DU MONT

VOL. 7 NO. 4 JULY-AUGUST, 1945

OSCILLOGRAPHER

HIGH SPEED PHOTOGRAPHIC RECORDING AND PROJECTION OSCILLOGRAPHY WITH THE NEW DU MONT TYPE 5RP MULTI-BAND TUBE

By Rudolf Feldt

In the past, the insufficient light output of cathode-ray tubes operated in commercial oscillographs has placed a limitation on the photographic recording and visual observation of high speed transients. In certain cases, instruments have been built in which frequency response characteristics of the electrical circuits exceed by far the possibilities of the tube, since the corresponding light pulses produced on the cathode-ray tube screen were so weak that satisfactory observations or recordings could not be made. In the case of recurrent phenomena, the light output of all commercial cathode-ray oscillographs was insufficient for picture enlargement by means of a projection lens system. The solution of both of these problems evidently lay in a cathode-ray tube with greatly increased light output. After much experimentation along these lines, Du Mont has recently announced the Type 5RP Multi-Band Cathode-ray tube series, development of which was carried out along the following lines.

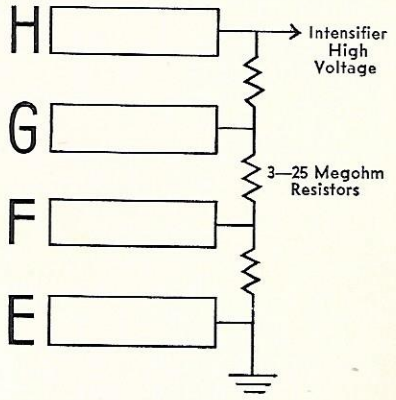
For any given screen material, there are only two practical methods of obtaining increased light output, namely; either by increasing the screen current or the accelerating voltage. The current range is limited by the maximum permissible spot size, since the spot size increases with the current. As the deflection sensitivity is inversely proportional to the accelerating voltage, the maximum voltage which may be applied is restricted by this factor. In addition, the insulation problem of the cathode-ray tube heater transformer becomes difficult with increased voltage since the cathode is at high negative potential with respect to ground. Some improvement has been

Fig. 1. Du Mont Type 5RP Multi-band Cathode-ray Tube

obtained by the use of the intensifier principle in which the total accelerating voltage is divided into two parts applied before and after deflection. The second anode voltage, Eb_2, is the potential between the negative cathode and the grounded second anode, and the intensifier, Eb_3, is the total accelerating potential between cathode and intensifier terminal. The difference, $Eb_3 - Eb_2$ is the so-called post-accelerating voltage which exists between ground and the intensifier terminal; this is the potential which has to be delivered by the intensifier power supply. Here again a serious limitation exists. If, on regular intensifier type tubes, say of the 5LP or 5CP type the ratio between intensifier voltage and second anode voltage is increased much above 2, considerable spot and pattern distortion occurs, and only a very small area in the center of the tube screen can be used.

The new Type 5RP high voltage Multi-Band tube overcomes all such difficulties. Without going into theoretical details concerning this tube, a complete description of which will be given soon in another publication, it can be said that this tube is of the intensifier type in which, by means of suitable shape of the tube bulb, by gradual upstepping of the intensifier voltage, and by proper location of the three intensifier rings, distortion is kept to a minimum. This makes it possible to operate this tube with satisfactory results at ratios of intensifier to second anode voltage up to 10:1. In other words, Eb_2 may be, for instance, 1500 V, and Eb_3, 15,000 V. Since in this case the loss of deflection sensitivity is less than 50% as compared to the operation at the ordinary ratio of 1:2 (Eb_2 = 1500 V, and Eb_3 = 3000 V), it can be seen that this tube type can be operated on standard equipment with standard amplifiers. The loss of the deflection sensitivity can be compensated for easily by means of either photographic enlargement of the recordings, or by optical compensation in the projection system.

Fig. 1 shows a picture of the 5RP tube from which its general design can be clearly seen. Starting from the diheptal base toward the screen, there is located first the gun followed by the deflecting plates, the connections to which are brought out through the tube neck. This feature keeps the capacitance of the deflecting leads low and is a distinct advantage for high frequency operation. The contacts to the deflection plates are grouped by pairs and separated by a center contact that is connected to the second anode and normally grounded. The first flush contact on the cylindrical part of the tube body must also be connected to second anode by means of an external connection. The conductive coating to which it is connected provides shielding of the deflection plates from the intensifier field and also from external electrostatic fields. The above following flush contacts next to the screen are for the increasing steps of intensifier potential. The tube face is flat, a factor introducing many optical advantages, since it eliminates any difficulty that might exist in focusing the photographic or projection lenses over the whole screen area.



H Intensifier Electrode No. 3
G Intensifier Electrode No. 2
F Intensifier Electrode No. 1
E 2nd Anode

Fig. 2. Voltage Divider for Intensifier Electrodes

OPERATION

The type 5RP tube has the same base as the type 5CP tube, and the same basing except for second anode and deflection plate connections which are made through the tube neck. If the 5RP tube is to be substituted for the 5LP or 5JP tubes, a change in tube socket is necessary. Because of the difference in tube shapes, the magnetic shields must also be changed. Connections to the intensifier terminals may be made either by connecting only the last ring (next to the screen) to the high voltage terminal, leaving the others floating, or by using a voltage divider according to Fig. 2. The latter connection results in the best performance.

The high voltage power supply for the 5RP intensifier electrodes should be variable, and should be capable of delivering a maximum of 10 times the second anode voltage at which the tube is operated. This means, for operation with existing commercial equipment, an intensifier voltage of 10-15 KV with an output current of about 200 ua (including voltage divider current). It should be noted, however, that for many applications, voltages in the range of 5000-8000 V will be adequate. On the other hand, for certain extremely high speed recordings, tubes have been used at voltages for in excess of these ratings, for instance, $Eb_2 = 5KV$, and $Eb_3 = 45KV$.

SCREENS

The type 5RP tube is normally manufactured with either of two screens, the medium persistence, green (type 5RP1) for visual observation and projection, and the short persistence, blue (type 5RP11) for photographic recording and visual observation of transients of extremely short duration of the order of fractions of microseconds. Other screen types, particularly those having long persistence (5RP2; 5RP7) are also available.

PERFORMANCE AND APPLICATIONS

A. Projection Oscillograph

For lectures and classroom demonstrations most standard oscillographs may be readily converted into projection oscillographs by means of the type 5RP1 tube, and external intensifier power supply, and a projection lens. Both our Type 263 High Voltage Power Supply and a projection lens, the development of both being nearly completed, will be described in later issues of the OSCILLOGRAPHER. Intensifier voltages of about 6000 V for classroom demonstrations and of 15 KV for fairly large auditoriums are satisfactory. The projection lens has an effective speed of about f:2 with a focal length of 8″. A beaded reflective projection screen is desirable to obtain the best light efficiency.

B. High Speed Photographic Recording

For photographic recording as well as for visual observation of very high speed single transients, the type 5RP11 tube should be used. It is expected that these new tubes will open new fields to the sealed-off cathode-ray tube with hot cathode; fields which heretofore were the exclusive domain of the high voltage cold cathode-ray oscillograph employing photography in vacuum. The photographic writing rates which so far have been reported, and which, in one particular case went up to 400 inches/microsecond (10,000 KM/sec) for an f:1 lens, and 5:1 picture size reduction, are very encouraging. Application in the field of high voltage surges seems to be particularly promising. Success at these extreme speeds depends naturally, not only on the tube performance, but also on certain factors such as lens speed, object-to-image ratio, film sensitivity, and development procedure*. Because of the increased light output of the type 5RP tubes, the lens problem becomes less

difficult, and for medium speeds, an f:3.5 lens is perfectly satisfactory. For high speeds, an f:2 or better lens may become necessary. Recognizing the importance of photographic recording, Du Mont is preparing a complete series of photographic accessories, still and continuous motion cameras, which will be described in coming issues of the OSCILLOGRAPHER.

The range of recordings, with continuous motion cameras will be extended considerably by use of the 5RP11 tube, and the only limitation to be expected is in the mechanical speed of the recorder.

VISUAL OBSERVATION OF TRANSIENTS

The high brilliance of the 5RP Multi-Band tube makes possible visual observation of very rapid phenomena which otherwise remain invisible. For most purposes, the 5RP1 tube is preferable, although it seems that in the case of extremely high writing rates, the P11 screen has somewhat higher efficiency. No definite data is yet available, and this question will be investigated further.

The study of slow phenomena is also facilitated by the increase of persistence on 5RP2 and 5RP7 tubes.

* "Photographing Patterns on Cathode-ray Tubes", by R. Feldt, ELECTRONICS, February, 1944.

BIBLIOGRAPHY:

(1) "On the Post-Acceleration Problem in Cathode-Ray Tubes" by E. Schwartz, FERNSEH MITT., December, 1938

(2) "Quadruple Beam Cathode-Ray Tube of High Recording Speed", by A. Bigalke, ARCH. F. EL. 1939, No. 2

(3) "On Post-Acceleration in Cathode-Ray Tubes", by W. Rogowski and H. Thielen, ARCH. F. EL., 1939, No. 6

(4) "Problem Concerning the Production of Cathode-Ray Tube Screens", by H. W. Leverenz JL. OF THE OPTICAL SOC. OF AMERICA, Jan. 1937, pages 25-35

(5) "Cathode-Ray Tubes and Their Applications", by P. S. Christaldi, PROC. IRE, June, 1945, pages 373-381

ALLEN B. DU MONT LABORATORIES, INC., 2 Main Ave., Passaic, New Jersey