (18 MeV strongfocusing Linac) with a 100 mA ion source.
- b) Improved Shielding - A major civil engineering project of about 1.5 million dollars.
- c) Experimental facilities - Nearly double the present beam transport elements.
- d) R.F. System - A more or less rebuilding of it, partly imposed by geographical incompatibility of the cavity with the new shielding.
- e) Magnet Power Supply - Replacement of the fly-wheels with new ones.
- f) Beam ejection (see 7.2)
- g) Flat top (not existing so far) - It is possible to realise a 300 msec flat top at the expense of 20 - 30 % reduction of the repetition rate.
- h) B ripple - Substantial reduction of, by means of a feed-back system using pick-up coils and pole-face windings for correction.
- i) Radial position feed-back - Building of the final system.
- j) New pole-face windings
- k) Beam position control
- l) Internal targets - Improvement.
- m) Dry-air cooling system - The air of the present cooling system is not dry giving rise to trouble when the vacuum chamber

is open up.

- n) Control of $\dot{B}$ at injection, to allow for the choice of the best spiralling rate.

- o) M.C.R. Displays, to obtain a more pictorial view of the target operation. This will possibly consists of a TV or scope display with the beam and target motion (no detailed plans are yet available).

9. New machines

9.1 Stanford "2-mile" linear accelerator (Project M)

This is an electron machine, working at the repetition rate of 360 p.p.s., which will include in the final stage 960 high power klystrons (24 MW peak) at a working frequency of 2 856 Mc/s. Each klystron will feed a 10-foot section of the accelerating structure through a wave-guide.

It is not the purpose of this report to describe the overall state of the project, but simply to underline certain problems which are strictly related to the distances involved, the high precision necessary and the high repetition rate.

9.1.1 Transmission of signals between the MCR and the accelerator

The Instrumentation and Controls Groups are faced with the following questions :

- "Is the laying of a pair of wires per signal a satisfactory solution, both from the economical and technical points of view, taking into account the thousands of metres involved ?".

- "How to avoid the interference problems brought about during each pulse by the high power absorbed by the modulators ?".

- "How to build a reliable interlock system, both from the personnel and equipment points of view, acting in between pulses, e.g. in the millisecond region ?".

It is possible to see that practically none of the above points were presented to builders of other accelerators so far in such a severe way.

Firstly, according to a recent investigation of the possibilities offered by the American market, the laying of a pair of wires per signal ceases to be an economical solution beyond 0.7 mile.

This point would lead to a "multiplexing" system, in the sense that the same wire should be shared by various signals at different times.

Secondly, if the interference problems cannot be solved in more conventional ways, one is lead to transmission during quiescent periods, technique which necessarily involves the storage of informations.

Thirdly, the necessity of the interlock system to work in the milli-second region prevents the use of relays. From what is mentioned above, it is quite understandable way the Group has been brought to investigate in detail all the possibilities offered by modern communication systems.

9.1.2 R.F. accelerating structure

Particular problems are the overall length to be produced and the close tolerances to be observed. It is therefore quite essential to set up a well automatised production process able however to fulfil the high precision required.

As already mentioned, the basic section will be approximately 3 m long (10 feet) joined together by means of bellows. Extensive tests are being carried out on the actual way of producing a section.

Brazing of injected aluminium pieces, properly machined, and electroforming are still under consideration.

9.1.3 Exploitation

It is interesting to note that attention is given as from now to the actual use of the machine both from the operation and experimental arrangement points of view. Operation is considered best carried out if the operator is presentex with "Go-No-Go" signals rather than complicated displays (e.g. lamp indicating within or out of tolerances, etc..). Of course, this is a rather crude approach but it may very well sustain a certain philosophy rather than another.

9.1.4 State of project

The project was approved finally by the U.S. Congress on Friday, September 15th and credits were allocated for above 100 Million dollars.

The present Group includes some 70 - 80 people, which are thought to increase to 600 - 700.

It is interesting to note that there is no strict separation between personnel and capital expenditures, so that there is a certain freedom to place development contracts outside or engage personnel. This has to be seen in the light of the American mentality, for which people are not particularly keen to obtain stable positions.

9.2 88" Spiral ridge cyclotron - Berkeley

This machine can accelerate deuterons up to 60 MeV and protons up to 50 MeV with an internal beam current (deuterons) of 1 mA.

Frequency modulation, not installed initially, can bring the proton energy up to 116 MeV.

The machine seems completely assembled and tests on the various parts are going on.

At the time of my visit a vacuum of 5×10^{-5} had been obtained for the first time.

No shielding exists as yet around the machine. It is worth noting that the main magnet as well as the 17 independent correcting coils are fed from dry-rectifier units. The main one, incorporated with the transformer, is installed in open air.

The whole machine seems to have been constructed with large views and taking in particular into account the future exploitation.

10. Constructional Details

10.1 Transistors directly water cooled - Berkeley

15 transistors type MOTOROLA 2 N 174 (240 Watt) have been assembled together on a strip and are directly cooled by a water flow.

Electrolysis is avoided by having the leads sealed off by means of O-rings.

10.2 Front-panel production

Engraving has been generally suppressed The most used technique is to produce a mask directly from the drawing, whichis then fixed to the finished panel (enamelled varnish) and rolled over with a special ink obtainable in various colours.

The result is not so good as engraving but the process is much faster and the readability excellent.

G. Brianti

<u>Distribution</u> : (open)

Scientific Staff of MPS Division
Controls Group

PS/2847/mh