8th International Congress on High-Speed Photography

General Report

By LARS HÖGBERG

THE 8TH International Congress on High-Speed Photography, organized by The Royal Swedish Academy of Engineering Sciences (IVA), Committee for High-Speed Photography, in cooperation with The Research Institute of National Swedish Defence (FOA), was held 23–29 June 1968, at St. Erik's Fair in Stockholm. There were 473 registered active participants with 66 accompanying persons from the following 23 countries: Australia, Austria, Belgium, Canada, Czechoslovakia, Denmark, Finland, France, West Germany, Greece, Israel, Italy, Japan, The Netherlands, Norway, Rumania, South Africa, Sweden, Switzerland, United Kingdom, USA (33 active members), USSR (approximately 30), and Yugoslavia. Over 140 papers were presented with major participation by: West Germany (31), USSR (24), United Kingdom (22), France (22) and USA (20). Topics covered by these papers may be categorized by various forms of high-speed cameras and their component parts: light sources including laser/-holography and flash x-ray; optical systems such as used in schlieren, interferometry and spectroscopy; materials and application; and terminology.

On an international basis, there is an increased use of high-speed photography in keeping up with the more stringent requirements of science. New techniques and equipments that permit higher writing speeds and frame rates with better resolution were revealed by manufacturers and users from several different countries.

National Delegates of each country met on Wednesday evening, 26 June 1968, for the purpose of reviewing overall International Congress policies and to accept invitations from different countries for future meetings. It was confirmed that the USA would be the host country for the 9th Congress in early August, 1970, in Denver, Colorado. Invitations for the 10th Congress were received from Greece and France. The committee accepted the French offer for Nice in 1972. A proposal for the 11th Congress to be held in 1974 in Moscow, Russia, was accepted, but will not be finally confirmed until the 1970 meeting. The Russian delegate, Dr. Dubovik, requested that Russian be included as an official language in future congresses, but decision on this was left to the sponsors of subsequent meetings. The 8th Congress was the first meeting that had a sufficient number of Russians present to warrant Russian as an official language.

A gold medal award honoring the late Dr. H. Schardin has been established for these International Congresses. The recipient will be selected by the International Committee for recent accomplishments in high-speed photography. The medal is sponsored by the German Physical Society. Dr. Heinz Reichenbach of the Ernst Mach-Institut, Freiburg, Germany, was the recipient of the first medal.

As has been reported by USA Delegate Max Beard, the meeting was highly successful and was undoubtedly advantageous for all concerned, both from an immediate use standpoint and future progression of the technology. There is a rapid growth in the European design and manufacture of equipments for their own use as well as potential USA markets.

Advanced efforts on the part of USSR scientists in international terminology were recognized as a very worthy international endeavor. The National Delegates were requested to set up programs for the review of terminology to make additions or deletions. The intent is to get this into the works of the High-Speed Photography Committee.

Equipment Exhibit

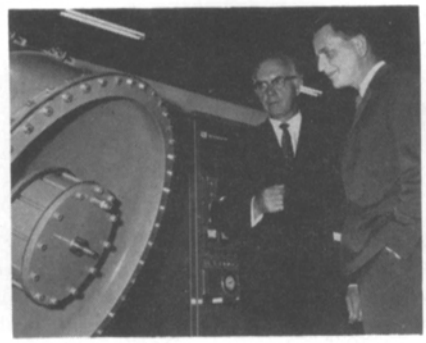
A noteworthy adjunct to the Congress was the Equipment Exhibit where 24 companies and organizations from

A contribution submitted on August 16, 1968, by Lars Högberg, The Research Institute of National Swedish Defence, Institute of Physics, Box 530, S-751, 21 UPSALA 1, Sweden.

Left to right: Tryggve Ramqvist, 8th Congress Secretary-General; Max Beard, U.S. Delegate to the International Committee on High-Speed Congresses and SMPTE Vice-President for Educational Affairs; Dr. J. S. Courtney-Pratt, SMPTE Vice-President for Photo-Science Affairs; Professor Erik Ingelstam, President of the 8th Congress; and Carlos H. Elmer, Chairman of the 9th Congress.

Tryggve Ramqvist, Secretary-General of the 8th Congress in the exhibit hall ringing bell to announce start of a papers session.

Presentation of the first Schardin Medal in High-Speed Photography to Dr. Heinz Reichenbach, left. Presenting the medal is Professor Erik Ingelstam, President of the 8th Congress. At the podium is Dr. Rudi Schall, who read the citation. Dr. Schall is German Delegate to the International Committee on High-Speed Congresses.



Left, Dr. M. Fehrm, Director General for the National Swedish Board for Technical Development, and Mr. O. Palme, right, Minister for Education, at Scanditronix Megavoltpulse generator.

eight countries, including, for the first time, the Soviet Union, displayed the latest developments in high-speed photography and instrumentation. It was observed that since the 7th Congress (1965) in Zurich, considerable progress has been made in the fields of photo-electronic image devices and holography.

Image-Converter Systems

Ultra-fast image-converter systems were described in papers from the USSR presented by Basov, et al., and by Korobkin, et al. The systems, when operated in a streak mode, provide time resolution in the 10^{-11} to 10^{-12} second range and have been used in laser studies. R. W. Smith of the Imperial College of Science and Technology, Great Britain, presented framing sequences taken at 5×10^8 frames/s with the electron beam storage and sampling tube first described at the 7th Congress in Zurich.

Exhibit at the 8th Congress of color pictures of human arteries made by Swedish photographer Lennart Nilsson.

The British Government Display organized by Optics, Aldermaston.

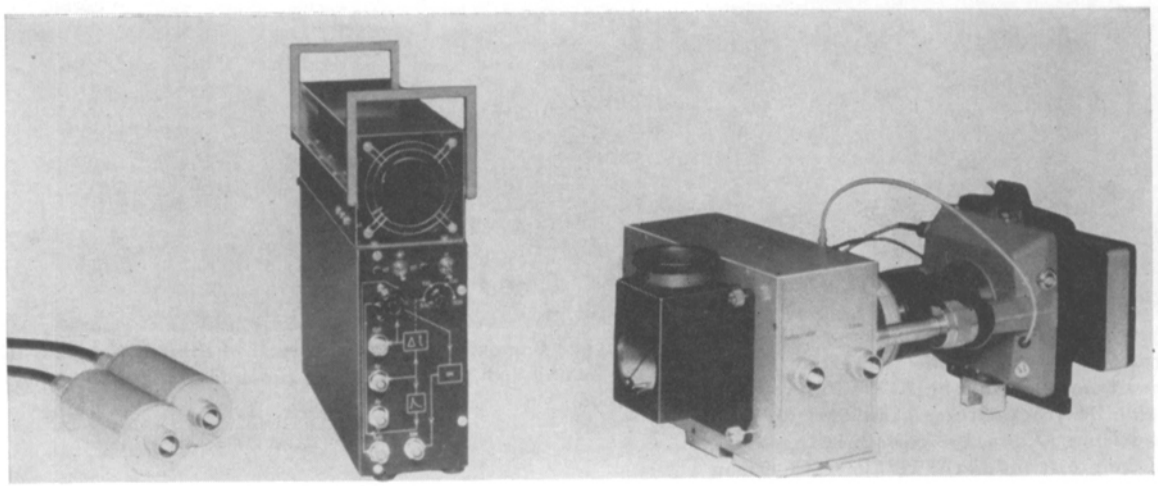


Fig. 1. High-speed camera — 5 to 500 nanoseconds.

A number of new image-converter camera systems providing multiple frame and/or streak operation in the nanosecond to microsecond range were exhibited. These included the Imacon (J. Hadland Ltd., England); TE 70 (Telford Products, Ltd., England); TH N 500 Series (Thomson Houston, France) and ZIS-1 (V/O Mashpriborintorg, USSR) systems. Single-frame tubes and complete cameras, based on the proximity focusing principle, yielding practically distortion-free pictures of high resolution at exposure times below 1 ns and up were displayed by several companies, among them, Technical Operations, Beckman & Whitley (USA), J. Hadland Ltd. (England) and Laboratories d'Electronique et de Physique Appliquée (L.E.P., France). L.E.P. exhibited a line of cameras and tubes with image diameters up to 120 mm, including tubes with fiber-optics faceplates.

Among the L.E.P., exhibits were a high-speed camera (exposure times from 5 to 500 ns) (Fig. 1) and an ultra-high-speed camera with exposure times of 1 and 2 ns (Fig. 2). Also exhibited were electronic shutter tubes (Fig. 3) with a minimum exposure time of 1 ns and a testing bench for electronic shutter tubes.

Fiber Optics

An invited lecture was given by W. P. Siegmund (USA) on the subject of fiber optics in photoelectronic image devices. Use of fiber-optics "relay plates" instead of the usual transmission dynodes has resulted in rugged image intensifier tubes with high performance (gain of 40,000 at resolution better than 20 line pairs/mm). These tubes and their application in military night vision devices were recently declassified by the United States Government.

Holography

Some 10 papers were devoted to high-speed holography, mostly using the original Gabor "in line" method with pulsed ruby or neodymium lasers as light sources and exposure times in the 10-s to 30-ns region. Some working multiframe systems were presented, e.g., 3 frames at 2.5×10^7 frames/s using optical delays (Ostrovsky and Zaidel, USSR) or 10 frames at 10^4 frames/s using rotating prism (Gates et al., United Kingdom).

Of the two papers presented by J. W. C. Gates, R. G. N. Hall and I. N. Ross, the first of these, "Repetitive Q-Switched Laser Light Sources for Interferometry and Holography" (75), presented a relatively simple and compact Q-switched laser which provides 30-ns light pulses at repetition rates up to 25 kHz. It gave some examples of the way in which this source may be used to record traveling events, or with simple streak arrangement to give separated images (Figs. 4 and 5). The second paper, "Holographic Recording of Rapid Transient Events and the Problems of Evaluation of the Reconstruction" (76), gave examples of a sequence of development in applying holography to high-speed recording of amplitude and phase distrubances, using pulsed lasers. The advantages in three-dimensional recording to reveal progressive phase changes and to record short sequences of separable records without a specialized high-speed camera were described.

The field appears to be in a rapid but early growth phase and no commercially available systems were displayed.

Application of holographic techniques in optical information processing to provide better display of multi-image pictorial information was demonstrated at the exhibition stand of the Optics Aldermaston Group (United Kingdom). A large number of ordinary photographs, e.g., taken of an object from different angles were, in a second step, holographically combined into a single plate, which, when viewed under proper conditions presents a three-dimensional image of the object.* (A true reconstruction of the wavefront from the object is of course not obtained in this way.) The principal advantage is that any photographic technique can be used for the first step, whereas the holographic process in the second step can always be carried out under controlled laboratory conditions. Holograms of large scenes as well as x-ray holograms produced in this way were displayed. A large number of pictures taken of an object at different times could, in the same manner, be combined onto a single hologram which, when viewed from different angles, would reconstruct images of the object as recorded at different times. Such processing might facilitate viewing and evaluating of high-speed as well as time-lapse photographic recordings.

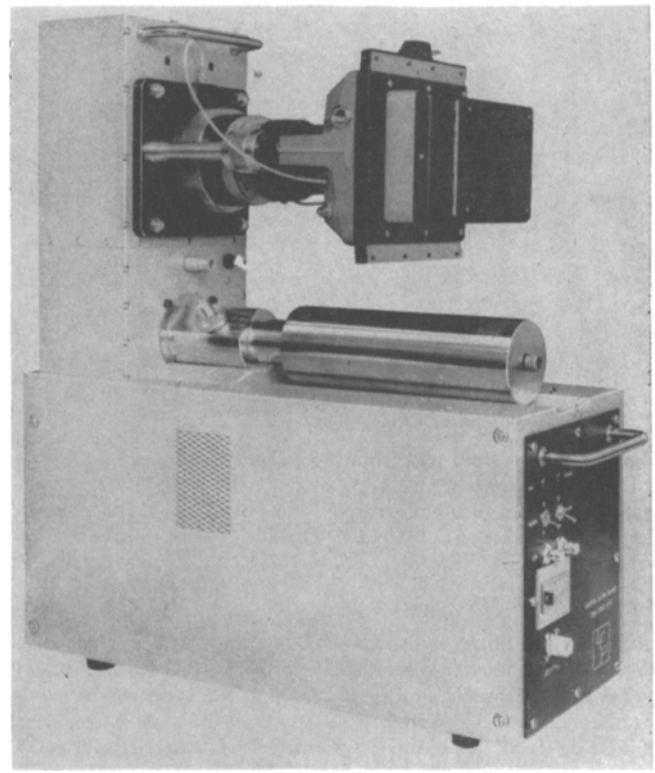


Fig. 2. Very high-speed camera — 1 and 2 nanoseconds.

Fig. 3. Two-stage shutter tube image diameter of 35 mm.

X-Ray Flash Systems

In x-ray flash systems, Field Emission Corp. (USA) presented a 600-kV, 3-ns unit providing for simultaneous x-ray and electron beam radiographs (Figs. 6 and 7) the latter providing remarkable resolution. Objects made to fluoresce under electron irradiation could also be simultaneously photographed by the visible light thus emitted. Equipment for high-speed ciné-radiography at frequencies up to several thousand frames per second at 200 to 300 kV was presented by Impulsphysik GmbH (Germany). New, compact 20-ns x-ray flash

* This technique is similar to the multiple lens array (fly's eye) technique, presented by the I.B.M. Laboratories early this year.

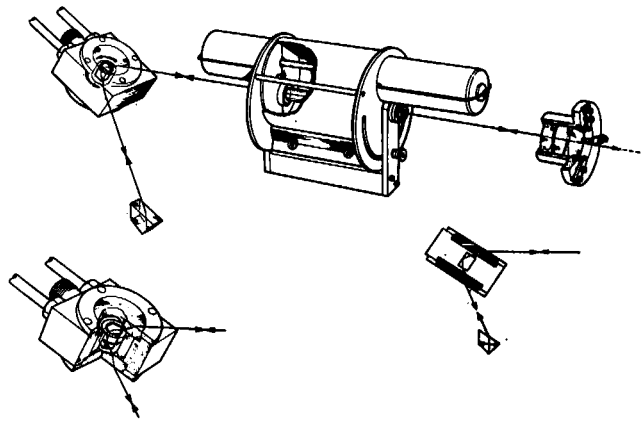


Fig. 4. Laser system with rotating prism Q-switch.

systems in the megavolt range, developed at the Research Institute of National Swedish Defence, were marketed by Scanditronix, Inc. (Sweden).

Rotating-Mirror Systems

Rotating-mirror cameras with framing rates in the range 10^6 to 10^7 frames/s were displayed by SOPELEM (France) and V/O Mashpriborintorg (USSR) in addition to the well-known Beckman & Whitley (USA) and Barr & Stroud (J. Hadland, Ltd., England) systems. The Russian SFR–2M rotating-mirror unit could be used with framing, streak, spectrographic and image-dissection attachments, the latter providing 100 frames at framing frequencies up to 10^8 frames/s with a resolution of 110 × 80 image elements.

Image Dissection Camera

A new image dissection camera, the Megadyne 300, was presented by Photosystems Corp. (USA). The camera will provide 1500 frames at rates up to 600,000 frames/s with a resolution of 317 × 254 image elements. The multiple-lens arrays used in the instruments are also marketed as separate components.

Cameras With Mechanical Film Transport

For cameras with moderate framing speeds (≈500 frames/s) there seems to be a trend toward improved mechanical film transports including positive pin registration, and several such cameras are now marketed. A new film trans-

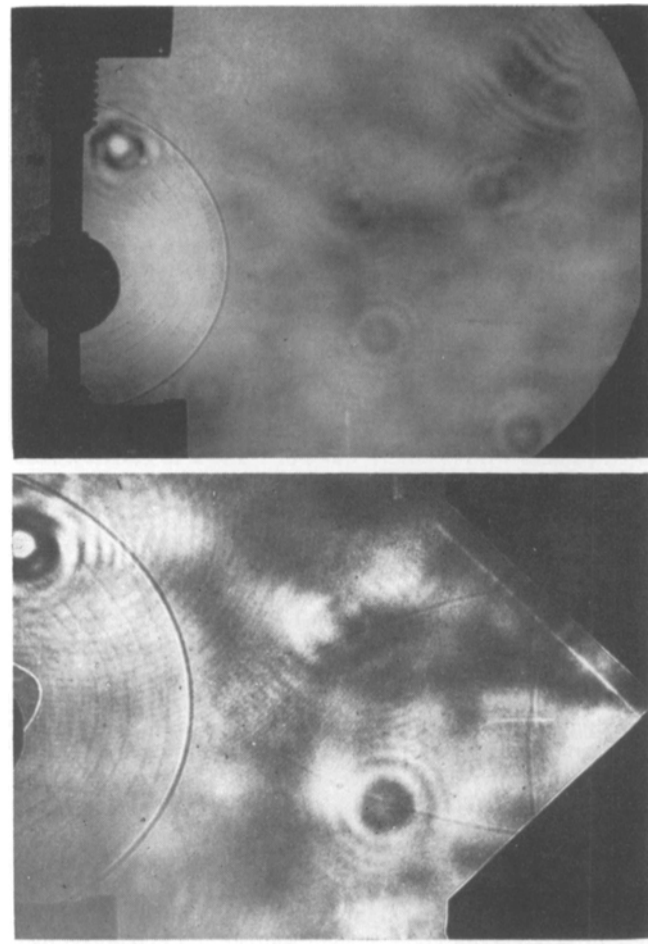


Fig. 5. Single pulse and double pulse recording of a shock wave, using ruby laser, pulse duration of 30-ns, an an interval of 130 μs.

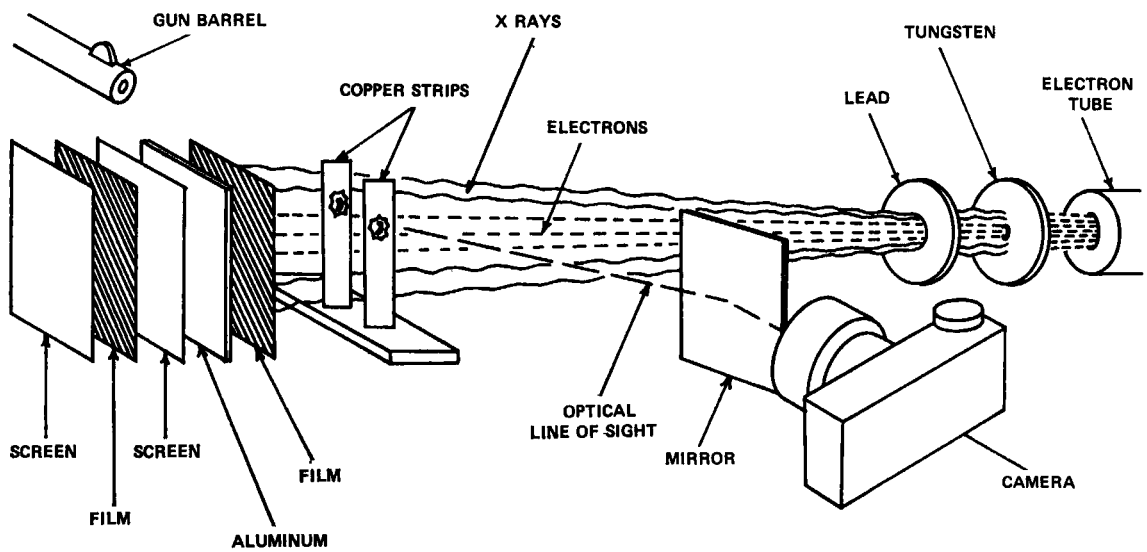


Fig. 6. Experimental arrangement for simultaneously obtaining electron photograph, radiographic negative and a visual light photograph of the same event. The pulsed electron beam source is Febetron Model 706, 600 kV, 3 ns pulsed electron accelerator(Field Emission Corp.).

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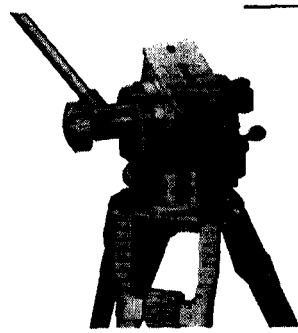

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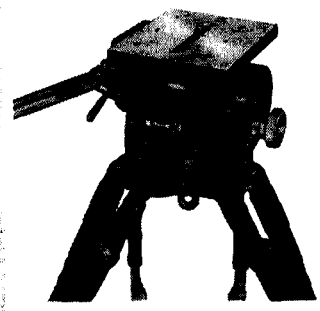

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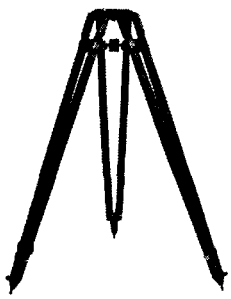

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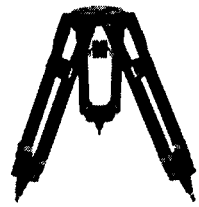

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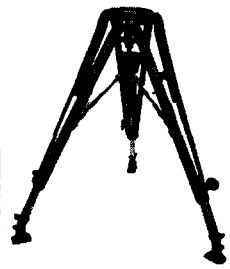

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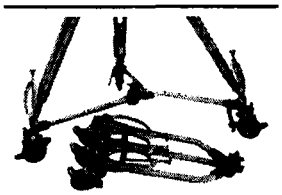

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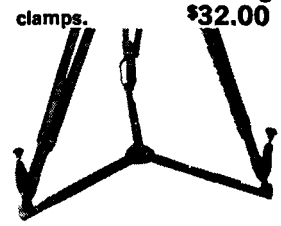

port mechanism for a camera of the rotating-prism type operating up to ~30,000 frames/s was shown by Hitachi Ltd. (Japan) in their Model 16HD camera.

The exhibition also featured conventional instrumentation for photographic recording, processing and analysis.

Proceedings of the Congress

The *Proceedings* are in process of preparation and will be published by John Wiley & Sons, 605 Third Ave., New York, N.Y. 10016. An announcement will appear in a later issue of the *Journal*.

Report on Papers From the USSR

By GEORGE H. LUNN

THE International Congresses on High-Speed Photography are of particular value in that they afford scientists from many countries an opportunity to meet each other and compare their work. There is no doubt that in this field contributions from the USSR are among the finest. This year's Congress in Stockholm was noteworthy in that there were present many more scientists and engineers from the USSR than at previous congresses and in that, for the first time, equipment developed in the USSR was displayed. This display attracted much attention. Cameras described in previous papers were shown together with designs described in papers presented this year.

Professor Dubovik, of the Institute of the Physics of the Earth, Academy of Sciences, was the main organizer of the Equipment Exhibit. Much of the equipment originated in the Institute. The SFR camera was on display with the many attachments which permit it to operate in numerous modes, such as streak, framing, image-dissection, spectrograph and stereoscope (Fig. 8).

A number of papers were presented by Prof. Dubovik and his associates in the Institute. "The General Theory of Mirror Image Scanning in Matrix Form" (paper No. 29) by Dubovik is a closely reasoned mathematical study of the subject. Equations defining geometry and image coordinates are given. "Continuously Operating Mirror Scanning System in High-Speed Photographic Cameras." (30) by Shnirman, Dubovik and Granigg is a study of mirror scanning systems giving continuous access. These papers add to design principles described in previous papers and in *Photographic Recording of High-Speed Processes* by A. S. Dubovik.*

A drum camera with mirror compensation from frame rates up to 20,000 frames/s and streak operation with time resolution of 5×10^{-7} s is described in "High-Speed PhC-1 Camera With a High Aperture Ratio" (31) by Dubovik, et al. Two papers by Grenishin, et al., discussed time-resolved spectroscopy: "High-Speed SP-111 Spectrograph" (46) and "SP-142 Time-Resolved Spectrograph" (47). The authors of these two papers are affiliated with the Institute of the Physics of the Earth. Both of the devices described employ diffraction gratings as the dispersive elements, with resolutions, respectively, of 0.5 Å and 1.0 Å (spectral), 10^{-8} s and 10^{-7} s (temporal), apertures of $f/8$ and $f/2$ to $f/3$ and are intended for use between 2,000 and 9,000 Å. The SP-142 is a further development of the SP-75 reported at earlier congresses.

An interesting paper on the study of large-scale explosions at Alma-Ata for earth-moving and dam-building (99) (Garnov and Fomichev) was not presented at the Congress but will be included in the *Proceedings*.

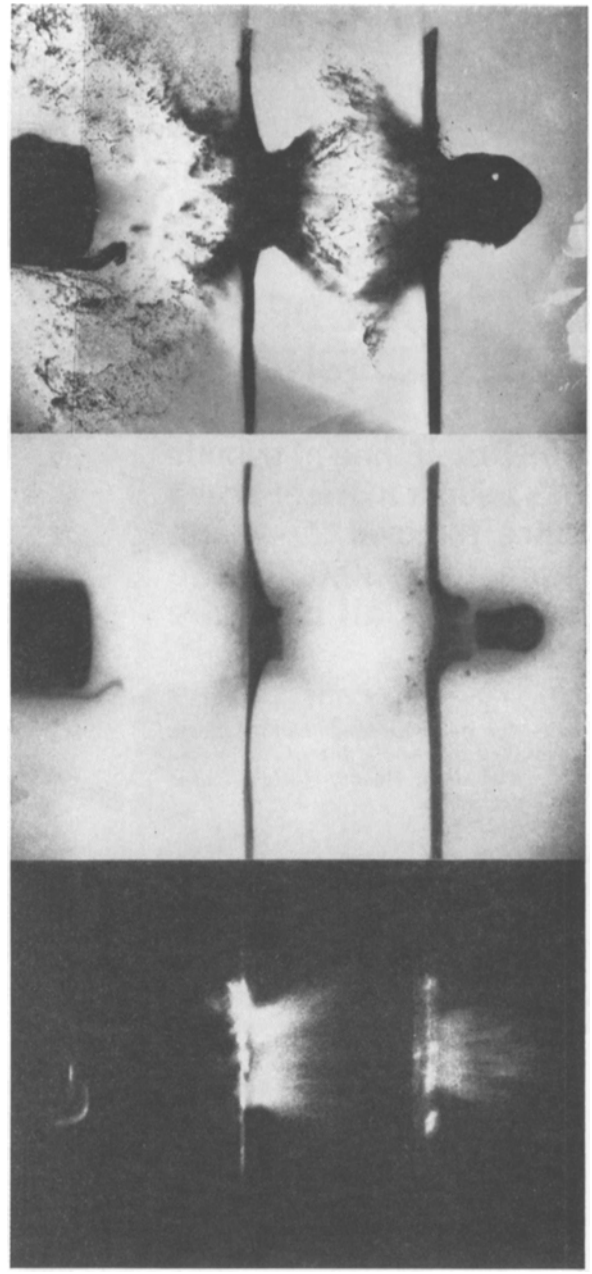

Fig. 7. Simultaneous 3-ns exposures of a bullet penetrating two copper plates using (top) electron beam, (middle) x-rays and (bottom) visible light excited by electron beam fluorescence (Field Emission Corp.).

Authors from two other large institutes presented papers on image tubes and other subjects — the P. N. Lebedev Physical Institute (Moscow) and the Institute of Automation and Electrometry of the Siberian Division at Novosibirsk. They are usually referred to as the Lebedev and the Novosibirsk Institutes. A link between the two is evident in papers read by M. Ya Schelev (7 and 8). Two papers on image converter systems (9 and 10) were read by E. P. Krugliakov. Both Mr. Krugliakov and Mr. Schelev set a high standard in style and timing.

An image-tube camera described in (8) has been used in laser spiking studies. These studies are described in "In-

A contribution submitted on September 16, 1968, by George H. Lunn, National Delegate from the Association for High-Speed Photography and the British National Committee for High-Speed Photography, 57 Whitedown Rd., Tadley, Basingstoke, Hants, England.

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