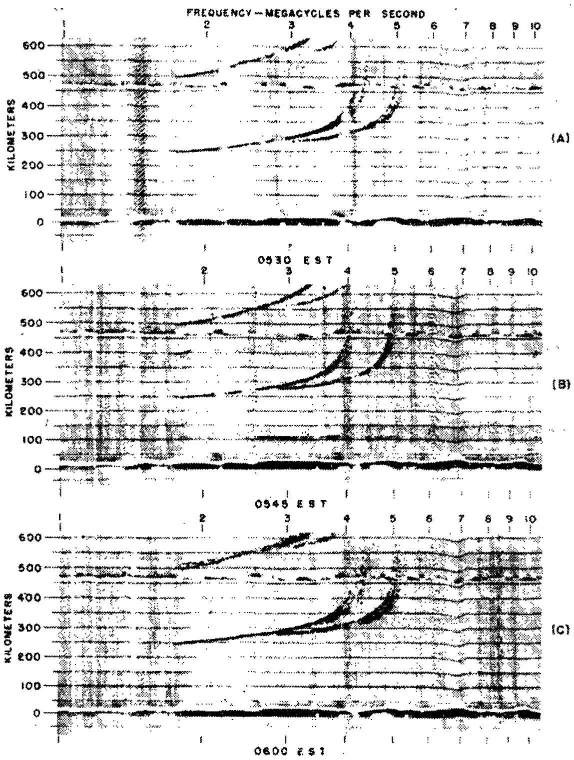

FIG. 4. Ionosphere recordings at Sterling, Virginia, Dec. 13, 1948, showing no sporadic E reflection but reflection from meteor trail (in B) at 105 km. (Simulated reflections at 470 km caused by synchronous interference.)

Fig. 4 is similar to Fig. 3 except that the records shown were made at a time when sporadic E was not present, and the meteoric reflection could be erroneously interpreted as a sporadic E reflection.

It has been found that the relative polarization of the antenna used with the ionosphere set and those used with the meteor equipment makes little or no difference at these frequencies. Coincidences of the type described occur when the orientation is such that the electric vectors are mutually perpendicular as often as when they are parallel.

Although it is beyond the scope of this note to go into an involved discussion of the relation of sporadic E reflections and meteoric ionization, it has been shown that reflections are obtained from meteoric ionization which can be distinguished from sporadic E reflections. A preliminary statistical examination, now under way, of a large quantity of data obtained over several months of nearly continuous observation does not appear to show that variations in meteoric activity are associated with corresponding variations in occurrence of sporadic E reflections. Continued observation of meteoric activity and perhaps a new line of approach in the technique of obtaining and evaluating the data are necessary before more extended conclusions can be drawn.

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Comments and Communications

The Betatron Building and Installation at the University of Saskatchewan

About two years ago the authors, all members of the staff of the Department of Physics at the University of Saskatchewan, felt that in order to carry out a significant research in nuclear physics they should act together as a team for the purpose of obtaining and using a 25-Mev betatron. The group was interested in investigating also its possible therapeutic uses in the treatment of cancer. Because of their wide interests they were able to enlist the generous support of the Atomic Energy Control Board of Canada in the purchase of the instrument and of the Provincial Government of Saskatchewan in the erection of the building to house it. Auxiliary equipment has been obtained through the support of the university, the National Research Council of Canada, the National Cancer Institute, and local cancer societies. The machine will be used both as an X-ray machine and as an electron beam machine. It is available to other groups in the university who may wish to investigate the biological and the chemical effects of high energy radiations.

The betatron building was built in one angle of the T of the main building but separated from it by 11 ft. It has the same floor level and is connected to the main building. The principal research rooms and instrument shop facilities of the main building are thereby made directly accessible to the betatron building, yet the betatron itself, a source of highly penetrating radiation, is well removed from persons in the main building. Its beam is directed away from the main building and is well below ground level.

The general plan of the betatron building, presented in Fig. 1, shows that the betatron room is surrounded by heavy concrete walls. The wall in the direct path of the X-ray beam is seven feet thick. In place of having a direct opening and a necessarily massive door between this room and the control room, entrance is made through a corridor long enough to reduce scattered radiation to a tolerable level. This corridor is entered from the control room through a doorway which is closed by a light, soundproof and airtight door. In spite of the greater walking distance between the control panel and the betatron room, experience has shown that this plan is very satisfactory.

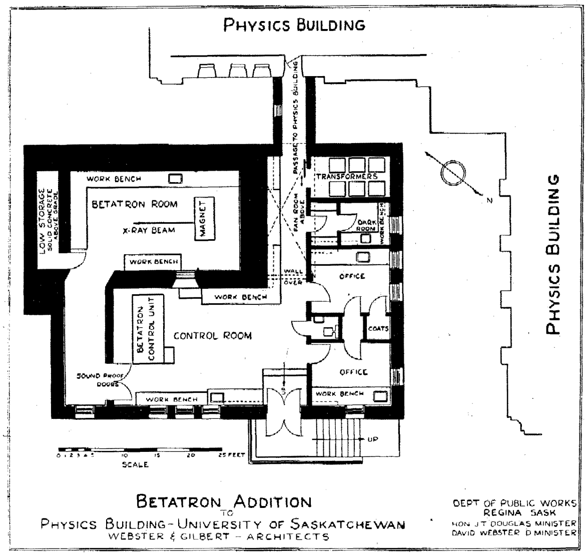

FIG. 1. General plan of the betatron building.

The betatron room is supplied with an overhead *I* beam with a chain block for lifting heavy equipment and moving it along a line normal to the front plane of the betatron and in line with the beam. Beneath this *I* beam are two steel rails on which a heavy truck with flanged wheels may be rolled. These rails and a closely adjacent steel scale of equal length are flush with the floor. Thus heavy equipment can be placed quickly at any point in front of the betatron and its position recorded. The work benches extending along each side and across the end of the room are fully equipped and have closed cupboards beneath them. The betatron itself rests on a concrete pier which extends 4 ft into the ground and is sufficiently distant from the rear wall to give room for the manipulation of air-pumping outfits which will be needed when donuts requiring continuous evacuation are used.

The control room contains, in addition to the usual laboratory benches, the large control unit. Between this room and the betatron room proper is a triple-glazed window, so placed that the operator at the control cabinet can see a large mirror mounted near the ceiling in the betatron room. This mirror can be rotated by the operator about either or both of two axes arranged so that he can constantly view the object or person being irradiated. Four large conduits inclined upwards at 45° from the betatron room make it possible to run experimental conductors from one side of the wall to the other without allowing any bundle of radiation to strike persons in the control room.

Four small rooms are provided. The transformer room is closed by a heavy fire- and sound-proof door. It contains three tripling transformers, three step-down transformers, and one 110-v service transformer. The photographic dark room is of the usual design. The remaining two rooms are similar and are equipped as small laboratories. However, should developments indicate the need, each with its small dressing room may serve as a reception room for patients. A washroom is included. Mention should be made also of a storage vault at the outer end of the betatron room, which utilizes space that otherwise would have been filled by concrete. Since the vault is entirely below ground level, 7 ft of concrete is not needed there for the absorption of radiation, as it is in the wall above.

As might be expected, the operation of the betatron results in the release of considerable heat energy. To remove this, a properly equipped fan room, not shown, is built over the hallway. Its blower discharges air into the airtight betatron room, forcing the air from that room through an acoustically-treated conduit into the control cabinet, which contains a large bank of condensers. From there it escapes either from the building or into the fan room to be recirculated, according to the outdoor temperature—an arrangement made necessary by the wide variations in temperature characteristic of our climate.

Fluorescent lighting is used throughout. All ceilings, the upper halves of the walls in the betatron room, and its entrance corridor are covered with Acousti-Celotex tile. A betatron usually has an objectionably loud hum, but it is found that the use of so much acoustical material and the L form of the room combine to reduce the noise level in the betatron room to 92 decibels. In the control room the hum is certainly not objectionable—its intensity there is only 54 decibels, a common level in offices. In the other rooms it is even lower.

TABLE 1

RADIATION RECEIVED DURING AN 8-HOUR DAY*

In line with the X-ray beam at ground level outside the building	0.02 r
Maximum observed on the roof of the building and above the axis of the X-ray beam	0.40 r
Near the door between the control room and the corridor leading to the betatron room:	
Control room side	0.06 r
Corridor side	0.25 r
In the corridor leading to the betatron room near the entrance to the betatron room proper	1.0 r
At the control panel in the control room	0.05 r
In the small laboratories	0.02 r
Directly behind the betatron in the hallway	0.10 r
In the dark room	0.05 r

* Betatron operating at 24 Mev and giving an output of 100 r/min at 3 ft.

The laboratory circuits distribute both a-c and d-c power, and include also storage battery lines. In the betatron room a special circuit makes it possible to block the operation of the betatron at three different points. A warning horn signal is automatically sounded 5 sec before voltage is applied to the magnet, thus giving any person working in the room ample time either to block the operation or to get out of the room. The uninsulated 16,000-v terminals on the back of the betatron are sufficiently dangerous to warrant these precautions. The corridor offers an easy and quick escape from radiation which would not have been possible had a heavy door been used instead.

Stray radiation at various points was measured by a Victoreen radiation meter, both inside and outside the building, and the results are recorded in Table 1.

It will be seen that the building affords adequate protection to everyone having to do with the betatron. When it is realized that the betatron will seldom, if ever, be operated continually for an 8-hr day the actual radiation likely to be received by any person is considerably smaller that that indicated in Table 1. The background count of a counter inside a lead castle situation in the main physics building is not affected by the operation of the betatron, although the background inside the betatron building is affected.

The betatron was manufactured by Allis-Chalmers Company of Milwaukee, Wisconsin, under the direction of Dane Scag. The machine is very similar to the one being used by the betatron group under D. W. Kerst at the University of Illinois. The machine is provided with four elevator screws simultaneously operated by a single motor to raise the upper yoke of the magnet. This greatly facilitates the replacement of donuts. The poles of the magnet are made of oriented steel and the field is adjusted for azimuthal uniformity by package coils. The machine is provided with a monitor which records the instantaneous intensity of radiation with auxiliary circuits to integrate this intensity. After a prearranged dose in roentgens has been given the machine automatically shuts itself off. The condensers for the tuning of the betatron are all located in the control unit.

The betatron, as installed, could operate only at an energy of about 25 Mev but it is being altered to operate through a range of energy levels below this value. An integrator circuit is being constructed to maintain any energy setting of the betatron to an accuracy of 0.1 percent. This will be accomplished by causing expansion of the electronic orbit to occur when the magnetic flux reaches a predetermined value. The machine will then operate at this energy or flux regardless of line voltage fluctuations or frequency changes. For constant voltage input to the betatron building, the magnetic flux is constant to within ± 2 percent as the frequency varies from 59.7 to 60.3 cycles per second.

The group working with the betatron plans to do experimental work in the field of nuclear physics. Some of the problems which will be attacked first include the measurement of the threshold energy for photodisintegration for (γ, p) and (γ, n) reactions in which the product of the reaction is not radioactive. This means that it will be necessary to detect the protons or neutrons produced in the reaction. Other problems involve the measurement of the energy distribution in the betatron spectrum so that the actual cross sections for photodisintegration may be measured.

For the investigation of the therapeutic applications of the betatron a d-c amplifier in conjunction with a small probe ionization chamber has been constructed. This will be used to measure the distribution of radiation within a water phantom. This distribution will be measured for a series of sizes of fields and for different types of step filters in an effort to get a clinically useful distribution. After this has been accomplished the machine may be used for cancer therapy. Many interesting experiments using the electron beam have been tentatively planned. These, however, must await the successful development of pumping techniques for use with electron donuts which have been obtained from the University of Illinois.

The authors would like to take this opportunity to thank those who have helped them to obtain the betatron and its building and auxiliary equipment in such a short time. In particular they wish to express their appreciation to D. W. Kerst and his associates, of the University of Illinois, who made available to them the facilities of their laboratory and who gave generously much valuable information and advice.

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Note on the Origin of Cosmic Rays[1]

W. Baade and F. Zwicky (*Phys. Rev.*, 1934, **45**, 138 and 46, 76), F. Cernuschi (*Phys. Rev.*, 1939, **56**, 120), and F. Hoyle (*Monthly Notices R.A.S.*, 1946, **106**, 384) have suggested that supernovae might be responsible for cosmic rays. Hoyle has recently considered this idea more closely in connection with his ideas about the origin of the chemical elements (*ibid.*, p. 343). He suggests that the heavy nuclei, or, better, the nuclear lumps, which are expelled during the supernova outburst might lose their accompanying electrons and thus become surrounded by strong electric fields in which nuclei might be accelerated up to energies as high as the largest energies found in cosmic rays. As a point in favor of this theory, Hoyle points out that, assuming that the average supernova will produce 0.1 M_0c^2 (M_0: solar mass; c: the velocity of light) energy in the form of cosmic rays, the density of extragalactic nebulae and the frequency of supernova outbursts are such that one can just explain the observed density of cosmic rays observed on the earth.

However, H. Alfvén (*Z. Physik*, 1937, **107**, 579) has pointed out that a galactic magnetic field of only 10^{-13} gauss would be sufficient to keep all cosmic rays inside our galaxy, and L. Spitzer, Jr. (*Phys. Rev.*, 1946, **70**, 777) has given strong arguments for the existence of such a galactic field. This means that we have to consider only our own galaxy as far as the production of cosmic rays is concerned. If we again assume that supernova outbursts are responsible for cosmic rays, we now have to estimate how large a density of cosmic rays we can expect. Assuming the production of cosmic ray energy per supernova to be about 0.001 M_0c^2 (Hoyle's estimate seems to us to be rather high, and we shall see that even a ten times smaller estimate would have been sufficient in order to get agreement between the observed and estimated energy densities), and assuming one supernova out-

[1] This letter was written while the author was temporarily at Yerkes Observatory, Williams Bay, Wisconsin.