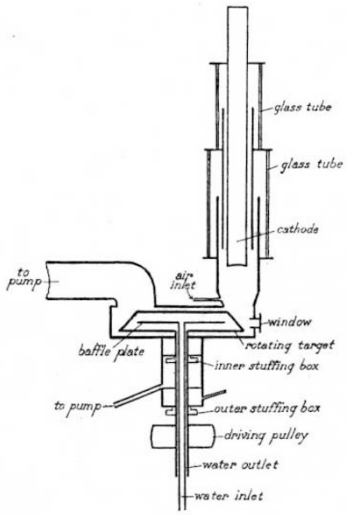
A Spinning Target X-ray Generator.

IT is a well-known fact that the energy density, that is, the energy per unit time and area in the focus of an X-ray tube, cannot be raised indefinitely owing to the extreme heating and consequent deterioration of the target surface. The input limit has been calculated for the usual type of X-ray tube in a previous paper (*Proc. Roy. Soc.*, A, vol. 117, p. 30; 1927).

In many applications of X-rays it would be very valuable to work with higher energy densities than those which had been used so far. This requires a method of removing the heat more radical than has been hitherto adopted. A simple way for doing this is



to produce the focus on the periphery of a rotating disc. The theoretical discussion which will shortly appear shows that the input limit can be raised as follows:

$$W_{\substack{\text{max.}\\\text{rotating}}} = W_{\substack{\text{max.}\\\text{rest}}} \times \sqrt{\delta \cdot \frac{\rho \cdot c}{k} \cdot v}$$

where $W_{\substack{\text{max.}\\\text{rotating}}}$ = maximum input for a rotating target, $W_{\substack{\text{max.}\\\text{rest}}}$ = maximum input for a target at rest, c specific heat of the anticathode material, k thermal conductivity, ρ density, δ radius of the focus in cm., v velocity of the target at the focus. This equation only holds if the expression under the square root is large compared with unity.

The use of the rotating disc avoids excessive local heating, but it is still necessary to remove the heat from the cathode as a whole, and this can be done by a water-cooling system.

An experimental X-ray plant embodying these principles of design has been built in the Davy-Faraday Laboratory. The target of the generator as shown in the diagram (Fig. 1) consists of a hollow copper disc with a bevelled surface on which the cathode rays impinge at about 5·5 cm. distance from the centre of the disc. The disc is mounted on a hollow shaft and rotates with about 2000 rev. per min. The cooling water is fed into the hollow target through a small tube inside the shaft and is directed against the inner cooling surface of the target by a baffle plate. The outlet is formed by the concentric space between the inlet tube and the inner wall of the driving shaft. The generator is permanently connected to a high-speed pump, and the pressure is regulated by a needle valve. The maximum input which the generator should stand according to calculations is about 5 kilowatts with a focus of 1 mm. diameter.

The generator was first tested on a high-tension plant which consisted of two large induction coils capable of standing an input of more than 20 kilowatts and operated by a specially constructed Wehnelt interrupter. The peak potential, judging from the spark gap, varied between 30 and 100 kilovolts. On one occasion, the input in the primary circuit being then about 30 kilowatts, a groove was cut in the disc of about 1 mm. width showing that a sharp focus must have been obtained in this experiment. Measurements of the actual energy striking the target were not made in this preliminary test. The X-ray energy must have been considerable, and visual observations of powder rings and of patterns due to reflections by a single crystal could be made on a fluorescent screen quite easily.

A second test was carried out at lower voltages, using this time a completely rectified supply. The generator ran very steadily at 25,000 volts and 100 milliamperes; at 19,000 volts and 200 milliamperes the discharge began to be unstable. This was possibly due to the heating of the cathode, the cooling of which depended entirely upon radiation in these preliminary tests.

I have been assisted in this work by Mr. R. E. Clay. A detailed description of the generator will be given later. I wish to express my thanks to the G.E.C. Research Laboratory in Wembley for letting me use their large high-tension D.C. plant.

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June 27.

The Origin of Variations.

AN article by Sir Oliver Lodge, dealing with the extracts from the Hooker Lecture on "The Origin of Adaptations" which were published in NATURE for June 1 (p. 841), appears in the issue for June 29 (p. 982). It is very gratifying that the lecture has aroused the interest of so distinguished a physicist, and I can assure him that all biologists will welcome his intervention and value the analysis of their problems to which he has given expression. With much of his article I am in full agreement, and for the rest, two quotations will perhaps most briefly make my position clear. The first has appeared on the title-page of every issue of NATURE since its first number was printed in 1869:

"To the solid ground
Of Nature trusts the mind that builds for aye."
—WORDSWORTH.

The second, in lighter vein which Sir Oliver Lodge with his keen sense of humour will appreciate, is from Prof. Eddington ("The Nature of the Physical World", p. 21):

"It does not seem a profitable procedure to make odd noises on the off-chance that posterity will find a significance to attach to them."

The course deprecated by Prof. Eddington seems to be the very one which Sir Oliver Lodge advises biologists to follow. With Wordsworth's lines he will, I imagine, be willing to express agreement, and they have this advantage that, perforce, he must abstain from making square-bracketed insertions which would upset the poet's rhythm, to say nothing of changing his meaning.

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