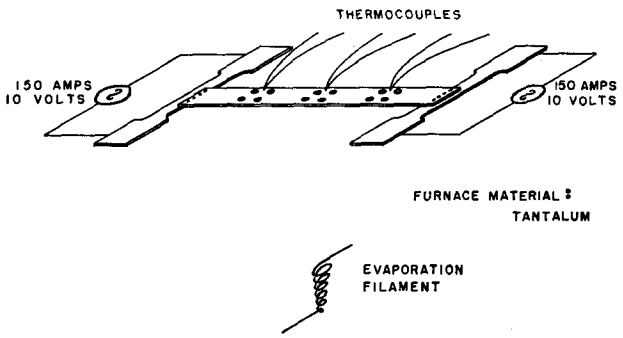

FIG. 1.

tures. With the furnace used for heating the rock salt crystals, selected temperature differences can be produced along the bar of any desired range between the limits of 900°C and room temperature.

As seen in Fig. 1, the furnace consists of three tantalum strips spot welded together in the form of an "*H*," thermocouples for measurement of the temperature at different points along the temperature gradient bar, and electrical circuits for heating the furnace. The legs of the "*H*" furnace are made of $\frac{1}{2}\times 0.01$-in. tantalum sheet approximately 3 in. in length, the cross member being $\frac{1}{2}\times 0.005$-in. tantalum sheet approximately 4 in. in length. Necessary thermal contact can be made between the three pieces by five or six spot welds at each junction. For our application of the metal films, three sets of four holes were drilled in the gradient bar so that rock salt crystals could be supported on top of the bar and the evaporation could be made from beneath.

Chromel-Alumel thermocouples were used to measure the temperature at different points along the gradient bar, the thermocouple junctions being spot welded to the bar. The thermocouple leads were carried outside the vacuum chamber to the cold junctions and the potentiometer by means of Kovar seals.

The legs of the "*H*" furnace are heated by separate 150-amp, 10-v transformers. By selection of the heating currents, either end of the gradient bar can be maintained at any temperature between room temperature and 900°C. We have successfully used various temperature differences between the limits of 500° and 22°C, for example, 500° to 400°C, 500° to 22°C, and 200° to 100°C. The unregulated ac line has proved stable enough to hold the temperatures constant to within 1°C for a period of an hour without any adjustments.

An advantage of this furnace is that the steady temperature conditions can be obtained in less than 10 min. This is due to the small mass of the furnace as compared to the available electric power and also to the fact that there is no appreciable outgassing from any of the components. A disadvantage is that the crystals to be heated are not in an isothermal enclosure and therefore, the measured temperature is not necessarily the true temperature of the crystals. This can be somewhat overcome by placing tantalum caps over the crystals so that they are in contact with both the crystals and the gradient bar. The temperature distribution along the bar is not linear because most of the heat loss is by radiation. This is not felt to be a disadvantage since the temperature can be measured at any point along the bar.

Letters to the Editor

Prompt publication of brief reports of NEW ideas in measurement and instrumentation or comments on papers appearing in this Journal may be secured by addressing them to this department. No proof will be sent to the authors. Communications should not exceed 500 words in length. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Experimental Demonstration of Electron-Optical Regenerative Image Amplification

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(Received March 13, 1958)

IMAGE intensifying tubes with quantum gains of 10^5 to 10^6 would have manifold uses in physics and astronomy. In particular such a tube is required for viewing a luminescent chamber of either the solid crystal[1] or plastic filament[2] type, since each photoelectron must be sufficiently amplified so that it can be photographically recorded. These very high quantum gains require that a tube have many stages of electronic amplification, but in only one case has such a multistage image tube been constructed successfully.[1] Kalibjian[3] has suggested an alternative scheme in which a single stage image tube could be made to have arbitrarily large gain by utilizing optical feedback between the output phosphor or the image tube and the input photocathode.

While engaged in the development of a cooled cesium iodide luminescent chamber, we have demonstrated the feasibility of this optically regenerative image amplification. The apparatus shown in Fig. 1 consists of a clear cathode Westinghouse 5997 Fluorex image tube[4] (which has a long decay time phosphor) together with a small Schmidt lens of the type used in "Snooperscopes." With the optical system out of alignment, a sequence of displaced images of an original image is seen on the anode

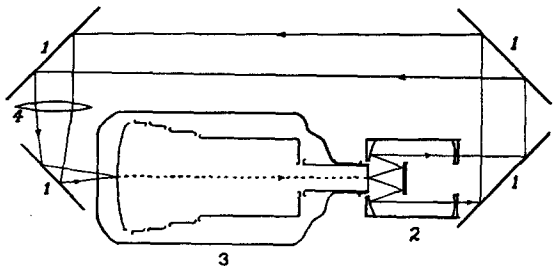

FIG. 1. Schematic drawing of system used in electron-optical image regeneration demonstration, showing (1) plane front-surface mirrors; (2) Schmidt lens assembly; (3) Westinghouse clear cathode image tube; and (4) simple lens. Light rays are indicated by solid lines and an electron trajectory by a dotted line.

phosphor, with successive images showing increasing brightness. When the system is aligned by adjusting the mirror the images superimpose and become extremely bright. Because the tube is on continuously, the light noise also builds up and the entire field of view of the anode also becomes extremely bright with or without an original image being present. In either case the optical light path must be quickly interrupted to prevent damage to the tube. Rough measurements using a 929 phototube give the collecting efficiency of this extremely crude optical system as 8%. The light from the tube phosphor appears more strongly peaked than from a Lambertian surface. The quantum gain of the tube[4] was measured to be about 15 and the total loop gain is 1.2. Although from 50 to 100 loops must be occurring to give the observed gain, the registry was obtained with surprising ease. With the present optics the field of view on the photocathode is 2.5 cm and on the anode is 0.5 cm in diameter.

The success of this very crude regeneration method, combined with the availability of optical systems with collecting efficiencies of 20 to 50% (from a Lambertian surface) and single stage image tube with gains of order 50 leads us to believe that a luminescent chamber using this principle is now practical. Although the application of this system to the filament scintillation chamber[2] is less apparent, its use with large inorganic crystals is straightforward. One geometry considered is shown in Fig. 2. In use it is planned to gate the image tube[5] with a pulse from counters indicating a desired event in the crystal, the pulse being of sufficient length to provide an adequately bright image of single photoelectrons. In this connection

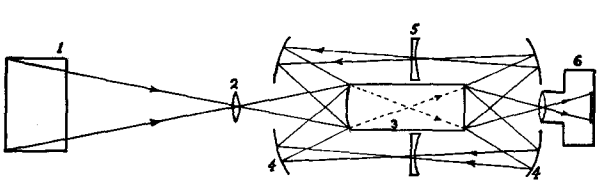

FIG. 2. Possible geometry for luminescent chamber, showing (1) large scintillating crystal; (2) lens; (3) image tube; (4) spherical mirrors; (5) Schmidt correcting plate; and (6) camera. Light rays are indicated by solid lines and electron trajectories by dotted lines.

P15 or P16 phosphors would be incorporated into the image tube for fast response. Unactivated cesium iodide crystals cooled to 77°K have been shown[6] to scintillate with 59% efficiency thus giving off in excess of 10^6 quanta per centimeter of minimum ionizing track. Thus with a 10% efficient photocathode, a photograph recording 5 photoelectrons per centimeter of minimum ionizing track in the crystal, with a resolution of ± 1 mm or better could be obtained from a crystal 14 cm thick, while the field of view may be much larger than the image tube photocathode.

We wish to thank the Westinghouse Electric Corporation for their generous loan of the image tube.

[1] Zavoisky, Blutsov, Plakhov, and Smolkin, J. Nuclear Energy **4**, 340 (1957).
[2] G. T. Reynolds and P. E. Condon, Rev. Sci. Instr. **28**, 1098 (1957).
[3] R. Kalibjian, University of California Radiation Laboratory Report 4732 (1956).
[4] J. W. Coltman, Radiology **51**, 359 (1948). This tube has a 5 to 1 linear demagnification with a 5-in. diameter photocathode and a 1-in. diameter anode. The tube used here is an early model and had been previously subjected to extensive testing by Westinghouse. Therefore the tube quantum gain is much less than would be expected in a new 5997 Fluorex tube.
[5] B. R. Linden and P. A. Snell, Proc. Inst. Radio Engrs. **45**, 513 (1957).
[6] Knoepfel, Loepfe, and Stoll, Helv. Phys. Acta **30**, 521 (1957).

Use of β Spectrometers with Linearly Increasing Magnetic Field

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(Received March 4, 1958; and in final form, March 31, 1958)

Y. RAMBERG and A. E. Blaugrund have investigated the properties of β spectrographs with linearly increasing and subsequent homogeneous fields.[1] In that paper the equations of motion are given for the linearly increasing range, the solutions of which are sufficiently good approximations for small angular deviations.

Similar results were obtained in our Laboratory[2] as a part of a more detailed analysis dealing with any angular deviations. The solutions, obtained by numerical integration, (Fig. 1) show that for linearly increasing magnetic field a suitable coordinate transformation clearly indicates that, if a ring target is located near the trajectory maximum, this setup may be used as an analyzer. It will be most sensitive to the momentum variation of electrons entering the spectrograph at an angle about 45 deg. The trajectories are extended by the same amount in any direction for increasing momentum. Due to the angular invariance property of the coordinate transformation used, the trajectories clearly show that this magnetic field is incapable of focusing for angles above 45 deg;