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NANOSECOND LIGHT-SOURCE, XP-20*

J. Johnson and D. Porat
Stanford Linear Accelerator Center
Stanford University, Stanford, California

The characteristics of the XP-20 miniature Gallium-Phosphide diode[1] were measured; it was found suitable as a nanosecond light source in counter techniques, such as testing of fast photomultipliers and hodoscope arrays in high-energy physics applications.

1. Relative light output

Data were obtained with 5.6 nsec pulses of 20-volt amplitude (into 50 ohms) applied to the photodiodes, which were epoxy-potted at the end of 50-ohm subminiature cables. The light sources were mounted flush against the cathode of a photomulitplier, RCA type 8575. The output from the P.M. was applied to a pulse integrator[2] followed by a multichannel pulse-height analyzer. Results from 63 samples are shown in Fig. 1. Forty-eight of these, or 75%, fall within about a factor of two. The average output corresponds to channel 83.5. Light from minimum ionizing particles passing through 1/4-inch scintillator was found to correspond approximately to channel 100. When one XP-20 was allowed to run continuously for 72 hours, its light output remained constant to within a percent.

2. Resolution

Figure 2 shows the distribution in resolution of the 63 spectra obtained as described above. The average was found to be 18.2% for 20 volts applied to the XP-20 junction, improving with increased input signal. The corresponding average number of electrons emitted by the photocathode of the RCA 8575 was estimated to be 45: a logarithmic plot of resolution versus relative output yields a straight line of slope -- 1/2, indicating that the resolution is mainly dependent on electron

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statistics, the multiplication statistics of the P. M. being negligible. To estimate the corresponding number of photons reaching the photocathode from the XP-20, one needs the photocathode quantum efficiency in the range of wavelengths where the P. M. spectral sensitivity (S-11) overlaps the spectral emission of the diode.

3. Dependence of light output on the applied voltage

The results for seven samples are shown in Fig. 3. A linear dependence is observed in the range of 10 to 40 volts applied to the light sources. The range expected to be used in typical applications is 20 to 30 volts.

4. Dynamic impedance

Z was measured by observing the amplitude of the incident pulse, $\overrightarrow{V}_1$, and that of the reflected component $\overleftarrow{V}_1$,

$$Z = \frac{1+\rho}{1-\rho} Z_o$$

where $\rho = \overleftarrow{V}_1/\overrightarrow{V}_1$, and Z_o is the characteristic impedance of the coaxial cable transmitting the pulse to the XP-20. The results are summarized in Fig. 4 for seven samples. With a 20-volt pulse applied to the light source one observes an average impedance of 36 ohms. Twenty volts correspond, on the average, to a current of .475 amp; thus in a typical case the reflected pulse is 3.3 volts.

The matching of the nonlinear impedance of the XP-20 to a 50-ohm coaxial line can be effected in several ways: (i) When the pulse amplitude applied to the light source does not exceed 25 volts the reflections are too small to cause after-pulsing and the system can be considered matched for all practical purposes; (ii) When the applied pulse exceeds 25 volts its reflection may be of sufficient amplitude to cause light emission from the diode junction. (The device is normally operated in the reverse breakdown mode. However, it will emit light in forward conduction, though with a reduced efficiency and exhibiting longer storage times.) The reflected pulse can be reduced to negligible amplitudes by insertion of a small T-attenuator (3 to 6 db), which then is transversed twice by the reflection before reappearing at the junction. Alternatively, one may add a 27-ohm, 0.1-watt resistor in series with the junction at the time of epoxy-potting.

5. Rise time and pulse shape

A faster photomultiplier, Amperex XP-1020, was used for this measurement. The finite rise time of the photomultiplier (XP-1020) permitted an estimate only of an upper limit in rise time of the XP-20, which was found to be 2.7 nsec (10 to 90 percent). The output pulse shape for 3.5 nsec input pulses of 25-volt amplitude is shown in Fig. 5.

6. Time-Jitter

The combined jitter of the photomultiplier and the XP-20 was measured to be less than 500 psec.

7. Pulse distribution

The relatively low pulse power requirements of the XP-20 permit the use of resistive fan-outs for simultaneous pulsing of a number of light sources. A typical application is on-line checking of hodoscope arrays. A fan-out was constructed to drive 36 XP-20 diodes simultaneously mounted on the counter hodoscope of the 1.6 GeV/c (SLAC) spectrometer. A pulse of 900-volt amplitude, 0.5 nsec rise time, applied to the input yielded at each of the 36 output terminals a pulse of 25-volt amplitude, ~ 1 nsec rise time. The reflections caused by the combination of 36 imperfectly matched loads were less than 5 volts, well below the level required for light emission from the XP-20.

REFERENCES

1. Ferranti Ltd., Gem Mill, Chadderton, Oldham, Lancaster, England.
2. R. Anderson and D. Porat, "Active Integrator for Nanosecond Pulses," submitted to Rev. Sci. Instr. for publication.

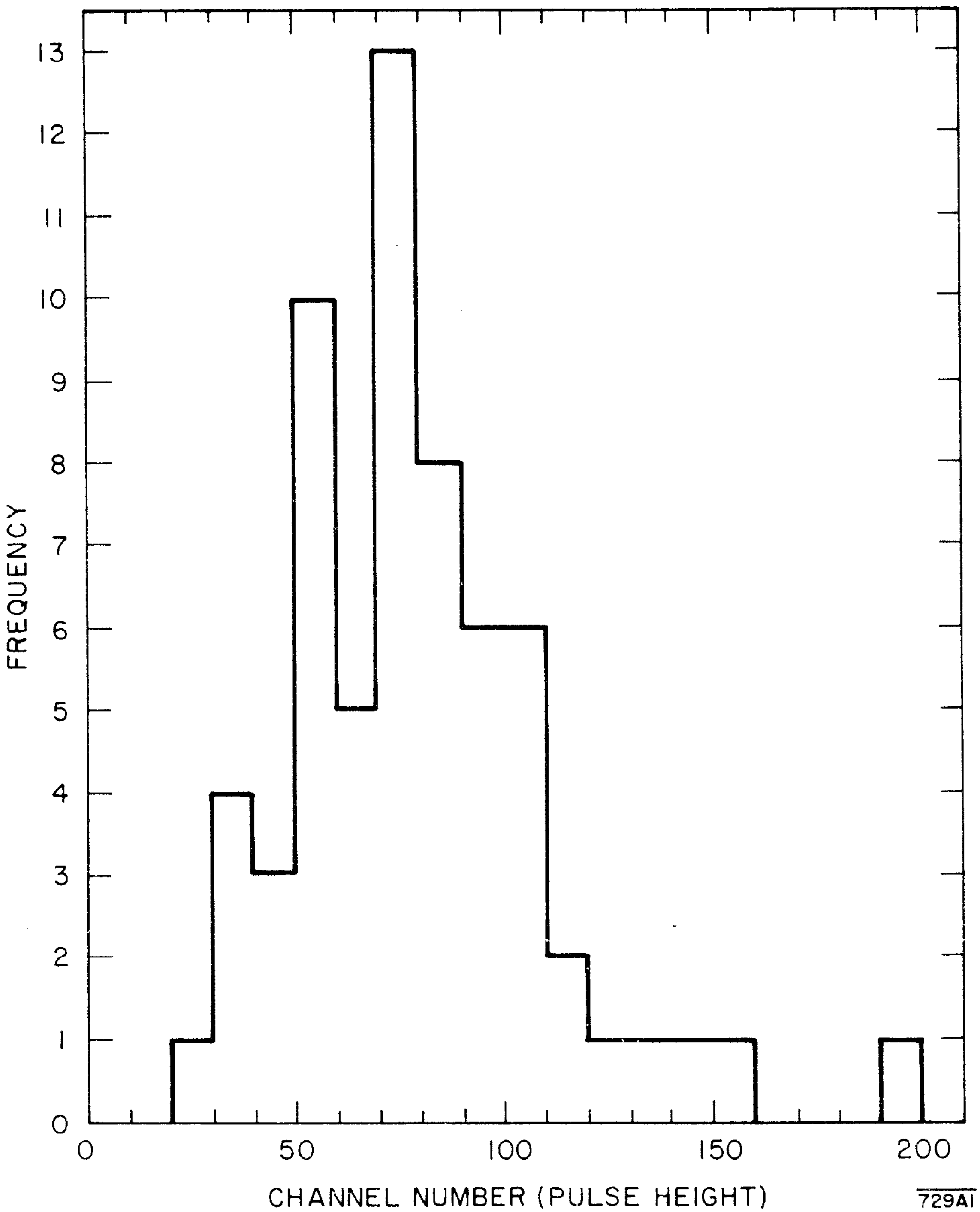

FIG. 1 -- LIGHT SOURCE XP-20. RELATIVE GAIN DISTRIBUTION.

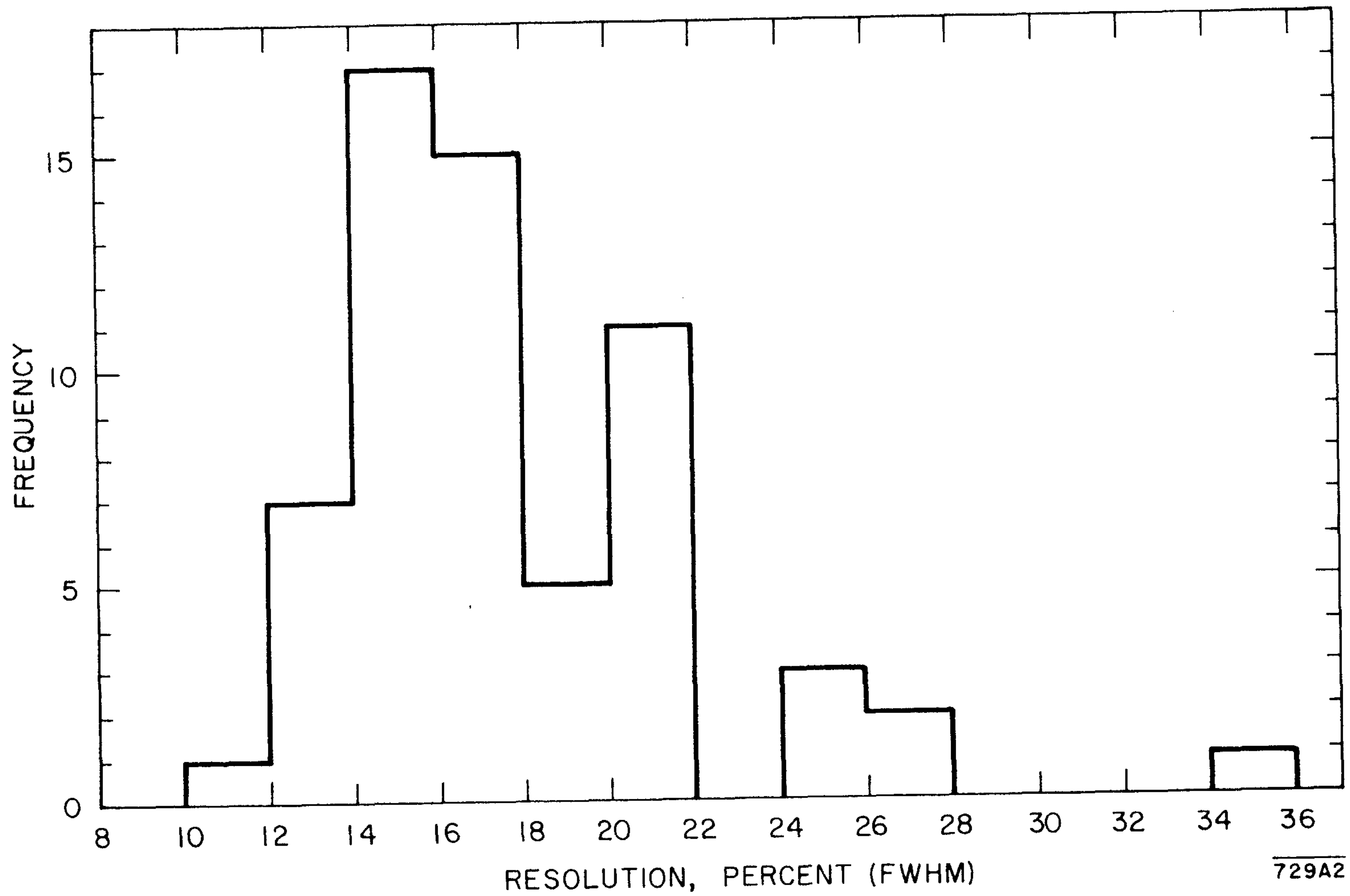

FIG. 2--LIGHT SOURCE XP-20. RESOLUTION

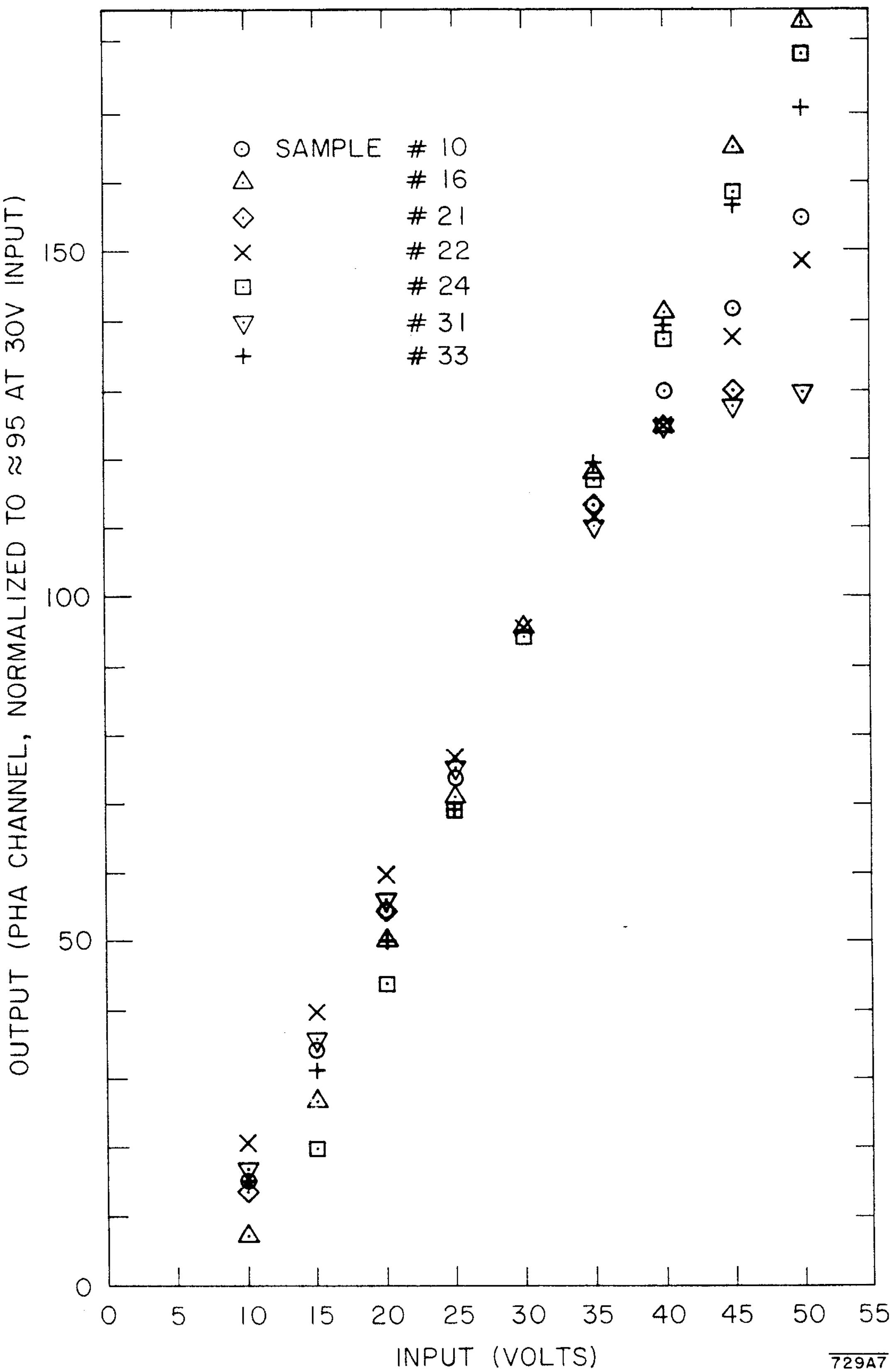

FIG. 3 -- NORMALIZED LIGHT OUTPUT vs APPLIED VOLTAGE

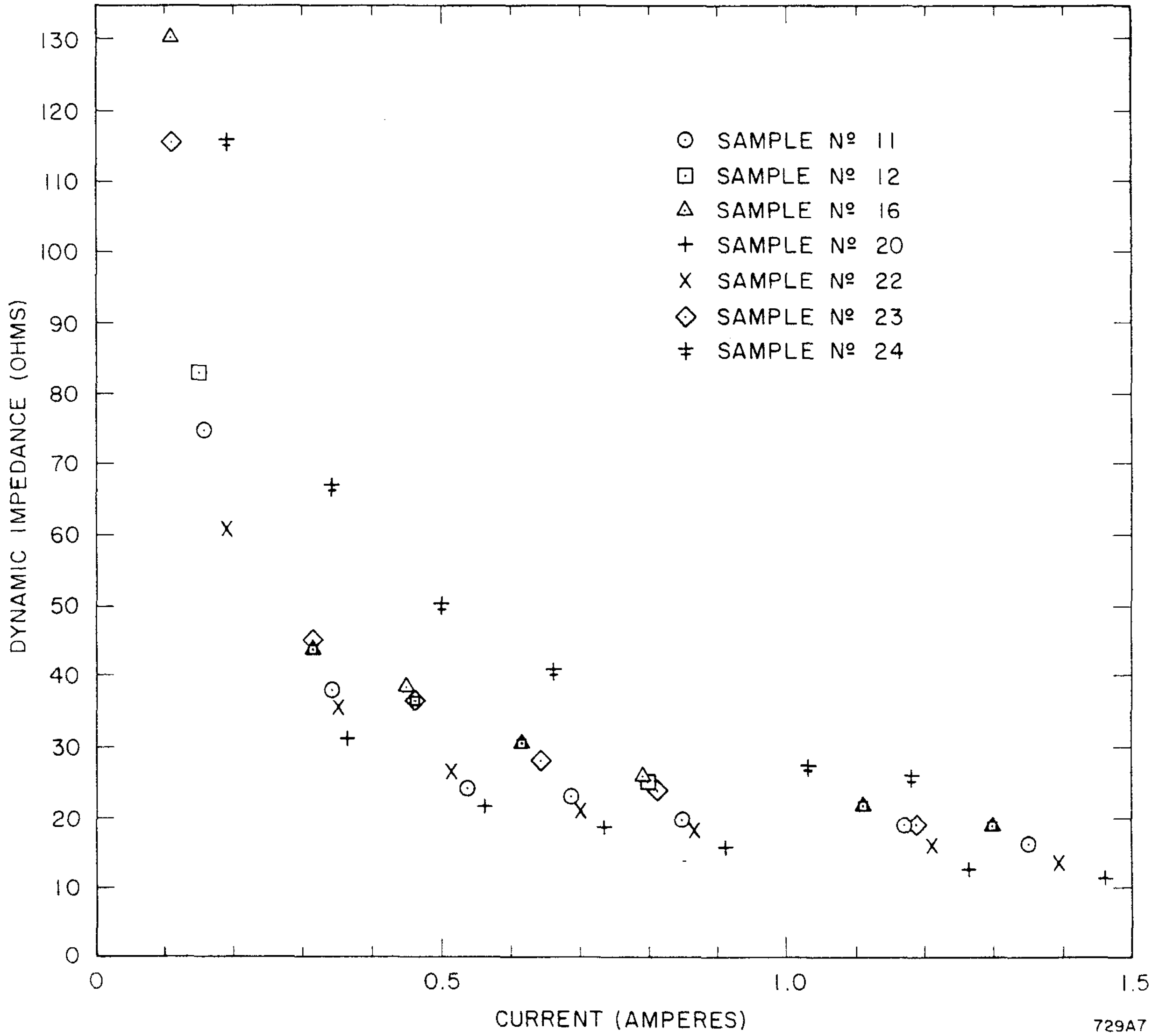

FIG. 4 -- DYNAMIC IMPEDANCE vs CURRENT

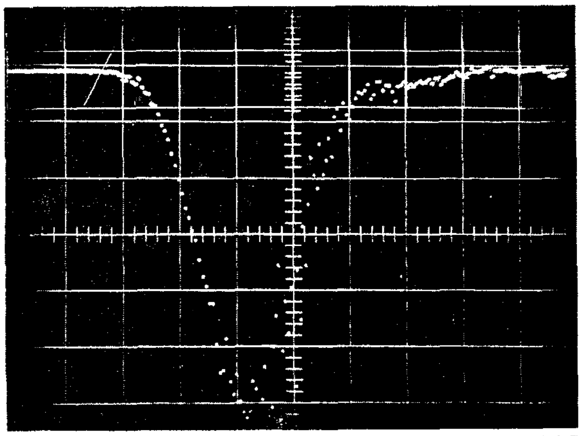

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FIG. 5

Light output from the XP-20 as viewed by an XP 1020 phototube with H. V. = 2.2 k volts.

Applied pulse is 25 volts, 3.5 nsec

Horizontal: 2 nsec/cm

Vertical: 0.25 volts/cm