**Title**
Summary of the Research Progress Meeting Jan. 20, 1949

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**Publication Date**
1949-01-26

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# Summary of the Research Progress Meeting

January 20, 1949

R. K. Wakerling

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## Summary of the Research Progress Meeting

January 20, 1949

R. K. Wakerling

**Proton Conversion. J. Vale.**

The first beam from the converted 184-inch cyclotron was obtained on December 22. At that time operation was achieved with both protons and deuterons. The machine ran very unsteadily and would hold voltage for only a few seconds at a time. As nearly as one was able to tell, 300 Mev protons were secured. Following the repair of many small leaks in the vacuum system operation was markedly improved. However, the change that created the greatest improvement was the installation of oscillator pulsing equipment. With proton operation the frequency must vary between 23 mc and 13 mc. Below 13 mc the oscillator ceases operation and trouble is encountered with parasitic oscillations. To get rid of these, a pulsing system was installed that turns off the power to the oscillator below 13 mc. With this device very steady operation is obtainable with protons.

After these changes had been made an examination of the beam position revealed that the proton beam was achieving a maximum radius of only 73 inches. At this radius it was found to curve out of the median plane and strike the dee. That is to say, the median magnetic plane was no longer midway between the poles at this radius. The effect seemed to be created by additional iron that had been added in the region shown in Figure 1 for the purpose of producing a better seal against oil that had been seeping into the vacuum chamber from the coil tank. This caused a tilt in the lines of force and a vertical component of the magnetic field toward the edge of the tank. By reconnecting the coils in the lower coil bank in a different arrangement it was found possible to move the median magnetic plane down again. After this was done protons were accelerated to the full radius corresponding to an energy of 350 Mev. As yet the magnetic field has not been accurately measured in this vicinity, but the operation seems to be entirely satisfactory as it is.

There has been some difficulty in measuring or estimating the beam current since rotons of this energy have a range of approximately 4 inches in copper. Thus far the current has been estimated by two methods which agree with one another and give a value between 0.5 and 1.0 microamperes. In the first of these methods a curve was plotted of the variation of beam current as measured on a 2-inch thick copper probe as a function of the radius at which the probe was placed. The curve exhibited the character shown in Figure 2. It seems reasonable, for a probe of this type, to assume the beam current to be that indicated by the flat portion of the curve. The beam current was also estimated from the bombardment of polystyrene foils making use of the carbon 11 reaction. The same time average current was obtained.

At this juncture satisfactory operation had been achieved with protons but not with deuterons, even with the improvements mentioned above. Dr. MacKenzie, who designed the oscillator system for this modification of the cyclotron, found that by removing the covering on an insulator housing the entire trouble was cleared up. A satisfactory explanation of this phenomenon has not yet been made.

Thus far the machine has been operated at the lowest possible dee voltage, since to increase it would necessitate increasing the speed of the rotary condenser and thereby risking its destruction, in view of its excessive vibration when operated above minimum speed. It has been decided to wait until the completion of a new rotor and other spare parts before the attempt is made to increase the dee voltage. It has also been found that the dee voltage has a tendency to sag, exhibiting the character shown in Figure 3a rather than the ideal illustrated in Figure 3b. To overcome this effect the power supply is being modified. This may also increase the beam output.

So far all operation has been with the undeflected beam. It is hoped that the new pulse transformer and power supply for the deflector will be ready soon so that attempts may be made to deflect the proton beam.

It has been noticed that targets bombarded with these high energy protons are extremely active. This was first noticed when attempts were being made to ovorcome the difficulty with the magnetic field mentioned above. X-ray film was exposed to the beam or one second, after which time it was found to have an activity of 2 r per hour. This should be compared with an activity of a few milli-r per hour created by the deuteron beam under similar circumstances before the conversion. In spite of this difference, the density of blackening was comparable in the two cases. All copper targets that have been used have become extremely radioactive. This means that a great deal of care will have to be exercised in handling materials bombarded in the cyclotron.

## The 18-inch Cyclotron. E. Lofgren.

A series of experiments have been under way with the object of developing a satisfactory injector for the proposed bevatron, and more immediately for use on the quarter-scale model. Present design studies call for injection into the bevatron at energies between 8 and 10 Mev, which means that for the quarter-scale model an injector giving particles an energy between 1/2 and 1 Mev is necessary.

In order to have a basis upon which to design such an injector, it was assumed that the goal was a beam of more than 100 microamperes in size and with a divergence not greater than ± 1 degree. It was expected that it would be possible to achieve large beams from a small cyclotron on a pulsed operation basis. However, it was felt that the problems of properly focussing the beam might demand some attention.

A small cyclotron has been installed between the poles of the existing JA magnet. A schematic diagram showing the dees is indicated in Figure 4. The cyclotron employs a double dee system and a magnetic field of intensity between 6,000 and 7,000 oersteds. The dee diameter is 16 inches, and the peak dee voltage is 20 kv with respect to ground. This instrument employs a novel ion source with cross section as shown in Figure 5. The gas is ionized in a small carbon box 1-3/4 inches high with 1/8 inch opening through which the protons are drawn by means of a potential between the box and an accelerating slit. The slit is maintained at the voltage of the left dee, while the box itself is at ground potential.

The operation is pulsed at the rate of one pulse per second, the pulses being of millisecond duration. Under best conditions currents as high as 7 to 8 milliamperes have been achieved with 5 milliamperes as an average. The half height of the beam is .45 inches.

A deflector system of cross section shown in Figure 6 has been employed with singular success. A probe placed at position A of Figure 4 of area 1/4 x 1/4 inch will receive as much as one-half of the beam, with a circulating beam of 5 milliamperes. Deflection efficiencies as high as 72 percent have been achieved under particular circumstances. Under most conditions the operation of the instrument is quite insensitive to deflector voltage. At position B of Figure 4 a probe 1-1/4 inches long and 1/4 inch high registered a current distribution having a width at half height of approximately 3-1/2 inches. This distribution exhibited the character illustrated in Figure 7.

When an iron guiding channel of the type illustrated in Figures 4 and 8 was used, a very narrow current distribution was recorded on a 1/4 inch wide probe. This channel was cut off at an angle of 45 degrees at the exit end in order to achieve a certain degree of focussing. The sharpness of the focus is indicated by the curve of Figure 9. Currents as high as 1/2 milliampere have been recorded on a 1/4 inch wide probe at position B when the magnetic channel was used. Under this circumstance the total distribution was 1-1/2 milliamperes. An examination of the beam shape by the use of a fluorescent screen gave a crescent-shaped outline approximately 2 inches long and 3/4 inch wide at the widest place. Evidently the energy distribution over this area is not uniform since one is able to obtain 1/3 of the total beam on a probe only 1/4 inch wide.

At present the design of a small cyclotron for use on the bevatron model is under way. This instrument will be similar in design to the one just discussed but will employ a different magnet.

## The Synchrotron. E. McMillan.

At the time of the last report before this group, preliminary operation had been secured and a photograph of the X-ray beam shape had been taken at the position indicated s A in Figure 10. This beam was produced by electrons striking the injector. An attempt was also made to locate the beam coming from the target and emanating in the direction B, but without success. At this point it was decided to change the location of the target by 180° and to reverse the beam direction in order to bring the X-ray beam out in a more desirable location. At the same time some of the temporary wiring was replaced and minor adjustments made in the machine.

When the machine was again put into operation, the intensity was low at first. The current gradually built up until it could be detected by a Zeus meter surrounded by 1/8 inch of lead placed 10 feet from the target. Thus far intensities as high as 60 mr per hour have been recorded on this meter, at a voltage of 13 kv on the magnet, corresponding to a $\gamma$-ray energy of about 260 Mev. The actual intensity in the beam is probably 100 times this value, at a distance of one meter from the machine. The highest energy thus far obtained is thought to be 304 Mev. This was achieved with a magnet voltage slightly greater than 16 kv.

A film was exhibited showing the spot produced by the beam at a distance of 5 feet from the target during a run in which nuclear photographic plates were being bombarded. The target was a piece of uranium wire. A 3-inch stack of photographic plates was employed followed by a 1/2-inch thickness of lead and a piece of X-ray film. This was surrounded by bakelite and lucite, which added a thickness of approximately 3 inches in the direction of the beam. Beyond this at a distance of 5 feet from the target was mounted the piece of film in question. The spot produced by the beam upon this film was less than 1/2 inch in diameter, showing an extremely small amount of scattering even with this amount of material between the beam and the film. This was done at an energy of 280 Mev.

Various kinds of nuclear plates were exposed in the stack. The most sensitive plates (C-2) showed a definite concentration of tracks across the center of the plate and when examined under a microscope exhibited rather a high background, probably as high as one could profitably employ. A number of proton tracks and a small number of stars ere seen. E-1 plates, the least sensitive of the group, showed under the microscope proton tracks with a few stars. One meson track was found in the first half-hour of search of the plates. Of course, this may not be significant. It is felt that the E-1 plates may be profitably used with exposures as much as ten times as long as in the present case. At the same time some electron sensitive plates were exposed, but these were too densely covered with tracks to be at all useful. Even at the present level of operation there is sufficient intensity for cloud chamber studies.

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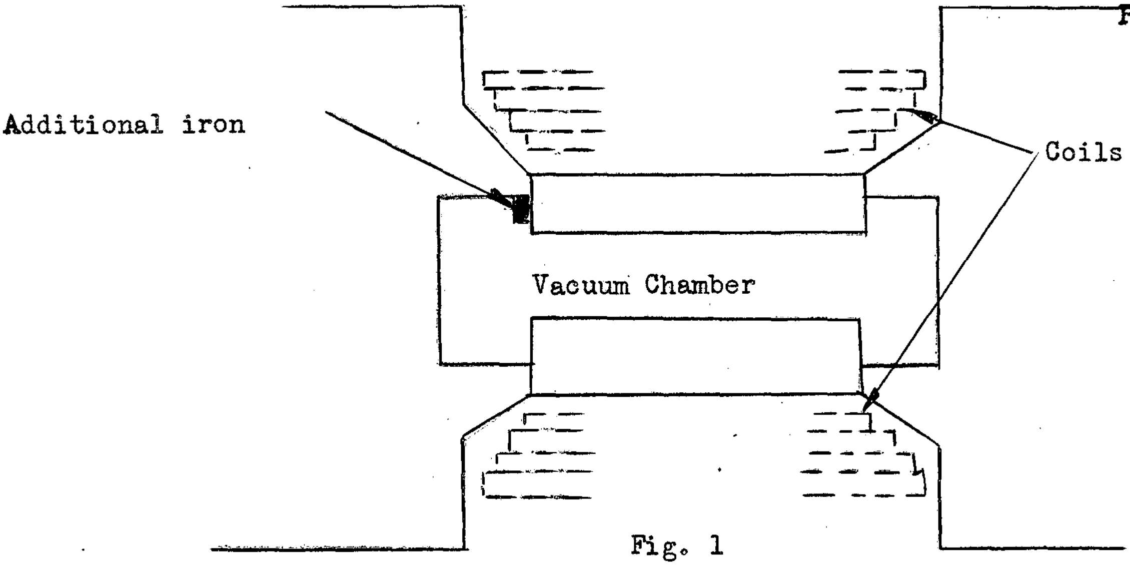


Fig. 1

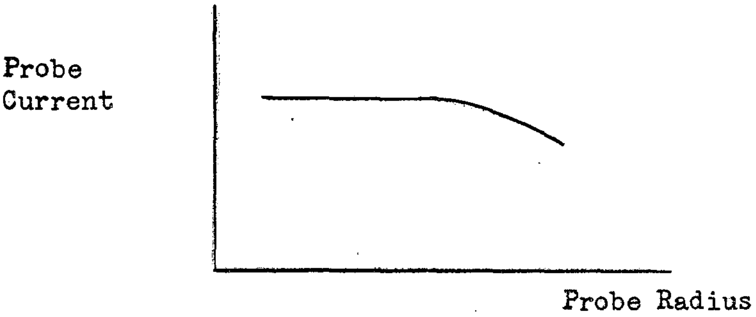
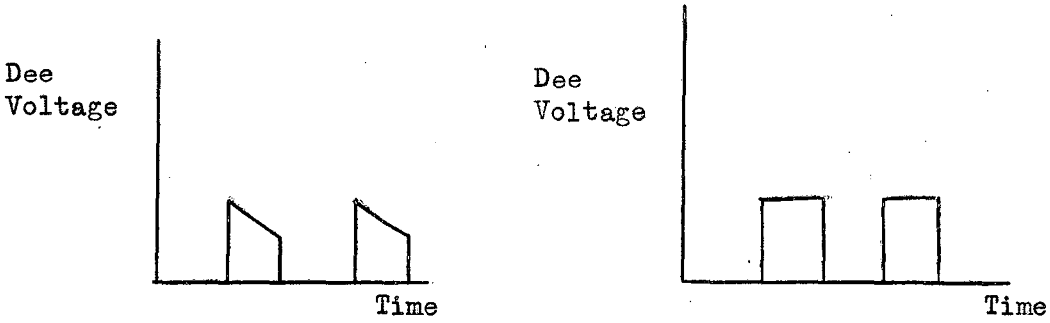


Fig. 2



a.

b.

Fig. 3

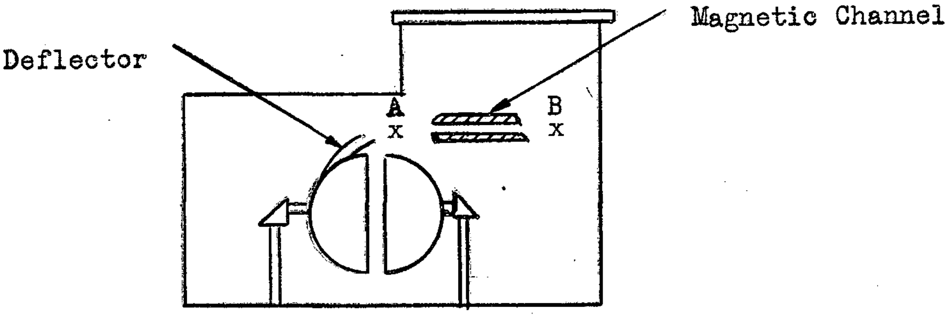


Fig. 4

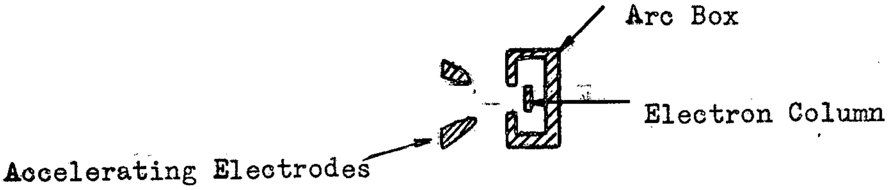


Fig. 5

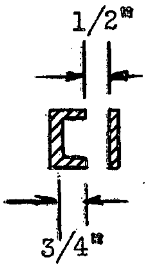


Fig. 6

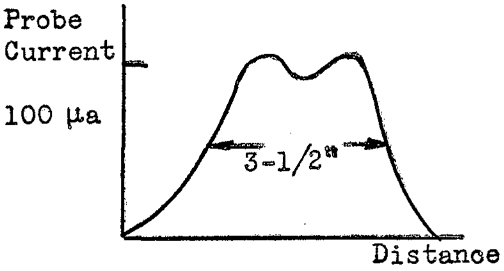


Fig. 7

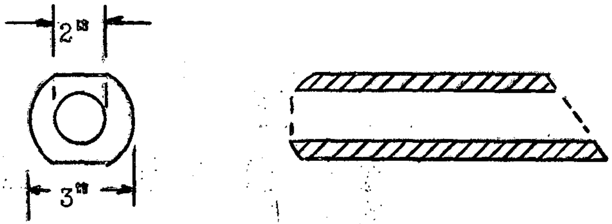


Fig. 8

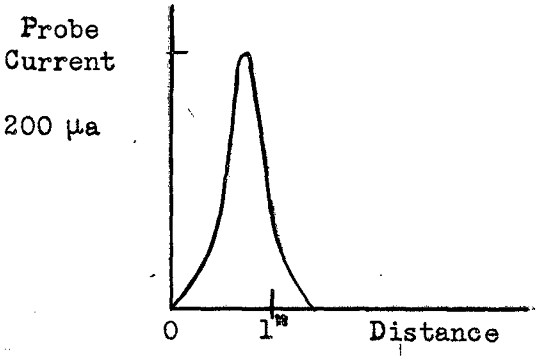


Fig. 9

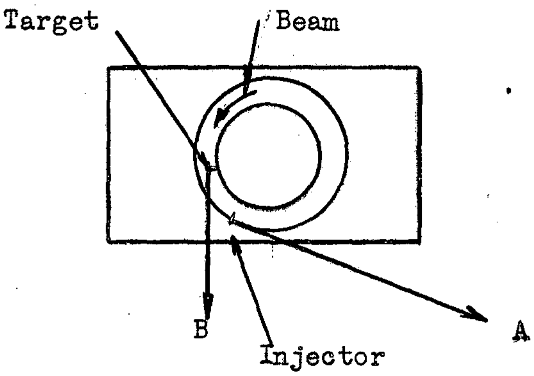


Fig. 10

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