The GENERAL RADIO
EXPERIMENTER

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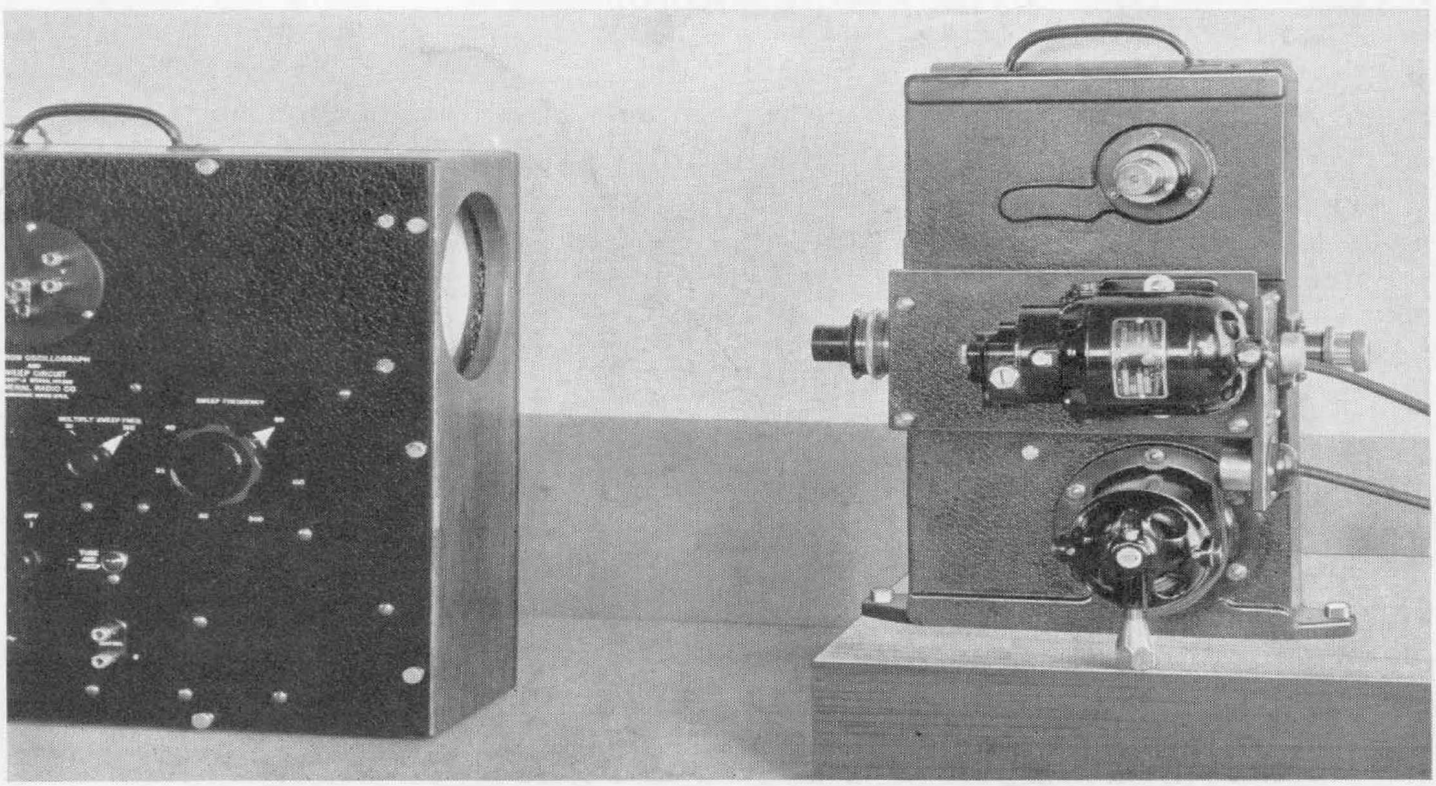
ELECTRICAL COMMUNICATIONS TECHNIQUE
AND ITS APPLICATIONS IN ALLIED FIELDS

A NEW MOVING-FILM CAMERA

A NEW magazine-type of camera, designed to operate over a wide range of film speeds, proves useful for all sorts of oscillographic and chronographic recording.

One of its most useful applications is in obtaining cathode-ray oscillograms of recurrent or transient phenomena, either as a continuous or an intermittent record. Recurrent phenomena, if synchronized with a sweep circuit, may be observed as a stationary picture and photographed with an ordinary "still"



The high film speeds at which the new continuous-film camera will operate make it possible to take cathode-ray oscillograms of high-frequency transients. The photograph shows the Class 651-A-E Camera Assembly and a TYPE 687-A Electron Oscillograph and Bedell Sweep Circuit camera. On the other hand, transient phenomena or recurrent phenomena which do not repeat at equally spaced intervals *must be photographed upon a continuously moving film* in order to obtain a suitable record. Examples of noise oscillograms taken with this camera unit are shown on page 3. They show how a considerable amount of resolution of high audio-frequency waveforms can be accomplished at a film speed of 32 feet per second.

Cathode-ray oscillograms are made by applying the voltage in question to the "horizontal" deflecting plates, thus producing a single straight line on the screen of the tube. The camera is set up as shown on page 1 so that the motion of the film supplies the necessary time axis perpendicular to the displacement of the cathode-ray beam. In this manner all sorts of oscillographic recording may be accomplished at audio frequencies showing elaborate detail and freedom from the distortions which might be introduced by an oscillograph employing vibrating members.

The Class 651-A-E Camera Assembly consists of a cast aluminum housing provided with two flanges for mounting it in any position. A removable slide gives access to a single compartment housing the magazine reel (capacity 100 feet), the 4¾-inch driving sprocket designed for 35-mm perforated film or paper, and the take-up reel.

The film, which is run continuously at a chosen and essentially uniform speed, is fed directly from the magazine reel over a portion of the drive sprocket and thence directly onto the take-up reel, there being no loops, as in the ordinary motion-picture camera. Idler guide rollers insure the proper lay of the film on the rim of the driving sprocket. While passing over the driving sprocket, the film is continuously exposed through a rectangular window opening extending along the film for ⅜ inch and across the film for one inch between the sprocket holes. The curvature of the sprocket is small enough to permit sharp focusing over this area.

An *f*/2.5 lens of 47-mm focal length is supplied. There is an iris diaphragm but no shutter. This lens is provided with an adjustable focus covering a range of linear object-to-image ratio of from 4.0 to about 7.0, corresponding to a distance of the object from the front face of the camera of from 10.25 inches to 15.5 inches.

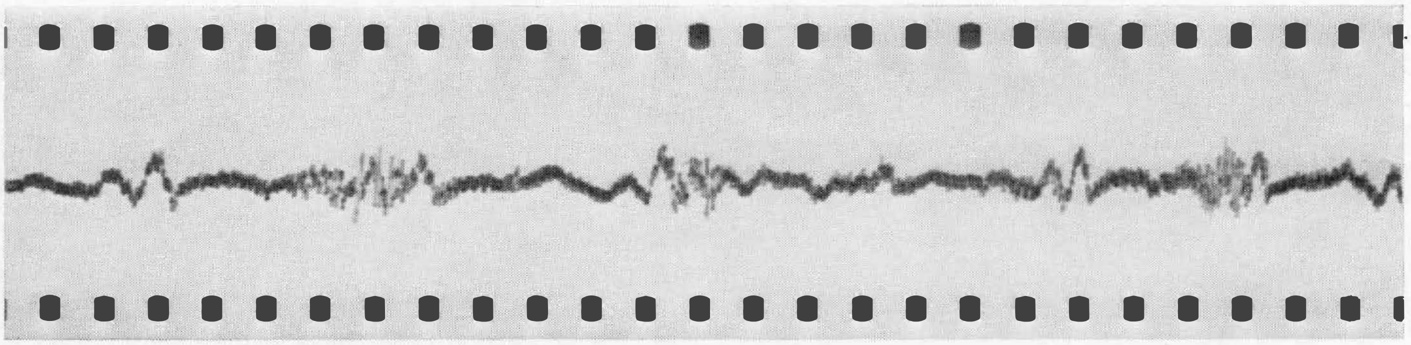
Opposite the lens mounting is located the focusing eyepiece which, by virtue of two rectangular holes in the rim of the drum sprocket, permits focusing and observation of the area of exposure.

The camera is driven by two 115-volt universal series-wound motors mounted externally on the side of the housing. One of these motors is connected directly and permanently onto shaft of the take-up reel. The other motor is connected through a self-contained 8.5-to-1 reduction gear and a universal joint to the drive sprocket. This dual-motor drive system provides a satisfactorily uniform film velocity over a wide range of speeds. The motor on the take-up reel tends to drive that reel at a speed higher than the rate of film travel over the drive sprocket and thus eliminates any slack between the sprocket and the take-up reel. The motor-driven sprocket pulls the film from the magazine reel with no slack, because of friction on the shaft of the magazine reel.

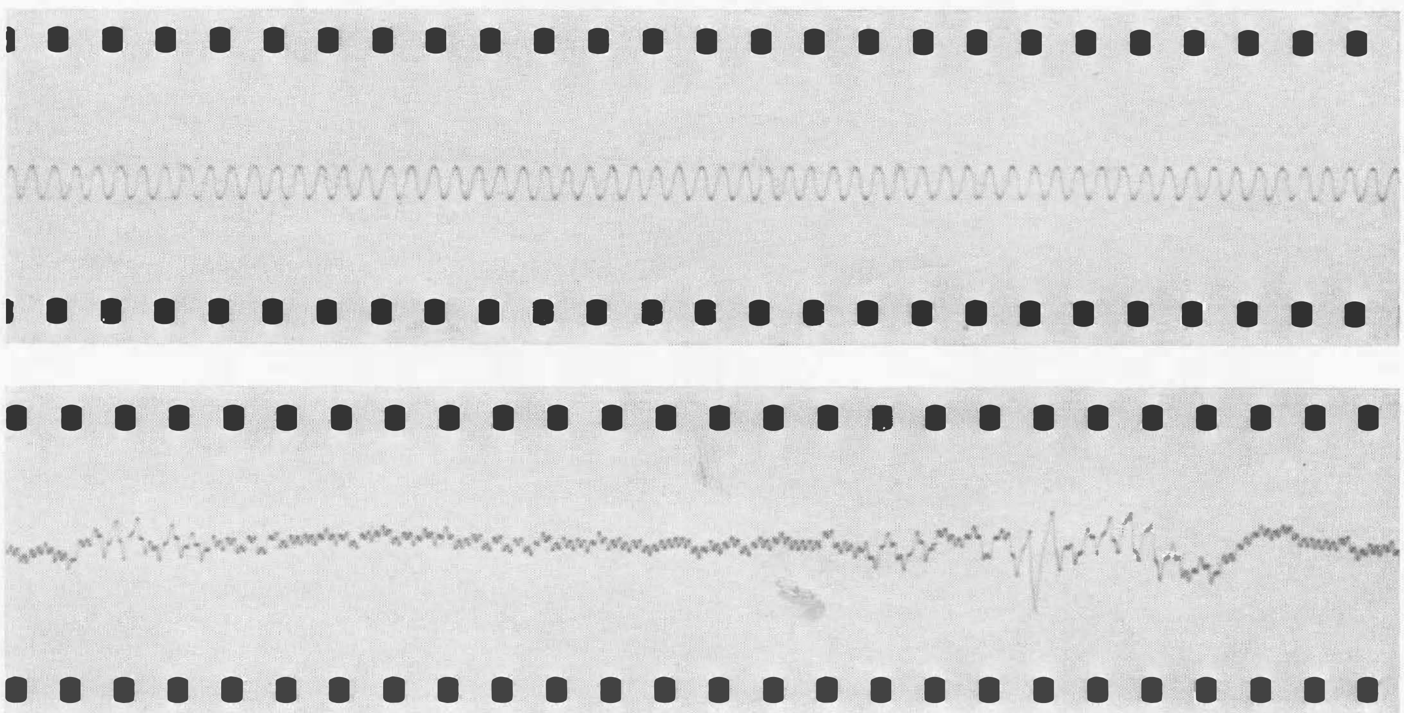
(*Continued on page 8*)

THE NEW CAMERA RECORDS HIGH-SPEED TRANSIENTS

Cathode-ray oscillograms of noise from an internal-combustion engine



An oscillogram of engine noise at a film speed in the vicinity of 8 feet per second, about the top speed for continuous-film cameras heretofore available. At this speed one cycle of a 10,000-cycle trace is a little less than 0.01 inch long



By running the film at a higher speed, resolution is markedly improved

BELOW: A 32-foot-per-second noise oscillogram from the same engine that made the record at the top of the page. An interesting blur becomes a trace that can be analyzed.

ABOVE: A 5000-cycle trace, made at a film speed duplicating that of the noise record as closely as possible. There are 13 cycles per inch, *i.e.*, 32 feet per second, just under the maximum-rated speed of the new camera

CONDITIONS

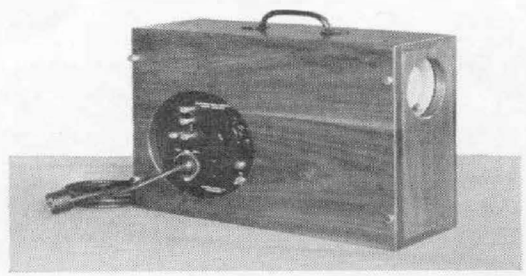
CLASS 528 Cathode-Ray Oscillograph Assembly with a TYPE 528-B Tube. Accelerating potential, 3000 volts. Lens aperture, *f*/2.5. Emulsion, Eastman No. 697 Recording Paper. Ratio between length of trace on oscillograph screen and image on film, 5 to 1

A COMPARISON BETWEEN CA

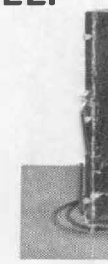
CHARACTERISTICS OF EACH OF THE THR

Showing differences between Slo. cre

TYPE 635-B ELECTRON OSCILLOGRAPH



TYPE
OSCILL
SWEEP

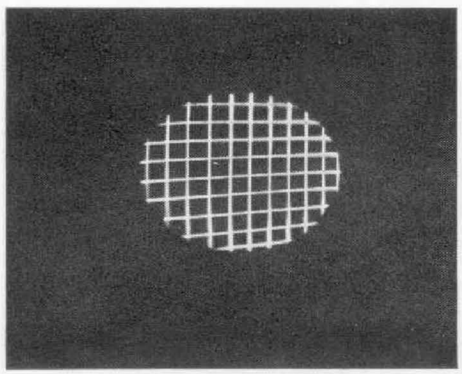


VOLTAGE SENSITIVITY and RELATIVE SCREEN DIAMETER

Traces spaced 25 d-c volts apart. Both Fast and Slow-Screens have the same voltage sensitivity.

Photographs ¼ Actual Size

ACCELERATING VOLTAGE FIXED AT 1000 V



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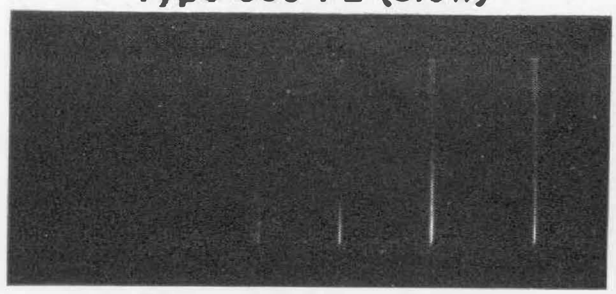
RELATIVE PHOTOGRAPHIC BRILLIANCE

Each photograph shows 6 successive snapshots of a trace from a linear sweep circuit for which only the camera-diaphragm opening was changed. The *f* number for each exposure is given beneath each line.

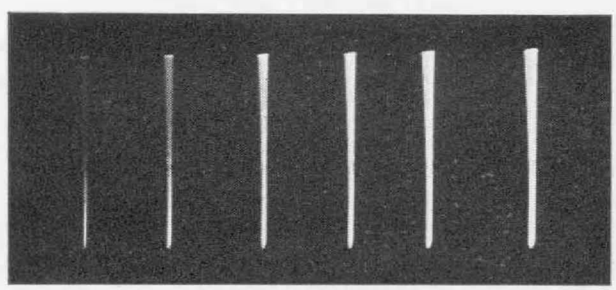
The length of trace, sweep frequency, shutter speed, and emulsion were the same for all exposures.

Note the greater actinic power of the fast-screen tubes. See table, page 7.

Type 635-P2 (Slow)



Type 635-P3 (Fast)



f/22 f/16 f/11 f/8 f/5.6 f/4.5

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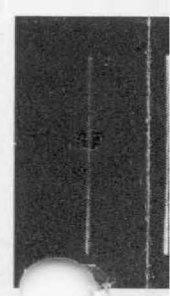


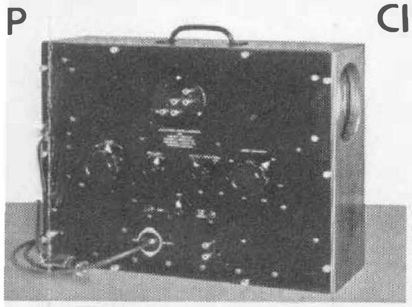
22 f/

ATHODE-RAY OSCILLOGRAPHS

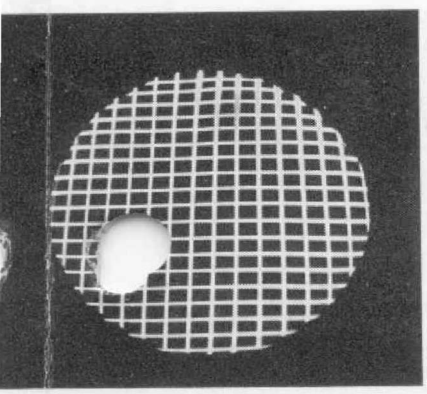
HREE GENERAL RADIO OSCILLOGRAPHS

cree   nd Fast-Screen Tube Equipment

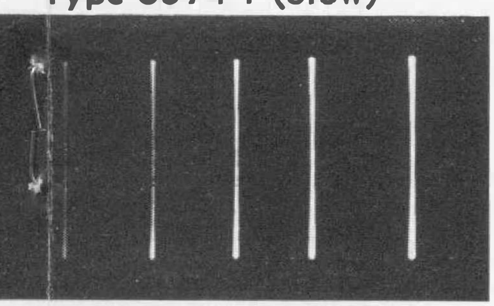
YPE 687-A ELECTRON
ILLOGRAPH and BEDELL
P   CIRCUIT



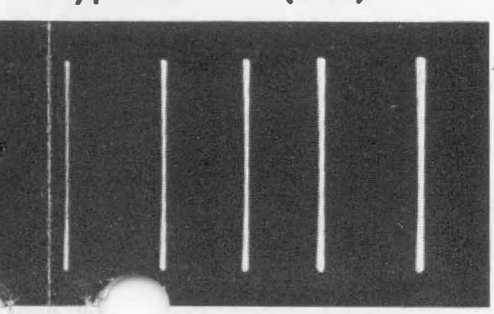
CELERATING VOLTAGE
FIXED AT 1500 V



Type 687-P1 (Slow)

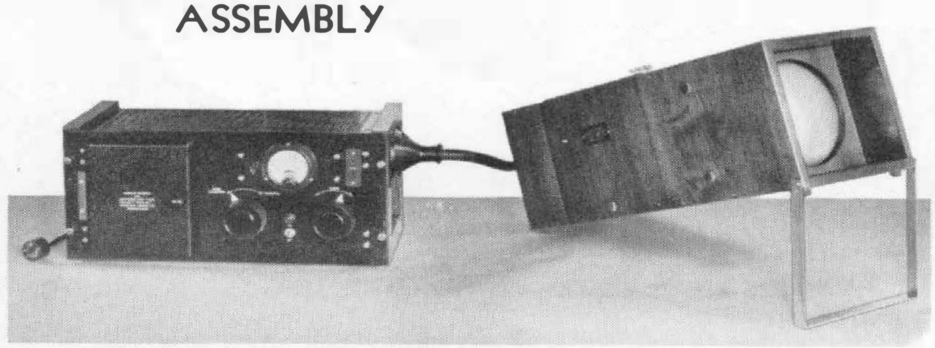


Type 687-P2 (Fast)



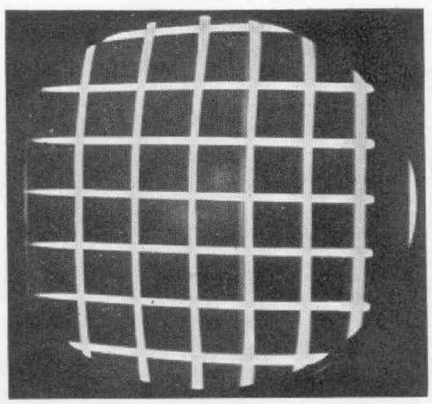
22 f/1   /11   f/8   f/5.6   f/4.5

CLASS 528 CATHODE-RAY OSCILLOGRAPH
ASSEMBLY

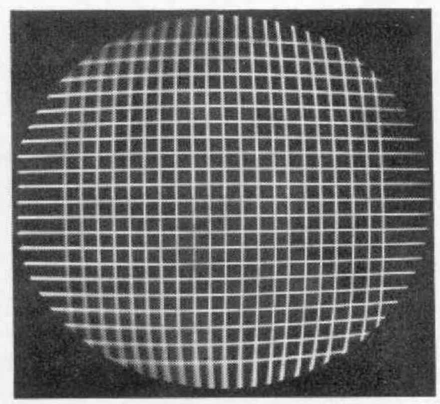


ACCELERATING VOLTAGE ADJUSTABLE

1000 V

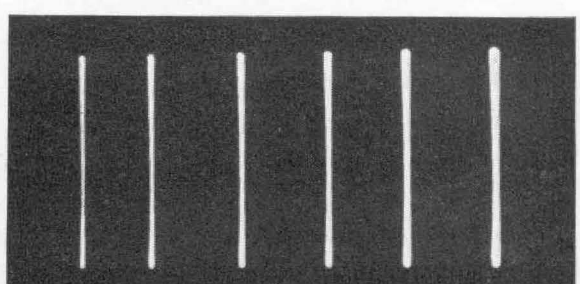


3000 V



Slow-Screen Tubes
No Longer Available
for This Oscillograph

Type 528-B (Fast) - (3000 V)



f/22   f/16   f/11   f/8   f/5.6   f/4.5

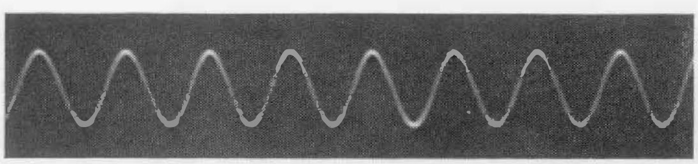
FAST-SCREEN versus SLOW-SCREEN TUBES

SINCE, for many readers, the data presented in the preceding two pages may be the first notice that not all tube-screens have the same characteristics, the essential difference between what we called "fast screens" and "slow screens" must be pointed out.

If one were to make a visual comparison in the same oscillograph between a fast-screen tube and a similar slow-screen tube he would notice first that the slow-screen tube produced a green pattern that appeared to be somewhat brighter than the blue pattern of the fast-screen tube. Then, if he were to compare photographic brilliancy using a camera loaded with verichrome or super-sensitive panchromatic film, he would find the fast-screen trace noticeably more actinic.

Another difference, extremely important in many high-frequency measurement applications of the cathode-ray oscillograph, appears when one attempts to take photographs with a moving-film camera. The accompanying photographs show what happened when a line on the screen produced by a 60-cycle applied voltage was spread out by swinging the camera on a pivot. The fast-screen trace is clear and sharp, but the slow-screen trace is blurred and foggy, due to the fact that in a slow-screen tube the fluorescence at any given point persists for an appreciable time after the electron beam exciting it has moved on. Where, in a fast-screen tube, fluorescence disappears in less than 25 microseconds, fluoroescence in a slow-screen tube persists for as much as 2000 times as long. The effect is very noticeable when resolving a 60-cycle trace, and it becomes increasingly bothersome as the frequency increases.

For most work around the laboratory, especially where photography is contemplated, the fast-screen tube is recommended. Its visual brilliancy, though less than the slow-screen tube, is nevertheless satisfactory for all ordinary purposes. Only when the brightest possible patterns are required (as in lecture-room demonstrations) or when persistence is an asset (as in viewing patterns with a sweep circuit adjusted for a very slow sweeping rate) should the slow-screen tube be purchased. A fast-screen tube is absolutely essential when photographs are being taken with the new CLASS 651-A-E Camera Assembly.



Spread-out traces from a 60-cycle voltage obtained by swinging the camera on a pivot. Fast-screen tube on the left, slow-screen tube on the right. Note the absence of blur in the fast-screen trace

FAST-SCREEN TUBES NOW STANDARD EQUIPMENT ON ALL GR OSCILLOGRAPHS — PRICE CHANGES

BECAUSE of the wider range of usefulness it affords the laboratory, all General Radio electron oscillographs are now supplied with fast-screen tubes unless specific instructions to the contrary accompany the order. Slow-speed tubes for the Class 528 Cathode-Ray Oscillograph Assembly are no longer available.

In order to determine the price of an oscillograph with a slow-screen tube, add the *replacement* price of the slow-screen tube to the price for the complete oscillograph and credit the *replacement* price of the corresponding fast-screen tube.

The following prices are now in effect:

TYPE 635-B Electron Oscillograph (with fast-screen tube) $82.00
TYPE 687-A Electron Oscillograph and Bedell Sweep Circuit (with fast-screen tube) . $184.00
*CLASS 528 Cathode-Ray Oscillograph Assembly (with fast-screen tube) $293.50

REPLACEMENT TUBES FOR CATHODE-RAY OSCILLOGRAPHS

For TYPE 635-B Electron Oscillograph

Type		*Code Word*	*Price*
635-P2	Slow-Screen Tube	CUMIN	$18.00
635-P3	Fast-Screen Tube	CUDDY	20.00

For TYPE 687-A Electron Oscillograph and Bedell Sweep Circuit

Type		*Code Word*	*Price*
687-P1	Slow-Screen Tube	ACCESSOBOY	$40.00
687-P2	Fast-Screen Tube	ACCESSOCAT	44.00

For CLASS 528 Cathode-Ray Oscillograph Assembly

Type		*Code Word*	*Price*
*528-B	Fast-Screen Tube	CAMEL	$78.50

*Fast-screen tubes only are available for this oscillograph assembly.

PERFORMANCE SPECIFICATIONS FOR CATHODE-RAY TUBES

(Based on Experimental Data Like That Shown on Pages 4 and 5)

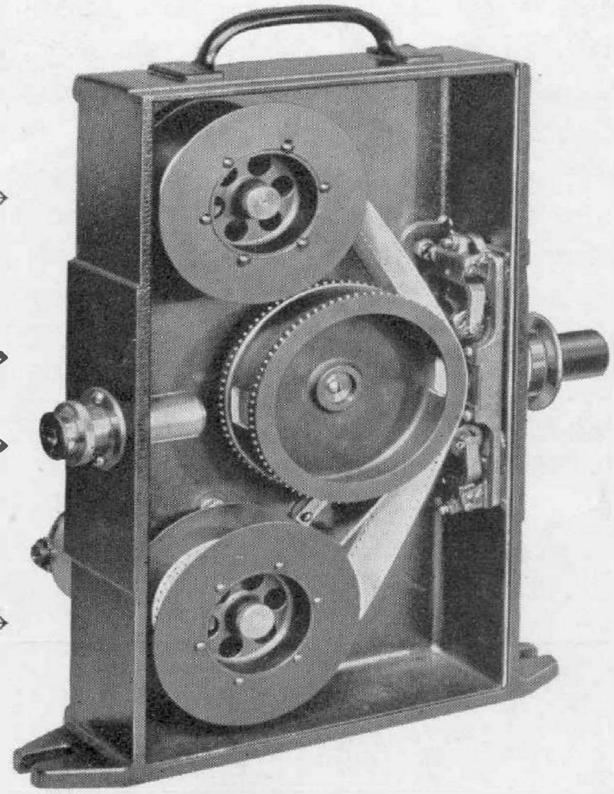
Type	*Screen Diam.*	*Fast or Slow*	*Accelerating Voltage*	*D-C Voltage Sensitivity**	*Maximum Spot Speed†*
635-P2	3 in.	Slow	1000 v	0.013 in/v	4,100 in/sec
635-P3	3 in.	Fast			11,000 in/sec
687-P1	5 in.	Slow	1500 v	0.012 in/v	6,400 in/sec
687-P2	5 in.	Fast			16,000 in/sec
528-B	7 in.	Fast	3000 v	0.0087 in/v	50,000 in/sec
			1000 v	0.0026 in/v	. . . .
			500 v	0.0013 in/v	300 in/sec

*Average for both pairs of plates.

†These values are maximum workable spot speeds S for Verichrome film, on the basis of a hypothetical aperture $f/1.0$ and with the screen at infinite distance from the lens. The maximum speed S' for any other aperture f/N and a ratio k between length of trace on screen and on the camera plate is: $S' = \dfrac{S}{N^2\left(\dfrac{1+k}{k}\right)^2}$.

A NEW MOVING-FILM CAMERA

(*Continued from page 2*)



The camera with the slide removed to show how the film is threaded. Driving sprocket and take-up reel are each driven by separate motors. The camera is focused by viewing the object through the focusing eyepiece when the two apertures in the driving sprocket are aligned as shown. The image forms on a small piece of translucent film inserted in the gate

Film speeds may be adjusted by controlling the voltages applied to both motors simultaneously. For this purpose, the TYPE 100-L Variac is to be recommended when alternating current is used. At 110 volts, a film speed of approximately 15 feet per second is obtained.

Increasing the voltage momentarily to 230 volts gives a speed of 35 feet per second. Decreasing the voltage to 65 volts gives a speed of about 1 foot per second.

For film speeds under about 5 feet per second, a full magazine may be used and the camera started and stopped as often as required.

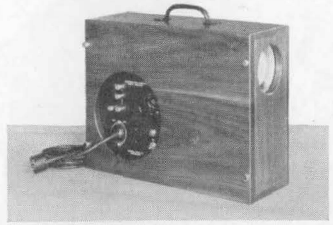
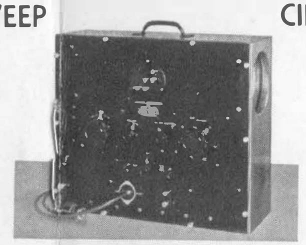
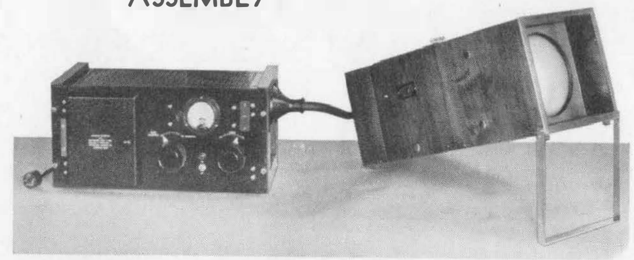
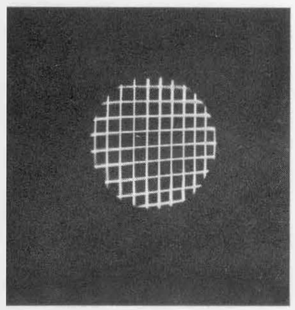
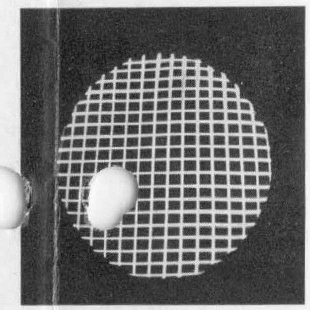
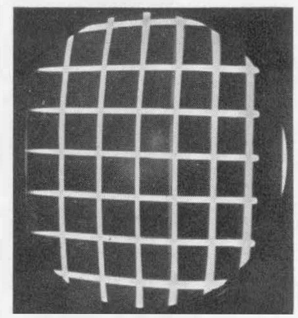
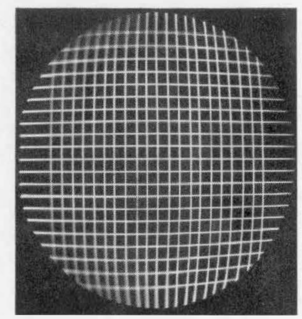
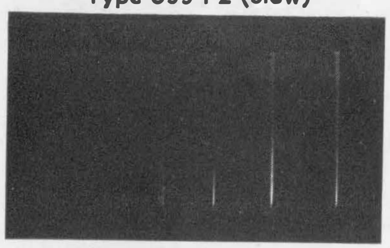
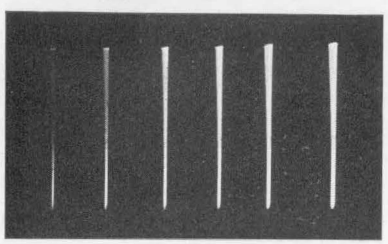
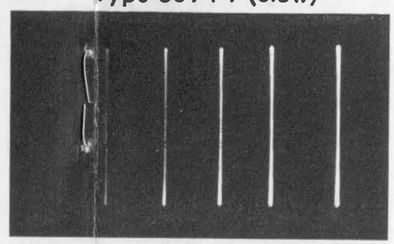
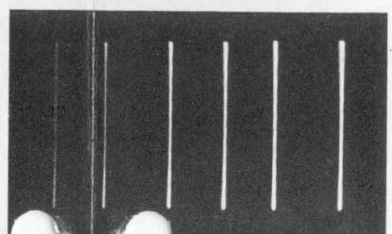
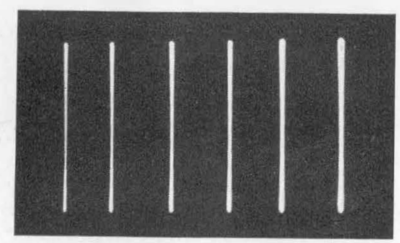
The camera is daylight loading if the film or paper has a length of black "leader" for threading. In high-speed camera work, however, leaders are seldom required because less film is lost in loading than is lost in getting up to speed. —HORATIO W. LAMSON

CLASS 651-A-E Camera Assembly, complete with *f*/2.5, adjustable-focus lens and two motors as illustrated on page 1: *Price*, \$495.00; *Code Word*, DINER.

A COMPARISON BETWEEN CATHODE-RAY OSCILLOGRAPHS

CHARACTERISTICS OF EACH OF THE THREE GENERAL RADIO OSCILLOGRAPHS

Showing differences between Slow-Screen and Fast-Screen Tube Equipment

	TYPE 635-B ELECTRON OSCILLOGRAPH	TYPE 687-A ELECTRON OSCILLOGRAPH and BEDELL SWEEP CIRCUIT	CLASS 528 CATHODE-RAY OSCILLOGRAPH ASSEMBLY
			
VOLTAGE SENSITIVITY and RELATIVE SCREEN DIAMETER Traces spaced 25 d-c volts apart. Both Fast and Slow-Screens have the same voltage sensitivity. *Photographs ¼ Actual Size*	ACCELERATING VOLTAGE FIXED AT 1000 V 	ACCELERATING VOLTAGE FIXED AT 1500 V 	ACCELERATING VOLTAGE ADJUSTABLE 1000 V  3000 V 
RELATIVE PHOTOGRAPHIC BRILLIANCE Each photograph shows 6 successive snapshots of a trace from a linear sweep circuit for which only the camera-diaphragm opening was changed. The *f* number for each exposure is given beneath each line. The length of trace, sweep frequency, shutter speed, and emulsion were the same for all exposures. Note the greater actinic power of the fast-screen tubes. See table, page 7.	Type 635-P2 (Slow)  Type 635-P3 (Fast)  f/22 f/16 f/11 f/8 f/5.6 f/4.5	Type 687-P1 (Slow)  Type 687-P2 (Fast)  f/22 f/16 f/11 f/8 f/5.6 f/4.5	Slow-Screen Tubes No Longer Available for This Oscillograph Type 528-B (Fast) - (3000 V)  f/22 f/16 f/11 f/8 f/5.6 f/4.5