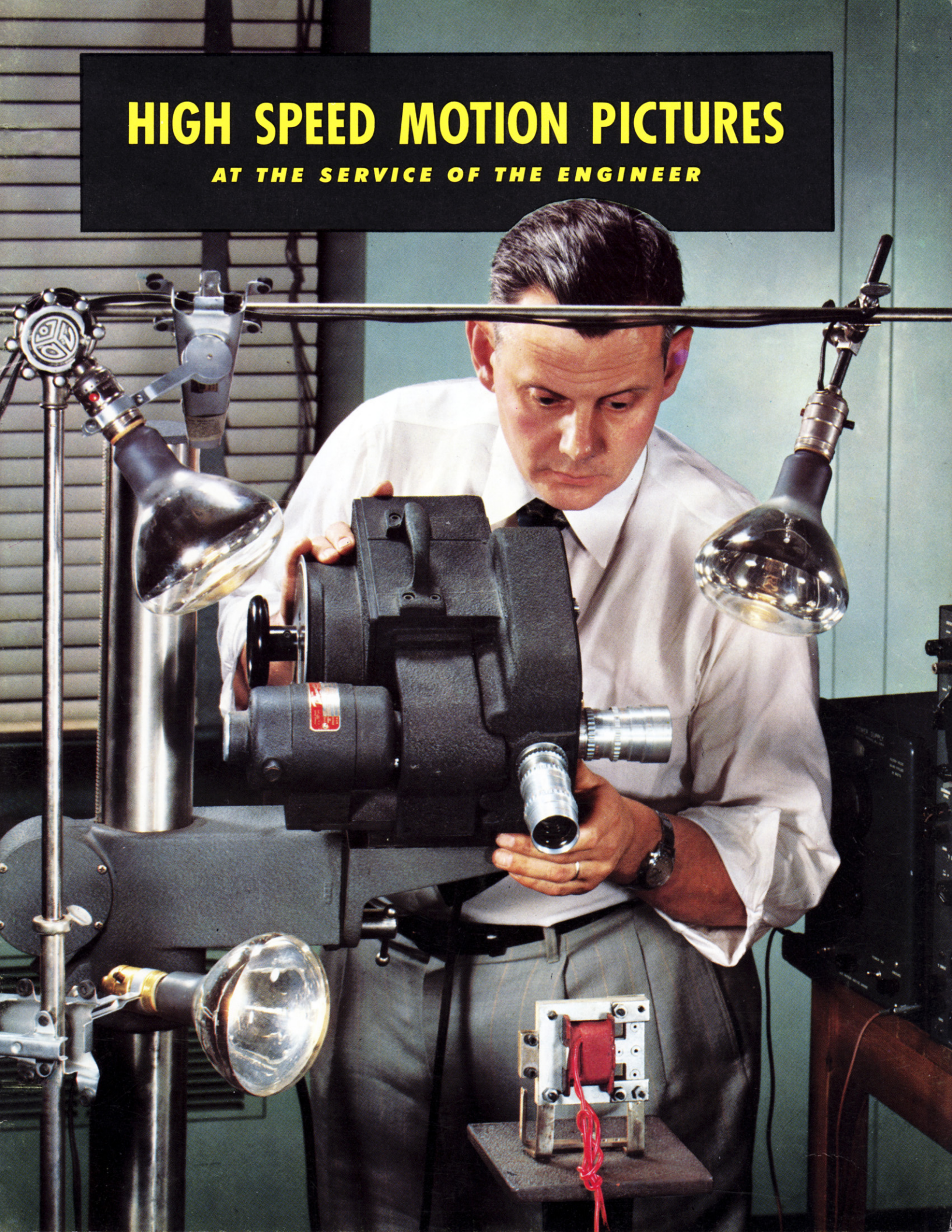
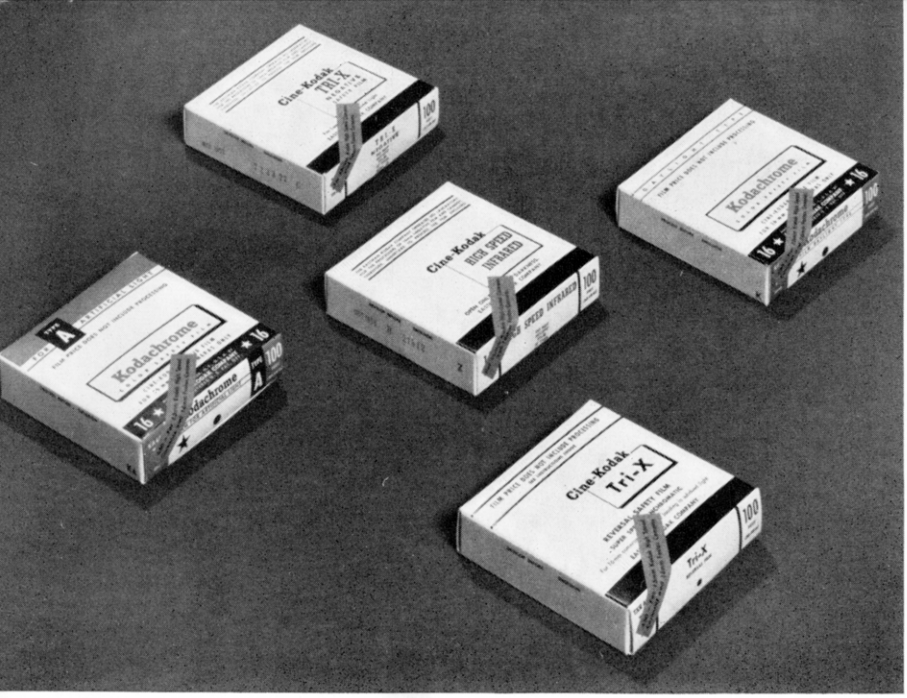
HIGH SPEED MOTION PICTURES

AT THE SERVICE OF THE ENGINEER





Film for High Speed Movies

● New advances in film sensitivity extend the scope of high speed movies

IN 1877 Eadweard Muybridge loaded 24 cameras with wet plates to settle the question of whether a galloping horse ever had all four hoofs off the ground simultaneously. The answer came out "yes." More important, the project led to the invention of movies in general and, in particular, to the use of movies for the analysis of events too fast for the eye to perceive.

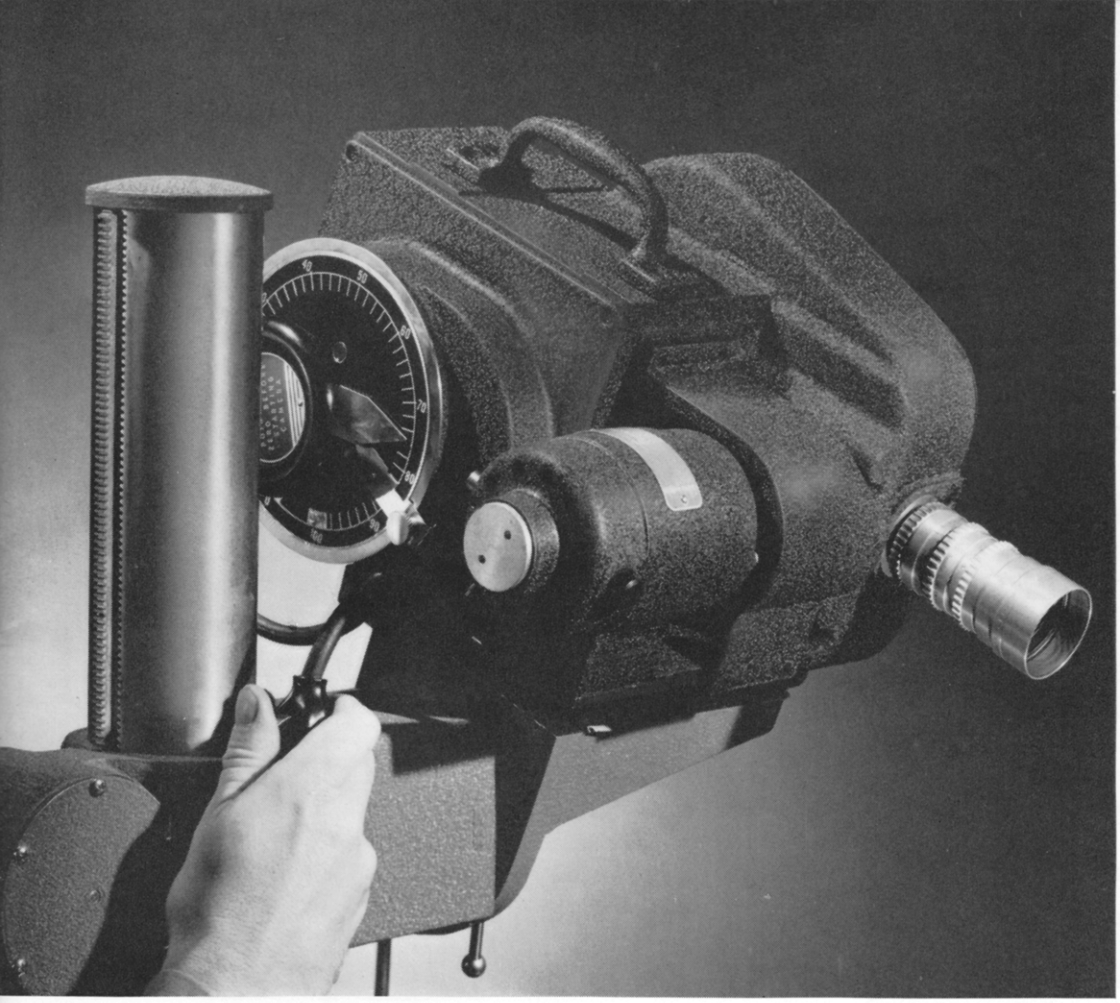
The very lingo of photography, in which "speed" is equated with sensitivity, attests to the continual striving for materials capable of recording an image as quickly as possible. The "faster" the film, the less the problems of lighting and optical limitations in photographing rapid events. For a long time, however, it has been an accepted fact of physics that as film speed is pushed upward, film granularity inevitably goes up with it. There comes a point beyond which the sacrifice in image clarity becomes—for most practical purposes—intolerable.

In the summer of 1953, Kodak announced a new breakthrough in the long battle to advance the point of feasible compromise between speed and granularity. The motion picture film version of this discovery is *Cine-Kodak Tri-X Film*. With respect to granularity, it is as good as, or perhaps somewhat better than, what had been the practical working standard in black-and-white movies for two decades. In "speed" it represents a tremendous gain, difficult to convey meaningfully in numbers because of new latitude characteristics that tend to undermine the reality of older conceptions of propriety in photographic exposure. To those who see with the eyes of engineers and in viewing high speed movies are concerned only with the informational content, *Cine-Kodak Tri-X Film*, given many times less than ideal exposure, can still deliver a most telling story. This is a precious attribute in film for high speed cameras—particularly those designed for such prodigious tasks in the region of microseconds (and less) that they need every bit of margin they can get. Film which allows great flexibility in illumination and aperture is a big help.

There are two types of this new film: for quick processing and early viewing, *Cine-Kodak Tri-X Negative Film*, from which prints can later be made if needed; *Cine-Kodak Tri-X Reversal Film*, which the user or a commercial laboratory processes to a positive.

Kodak also makes *Cine-Kodak High Speed Infrared Film* for motion picture photography of phenomena two ways invisible—too fast and too long in wavelength for the eye. On the other hand, high speed movie cameras are now very often loaded with *Kodachrome Film* to take advantage of the added information capacity conferred by the sensitivity of the human eye to delicate color differences. There is even a special duplicating type, *Commercial Kodachrome Film*, useful when the purpose of the high speed movies is to sell an idea by circulating numerous prints from the original footage.

For the rigorous requirements of high speed cameras, only film bearing a special red sticker on the carton should be used. This signifies that film and spool have been held to special tolerances. All the films mentioned above can be so obtained.



The Kodak High Speed Camera

• It slows down action up to 200 times

OF all the brilliantly engineered high speed movie cameras that have appeared over the years, the Kodak High Speed Camera has established its position with those more interested in slowing down industrially important mechanical action for observation than in pursuing the technique of high speed photography for its own sake.

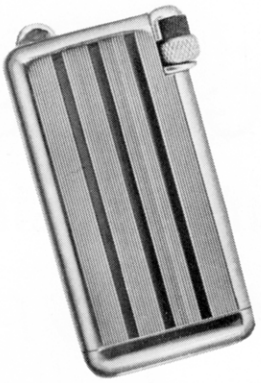
This camera has been adopted by a great many industrial plant photographers as part of their stock of working equipment. In other plants, the Kodak High Speed Camera is assigned to the engineering department on the valid principle that it requires no extensive photographic experience for successful use.

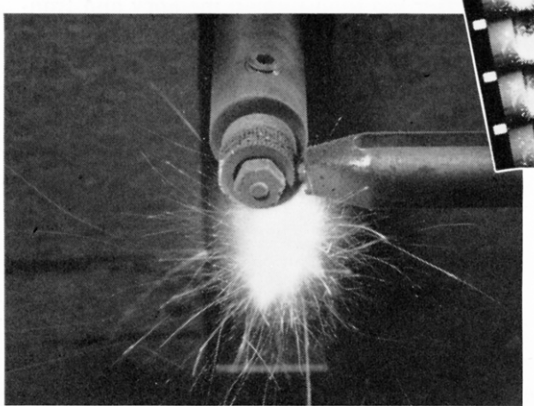
It is a simple, self-contained mechanism with few moving parts. When the switch is squeezed, the camera exposes some 4,000 individual pictures in sequence on a 100-foot roll of the familiar 16mm film—at any chosen rate from 1000 to 3200 pictures per second. At this speed range, which is right for most work in machine design and testing, it is still possible to maintain the picture sharpness for which the Kodak High Speed Camera is noted. (Excessive speed makes difficulty in catching the action of main interest without wasting film.)

The successive slices of time become a permanent record for measurement, analysis, and repeated study —in quiet concentration or in a discussion with diverse viewpoints trained on the fine details as they pass greatly enlarged across the projection screen at 16 to the second. One watches the actual dynamic operating conditions—which beats uncertain approximations from theory. Trouble spots and inefficiencies are spotted in advance, and their causes in flexure, inertia, and waste motion are made obvious to all who watch.

The Kodak High Speed Camera can be supplied with a second lens on the side. As pictured on the front cover of this booklet, it can put a continuous cathode-ray oscillograph record of electrical events on the same film, superimposed and self-synchronized with the picture of mechanical action.

Parker Pen Company *develops a more efficient lighter mechanism*





Above: Ready to film sparks produced by spark wheel testing machine. Note photo-electric cell, which has been adjusted to record only sparks of minimum acceptable intensity. *Below:* Close-up of sparking action. Speed of acceleration and rotation of spark wheel can be adjusted as desired.

TO light a cigarette seems like a simple matter. But to design an effective and dependable cigarette lighter is not as easy as it would first appear.

In producing the new butane-fueled Flaminaire Lighter, engineers and physicists of the Parker Pen Company, Janesville, Wisconsin, were confronted with the problem of obtaining the highest possible degree of ignition efficiency and dependability.

In evaluating the basic performance problems, the following facts were pertinent: (a) Combustion is dependent on the ignition qualities of compressed butane fuel—the butane gas being more difficult to ignite than benzene. Furthermore, the expansion of the gas when it is released creates a cooling effect which reduces the temperature of the spark. (b) Analysis of the sparking mechanism disclosed that several interdependent factors contribute to proper sparking action.

This much was known, but the relative importance of these various factors had to be determined before a logical approach toward an improvement could be undertaken.

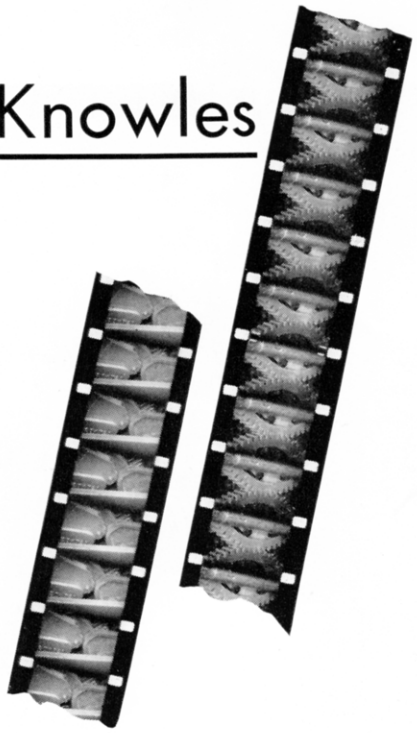
At this point, the Kodak High Speed Camera was introduced into the study to determine just what takes place in that split second as the spark wheel revolves against the flint. The Kodak High Speed Camera was also used to correlate the various factors influential in the over-all functioning of the lighter mechanism.

As a result of these studies, it was found that, for effective operating efficiency, definite relationships must be maintained in positioning of the flint, spark wheel, and gas jet. Other factors involved were: 1) spark wheel structure, 2) spark wheel velocity, 3) flint composition. By correlating these various factors, it was possible to increase the over-all efficiency of the ignition and spark-actuating functions of the lighter.

The scientific knowledge that ultimately emerged from these studies has been contributory to the outstanding dependability and wide acceptance of this new product of the Parker Pen Company.

Crompton & Knowles

improves a narrow fabric loom



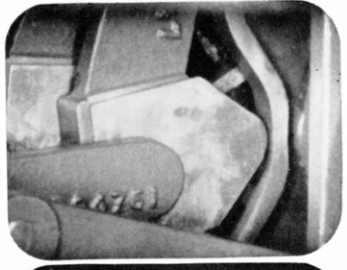
ENGINEERS at Crompton & Knowles Loom Works, Worcester, Mass., wanted to be sure that the various mechanisms incorporated into the pilot model of their narrow fabric loom operated as intended. So the Kodak High Speed Camera was called upon to study the operation of the loom in order to be sure that units in service would not require frequent attention and maintenance, repair, and down-time costs could be kept to the minimum.

Particular attention was paid to the harness motion, involving top and bottom cams that pulled the harness frames up and down. It was observed that backlash and torsion were preventing exact synchronization of the top and bottom cams. Furthermore, it was noted that at the point of greatest load the cams actually stopped, then jumped forward again.

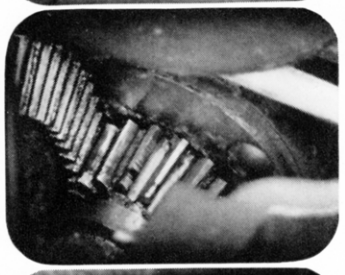
In the bevel gear drive to the vertical shaft, also, it was seen that meshing of the gear teeth was erratic. At the upper end of the vertical shaft, the gears, which should have been operating at a constant and uniform speed, were observed to stop and then jump ahead due to the torsion in the shaft.

Using the information obtained with the Kodak High Speed Camera, Crompton & Knowles engineers developed a new design. They eliminated the vertical shaft. Then they introduced an intermediate spur gear to drive spur gears on the top and bottom cam shafts, respectively, which eliminated the multiplication of backlash inherent in the old motion.

Again the Kodak High Speed Camera was called on, this time to check the new design in operation. Resulting films showed the cams operating smoothly, with the cam roll always in contact and all gears running at uniform speeds, without hesitation and with even meshing of teeth—assurance that the loom could be counted on for dependable, trouble-free operation under conditions of actual service.

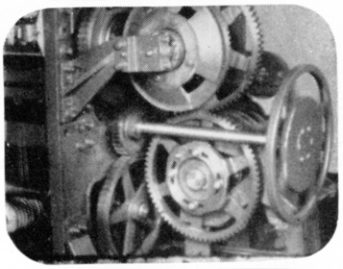


1 Camera reveals bouncing, hesitation in top and bottom cams.

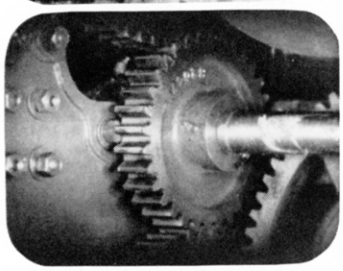


2 Bevel gear drive from bottom shaft (source of power) OK.

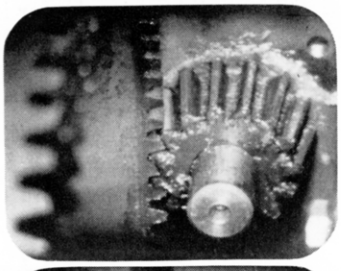
3 Bevel gears on vertical shaft hesitate, mesh erratically.



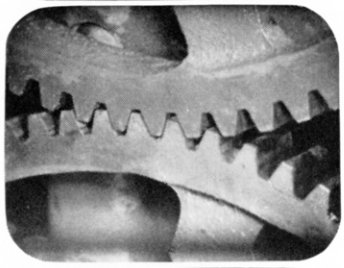
4 New design eliminates vertical shaft. Intermediate gear is added.



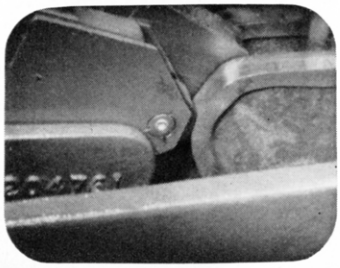
5 Spur gear drive from crank shaft meshes smoothly with step gear.



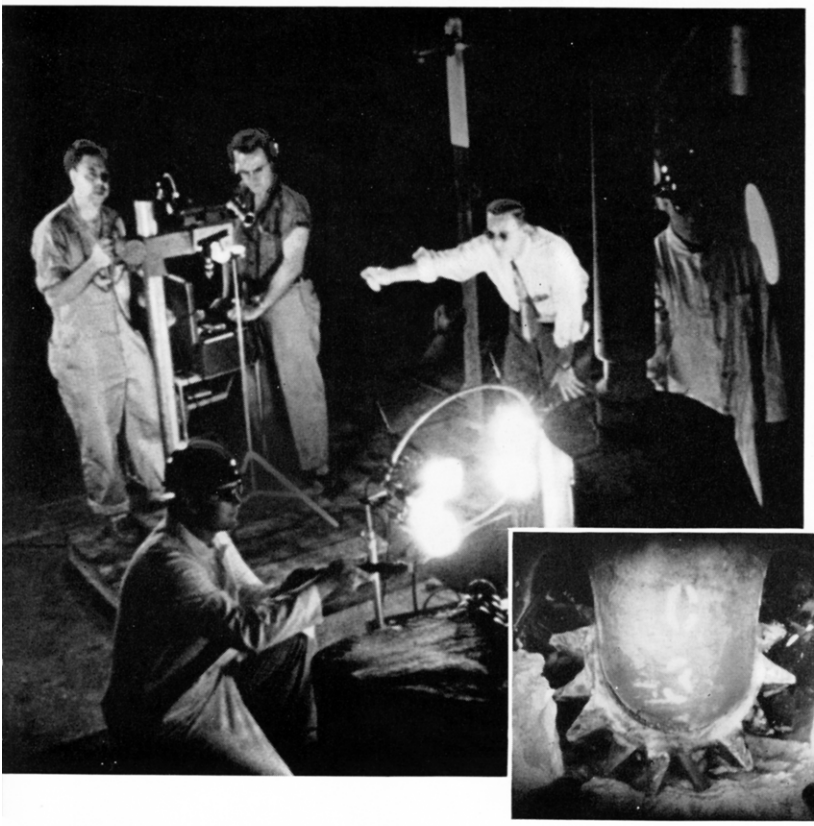
6 Bevel gear drive from step gear shaft also operates well.

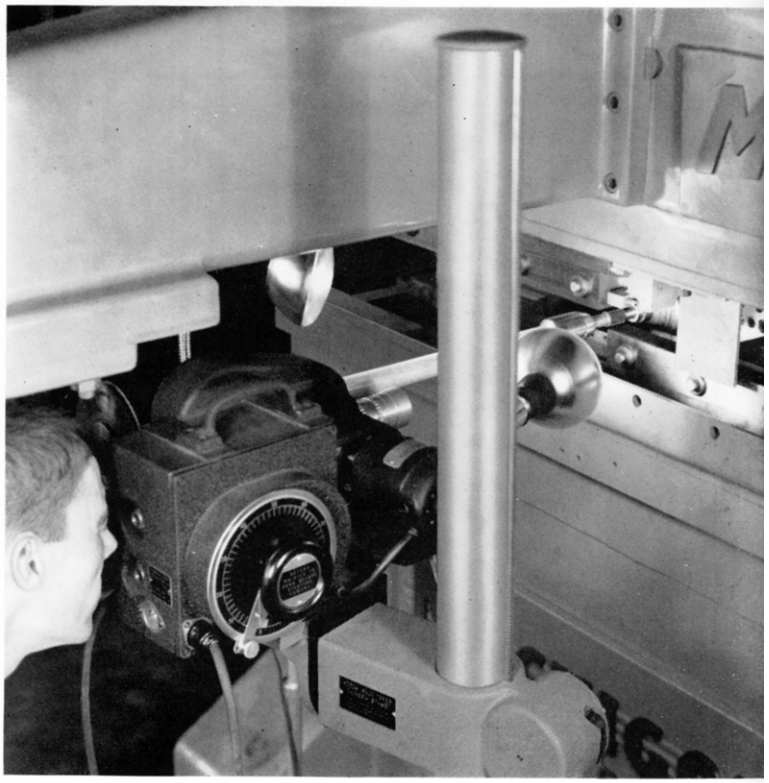


7 Intermediate spur gear drives cam shafts smoothly, uniformly.



8 Now no bouncing or jerky motion in top and bottom cams.





Hughes Tool Company and Michigan Tool Company

make entirely different kinds of tools but use the same means to demonstrate them

EACH is a leader in its field. Only an accident of name associates them. That and a common problem which each has solved with high speed movies.

Hughes Tool Company of Houston makes rotary rock bits that drill formations from the earth's surface to depths exceeding 20,000 feet according to a principle developed by Howard R. Hughes, Sr. in 1909. Michigan Tool Company of Detroit makes the revolutionary "Roto Flo" machine tools that form splines by flowing metal between two serrated racks without removing metal. For either company actually to demonstrate the unique action of its products would be no casual undertaking, even if the action were not too fast for human eyes to see.

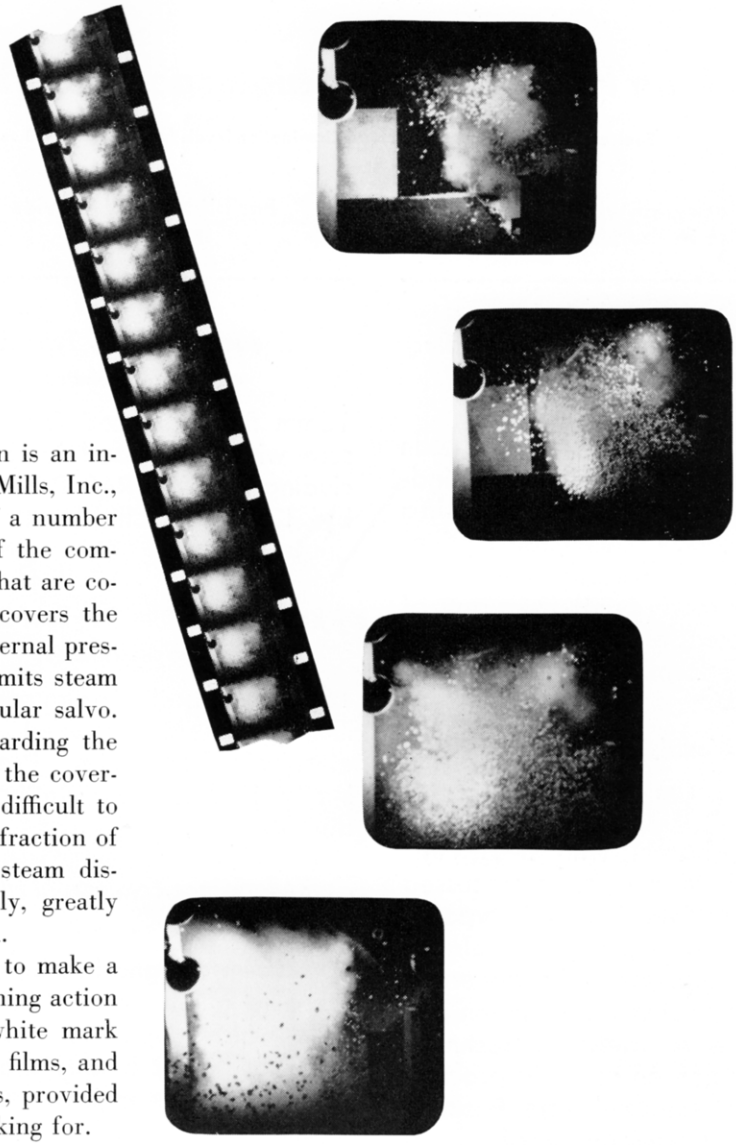
Hughes has in circulation among oil-well-drilling groups 14 prints of a movie consisting of Kodak High Speed Camera footage combined with narrative and normal-speed orienting sequences.

At 2,000 frames/sec., well below the camera's top speed, the Hughes film shows how the rock bit teeth bite into the formation, the effect of tooth structure and other design features on drilling efficiency. This film makes possible a better understanding as to what occurs deep underground when a well is being drilled.

Michigan Tool undertook their high speed photography with a similar purpose. But what the company's own engineers saw on the screen yielded a new insight into the process by which splines are formed in racks. There is something infectious about this deeper understanding that quickly gets to a sales prospect's mind too. When he sees *why* a piece of S.A.E. 1037 steel can be rolled into a splined shaft in 3 seconds, he is well along toward convincing himself that he needs the machine.

General Mills

Takes a look at puffing-gun action



PROCESSING cereals in a food-puffing gun is an ingenious technique that is used by General Mills, Inc., Minneapolis, Minn., in the manufacture of a number of its products. Developed by engineers of the company, this gun possesses a set of controls that are coordinated with the action of the lid that covers the gun's "muzzle." As the lid opens under internal pressure, a firing action is produced which permits steam and cereal particles to escape in a spectacular salvo.

In designing the gun controls, data regarding the exact action of the lid and the duration of the cover-opening event were required, yet seemed difficult to obtain since the action took place in a tiny fraction of a second. Furthermore, the product and steam discharged obscured the cover almost entirely, greatly hindering direct observation by any method.

Despite these handicaps, it was possible to make a high speed motion picture of the cover-opening action with the Kodak High Speed Camera. A white mark painted on the lid could be observed in the films, and its position, plotted at millisecond intervals, provided the design data the engineers had been looking for.

Hundreds of other companies, too, have found the KODAK HIGH SPEED CAMERA a valuable engineering and research tool—here are just a few:

- Eureka-Williams Corp., Bloomington, Ill., has used it to eliminate excessive wear on a vacuum cleaner drive belt.
- Royal Typewriter Co., New York, N. Y., has used it to save valuable time in typewriter development.
- Baldwin-Lima-Hamilton, Philadelphia, Pa., has used it to improve valve performance in a diesel locomotive engine.
- Allis-Chalmers Corp., Milwaukee, Wisc., has used it at its Boston Works to study contacts in an oil-filled, high-voltage circuit breaker.
- Thompson Products, Euclid, Ohio, has used it to check manufactured parts under test conditions.
- Addressograph-Multigraph Corp., Cleveland, Ohio, has used it in developing, engineering, and testing their products.
- Batelle Memorial Institute, Columbus, Ohio, has used it to study cleaning trash from cotton, making shot, flow of fluids in molds, simultaneous reading of meters, making glass wool.
- Mall Tool Co., Chicago, Ill., has used it to study performance of impact wrenches.
- Champion Paper & Fiber Co., Hamilton, Ohio, has used it to study formation of a sheet of paper from a pulp suspension . . . and to investigate mechanical problems connected with laboratory and mill machinery.
- Northrop Aircraft, Inc., Hawthorne, California, has used it to follow movement of rocket sleds traveling at supersonic speeds on a 2000-foot track.
- Lincoln Electric Co., Cleveland, Ohio, has used it to study arc-welding operations.
- Armstrong Cork Co., Lancaster, Pa., has used it to study action of automatic printing and screw-cap-making machines . . . and the effects of impact and tensile stresses on various materials.

DATA *on Kodak films for high speed motion pictures*

Footcandle values given are typical illumination levels for f/2, 1/16,000 sec, 3200 frames/sec with Kodak High Speed Camera

For black-and-white high speed movies in the visible spectrum

Cine-Kodak Tri-X Negative Film

3200 footcandles

16mm film that the user can process. Usually done in rewind-type 16mm film-processing equipment. Commercial motion-picture laboratories can make one or more prints from any of the footage to be viewed in positive form.

Cine-Kodak Tri-X Reversal Film

5000 footcandles

Same 16mm film that runs through the camera is processed to a positive. Since this type of processing requires more elaborate equipment, it is generally done by commercial motion-picture laboratories. Full technical information on reversal processing is available from Eastman Kodak Company, Professional Motion Picture Film Division, Rochester 4, N. Y.

Kodak Tri-X Negative Film

3200 footcandles

For 35mm "Fastax" and other 35mm high speed motion picture cameras.

For high speed movies in full color

Kodachrome Film, Type A

40,000 footcandles

16mm film balanced for exposure with photoflood lamps, including G. E. 750R40. Processing by Kodak available through dealers.

Kodachrome Film, Daylight Type

65,000 footcandles

16mm film better balanced for illumination synchronized from electronic flash lamps. Processing by Kodak available through dealers.

Kodachrome Commercial Film

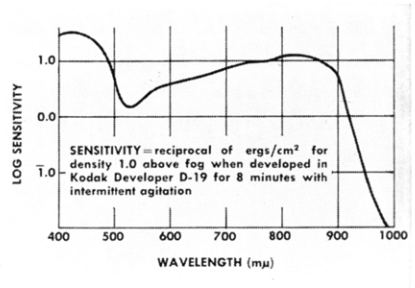
40,000 footcandles

16mm film designed to be processed to a low-contrast original from which duplicates can be made of higher quality than by duplication of regular Kodachrome Film. Balanced for 3200K lights. Processing by Kodak available. Printing of duplicates is done by commercial motion-picture laboratories.

For high speed movies by infrared radiation

Cine-Kodak High Speed Infrared Film

16mm film with spectral sensitivity of which the following curve is typical:



Kodak Wratten Filters can be used to block visible radiation. Undeveloped film should be stored below 50F. Loading must be done in total darkness. Exposure level and development conditions determined by trial. A motion-picture laboratory can supply a positive print if needed.

Kodak High Speed Infrared Film

Same emulsion spooled for 35mm "Fastax" and other 35mm high speed motion picture cameras.

• All 16mm film tabulated here is available in 100-, 200-, and 400-ft lengths (and longer lengths in some instances) *spooled for high speed camera use.* Orders should be so designated. For lengths available in 35mm film spooled for high speed cameras, write Eastman Kodak Company, Professional Goods Sales Division, Rochester 4, N. Y.

The Kodak High Speed Camera *—how it works*

In an ordinary motion-picture camera the film is stopped and started for each frame, but intermittent motion is not feasible at speeds above 250 frames per second. In the Kodak High Speed Camera the optical image moves with the continuously traveling film, being held on it long enough to expose the emulsion. This is achieved by rotating an accurately plane-parallel glass plate of precise thickness behind the lens. Diagrams below show how light rays are thus swept in pace with the film for each frame.

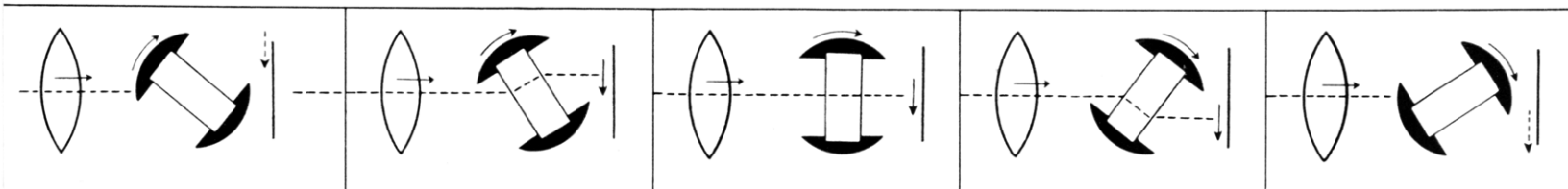
1. Steel housing acts as framer and shutter to block light until incidence angle becomes small.

2. Refraction displaces image upward.

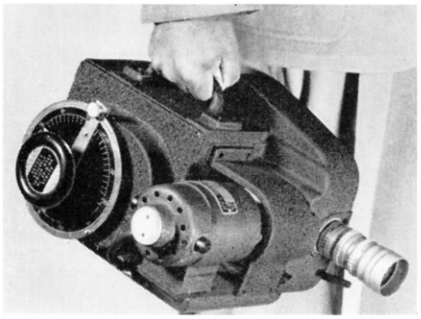
3. As plate rotates, displacement passes through zero.

4. Image is displaced downward.

5. Before incidence angle becomes great enough to deteriorate optical image quality seriously, housing cuts off light.

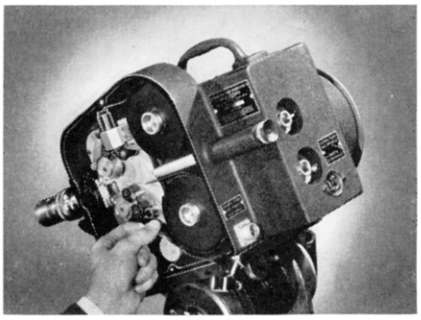


FACTS *about the Kodak High Speed Camera*



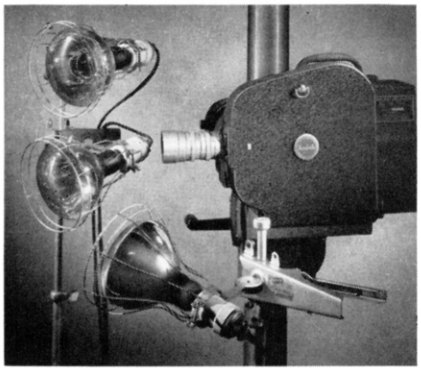
◀ **Portable, self-contained.** Weighs 32 pounds, 17 inches long. Requires only lights and a stand to operate. Camera draws 30 amps to start, 18 amps to run. Plugs into any 115-v line, a-c or d-c.

Easy to focus, load. Lens is focused by watching image on strip of frosted dummy film through magnifying eyepiece on back of camera. Then real film is threaded through, as in home movie projector. ▶

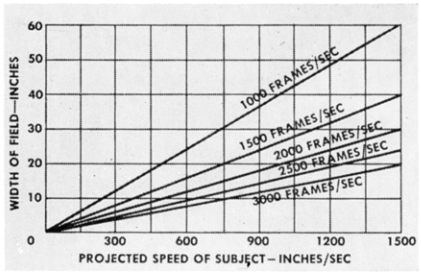


Speed selection. Speed is determined by voltage applied to motor through mechanically coupled rheostat. This gradually reduces series resistance until a stop is reached that has been set by the operator. When full 115 volts are available at the outlet, 1000 frames/sec is attained within the first five feet of film, 2000 frames/sec after 15 feet, 2500 frames/sec after 25 feet, etc. Camera speed at any point can be read from timing marks exposed on the film edge by an internal argon lamp. Fed 60-cycle ac, it makes 120 marks a second, or other frequencies may be used.

Convenient synchronization. By plugging into receptacle in rear of camera, external circuit can be momentarily opened or closed at any point in camera run, as selected by dial. With heat-sensitive subjects, this feature can be used with a latching relay to raise lamps to full voltage only when acceleration is complete.

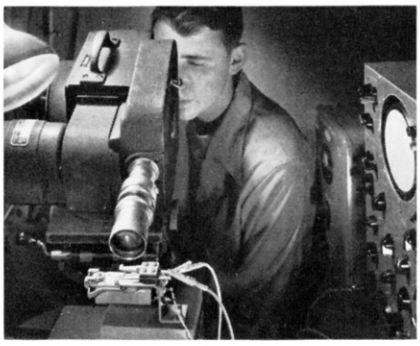


Lighting. General Electric 750R40 Lamps are specially designed for use in high speed motion picture photography. Three or four of them are usually grouped close to the lens axis. G-E Reflector Photoflood Lamps RFL2 or G-E Reflector Photospot Lamps RSP2 can also be used. Information about synchronizing repetitive discharge lamps to the camera to permit exposures as short as 1.2 μsec can be obtained from Edgerton, Germeshausen & Grier, Inc., 160 Brookline Avenue, Boston 15, Mass.

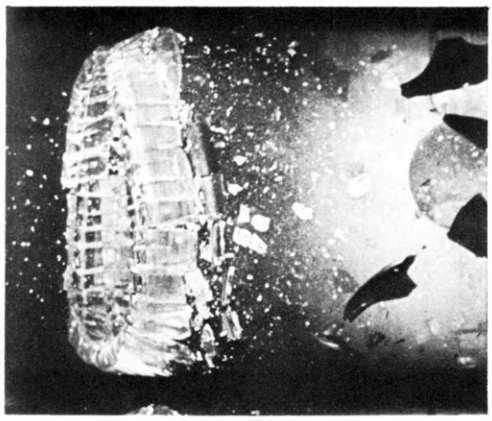


Relation of required camera speed to subject speed and field width is plotted here. (It is assumed that the true subject speed has been multiplied by the sine of the angle between lens axis and the direction of movement.) Graph is based on image motion of less than .002″ during exposure of a single frame and the fact that exposure time is always one-fifth the frame cycle. To study complex motions, it is well to allow extra margin in selecting speed, but higher speed than necessary in a given problem has disadvantages. Instructions are available from Kodak on operating at less than 1000 frames/sec.

Lenses. Kodak Cine Ektar Lenses are widely regarded as the finest series of lenses for 16mm photography that the art and science of optics have made attainable to date. The Type S mount (used on the Cine-Kodak Special II Camera), with a modification, fits these lenses to the Kodak High Speed Camera. The most broadly useful lens for industrial high speed movies has been found to be the 63mm. f/2.0, which can take in up to 11° of view. For coverage up to 26°, there is the 25mm. f/1.9. For distant high speed photography, the 102mm. f/2.7 covers 7° of total field, while for an extreme telescopic effect that selects 5° of field for close examination, one may choose the 152mm. f/4.0.



The Kodak High Speed Camera can be obtained with a modification by which a second lens, focused on a cathode-ray oscillograph of 8 kv or higher acceleration potential, exposes through the back of the film a trace uninterrupted by the frame lines. Signal is applied to the horizontal-deflecting circuit of the oscillograph only. Film travel provides the time base, calibrated, if necessary, by the edge-marking lamp in the camera. The middle fifth of the portion of oscillograph trace lying between any two frame lines covers the time interval during which that picture image was exposed.



Write for the film, "Magnifying Time"

A series of spectacular, revealing, and informative studies made with the Kodak High Speed Camera are featured in an interesting demonstration reel, which you can borrow for showing before groups in your organization. Some of the studies may suggest applications of high speed photography useful to you. To obtain this film, write on your letterhead to Eastman Kodak Company, *Professional Goods Division*, Rochester 4, N. Y.

Any good 16mm projector will do for viewing high speed movies. For the study of your footage right at the engineering conference table, however, a wise choice is the Kodascope Analyst Projector. It has a daylight projection viewer built into the carrying case. With its remote reverse control, its separately powered cooling system, and its heat-stopping coating on the condenser lens, it permits repeated reversing and rerunning without overheating.

What can you expect of your Kodak dealer?

This booklet describes only a part of the vast array of materials and apparatus with which Kodak serves all who turn to photography to get a job done in industry, in science, and in business. Your dealer has assumed the responsibility of acting as the link between you and Kodak for information about *all* Kodak photographic products, even the highly specialized ones for which consultation with the Kodak Technical Representative in your area or with Kodak headquarters in Rochester may be required. And, of course, you are always welcome to write, wire, or phone for information directly to

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LIST PRICES

Kodak High Speed Camera and Accessories and Kodak Film for High Speed Photography

Kodak High Speed Camera with Kodak Cine Ektar 63mm. *f*/2.0 Lens	$1713.50
Kodak High Speed Camera Stand	268.00
Kodak Cine Ektar 152mm. *f*/4.0 Lens	160.00
Kodak Cine Ektar 102mm. *f*/2.7 Lens	145.00
Kodak Cine Ektar 63mm. *f*/2.0 Lens	139.00
Kodak Cine Ektar 50mm. *f*/1.9 Lens	129.00
Kodak Cine Ektar 25mm. *f*/1.9 Lens	350.00

Kodak 16mm Films spooled for use in high speed cameras

	100 ft.	*200 ft.*	*400 ft.*
Kodak Tri-X Negative Film	$5.15	$ 8.25	$14.70*
Kodak Tri-X Reversal Film	5.95	—	17.50
Kodachrome Film	8.25	13.85	25.90
Kodak High Speed Infrared Film	5.95	—	—

Price of processing is not included.

*Special order

Prices shown are suggested list prices and are subject to change without notice. Federal Excise Tax included where applicable.

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