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*.

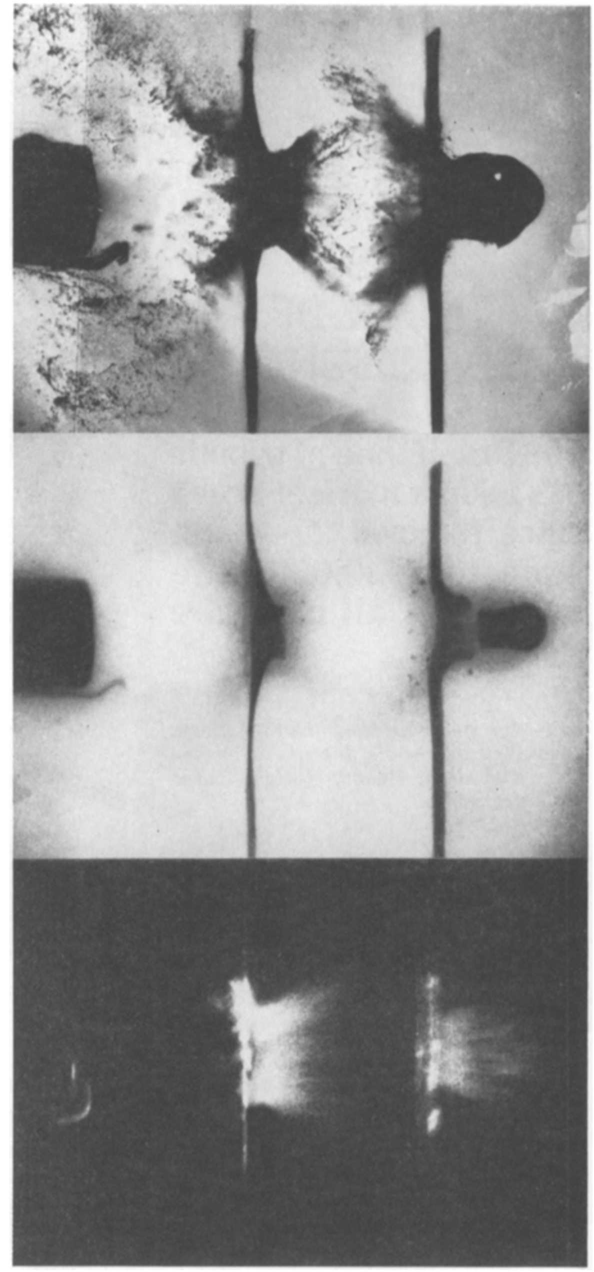

Fig. 7. Simultaneous 3-ns exposures of a bullet penetrating two copper plates using (top) electron beam, (middle) x-rays and (bottom) visible light excited by electron beam fluorescence (Field Emission Corp.).

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*.

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-

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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.

* Ed. G. H. Lunn, Published (1968) Pergamon Press, N. Y.

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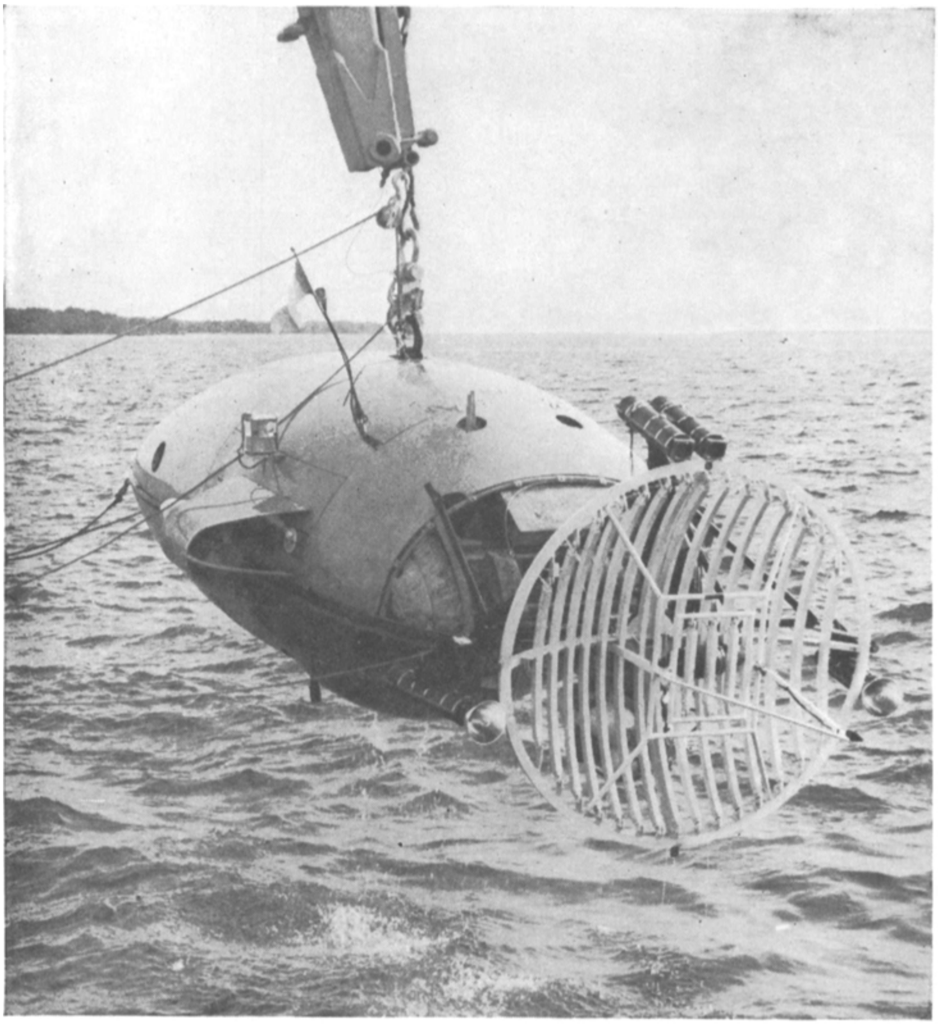

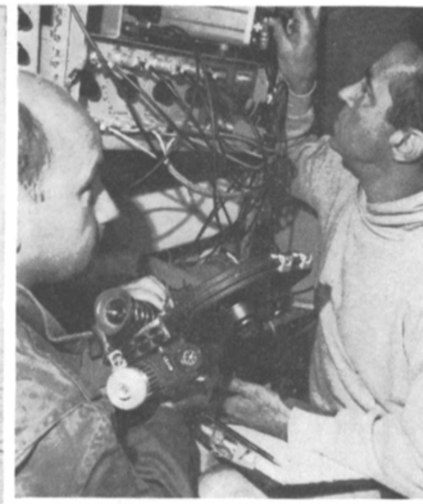

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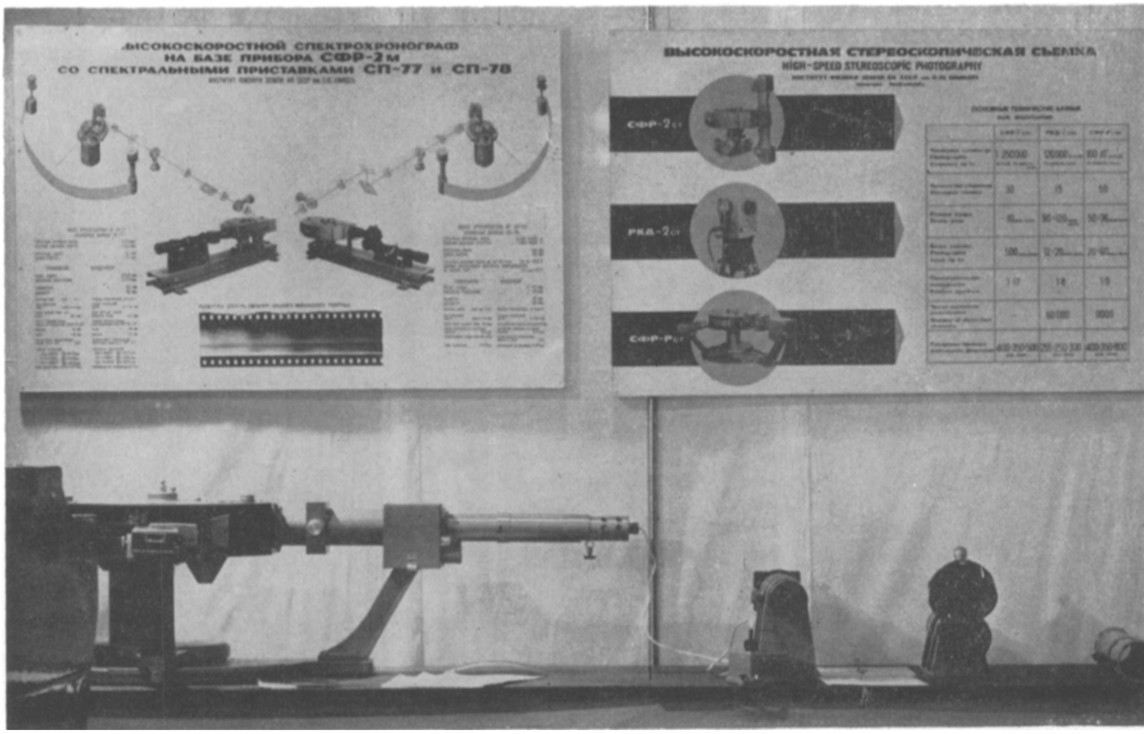

Fig. 8. The SFR Camera System from the Institute of Physics of the Earth, Moscow.

vestigation of Ultrashort Pulses of Light by Image Tube With Time Scanning" (Basov, et al. (7)). The camera is suitable for use over a very wide range of times and light levels. The extremes quoted are time resolutions up to 10^{-11}s (streak operation), single frames of 5×10^{-9}s. There is increased sensitivity since two tubes can be used — one is a normal high-speed single-stage electrostatic tube; the other has an additional stage of intensification. Pictures were shown of streak studies of lasers in which the recording period was about 1 ns and individual light pulses of about 20 ps were clearly recorded.

Two types of camera systems called high-speed image-tube systems (HSITS), developed at Novosibirsk Institute, were described by Gavganen, et al. (9), and their application to Q-switched ruby laser studies was described by Vorobyev, et al. (10). One HSITS camera system is based on a two-electrode image-converter tube, type ZIM, permitting multiframe recording; the second system uses a grid shutter, type ZIS-1, which permits recording of four frames with minimum exposure time of about 10 ns.

Vorobyev et al. (10), described the application of a battery of eight of the diode cameras to laser studies. An advantage of such a multicamera system is that each channel can be set to record at a different brightness range suitable to the light level at the instant of recording.

Another paper from the Lebedev Institute by Basov, et al. (70) described first a modulated laser system to produce five flashes, each 1.5 ns at 50-ns intervals and so arranged as to intersect at the subject and produce five separate shadowgraphs or schlierens on the same plate; single flashes were also used for interferometric studies and, by harmonic generation, simultaneous pairs at different spectral frequencies are possible. Gas shockwave examples were shown and then the use of a streak camera with a repetitive laser to give a framing sequence was discussed.

The same team from Novosibirsk led by Nesterikhin presented "Superfast Optical Methods for High-Speed Plasma Processes" (93) in which they describe time-resolved interferometry of plasma motion with 5×10^{-9}s resolution; the use of an image-tube shutter with an intensifier to measure plasma electron densities and a similar system for studying weak spectral lines (Fig. 9).

Fig. 9. The Novosibirsk image tube camera system (Y. Nesterikhin, Paper 93).

Three papers related to light sources came from the Yoffe Institute of Leningrad. Vanyukov and Daniel carried on in the Marshak tradition on flashtubes (55) discussing discharges in large-diameter tubes and pointing out the optimum characteristics for various configurations, presenting valuable data for tube and instrument designers. Arpishkin, Vanjukov and Danilov presented "A Method for Photographing Distant Objects" (102) which describes a laser operated at

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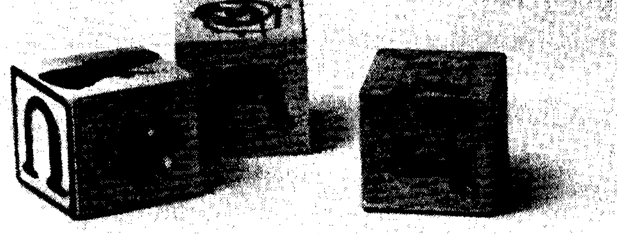

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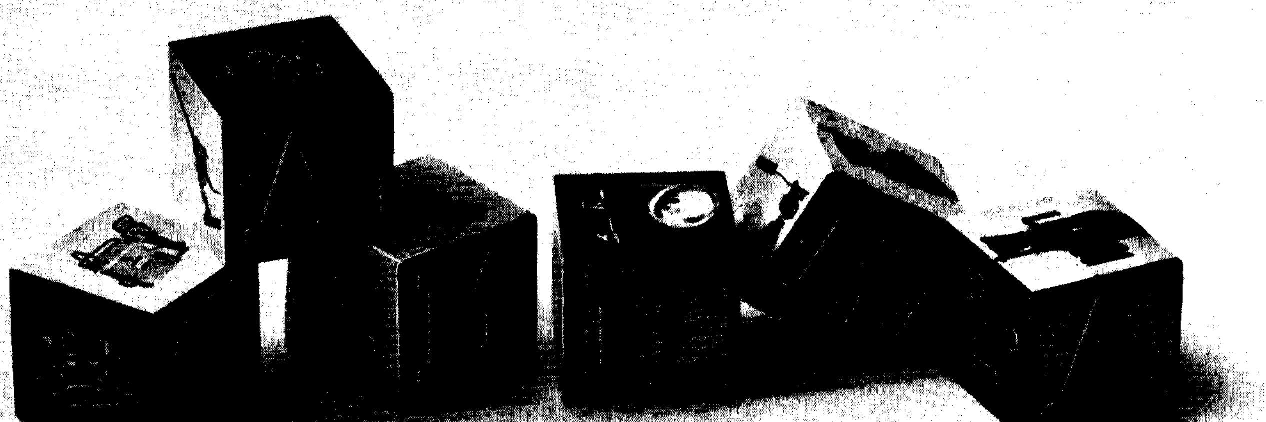

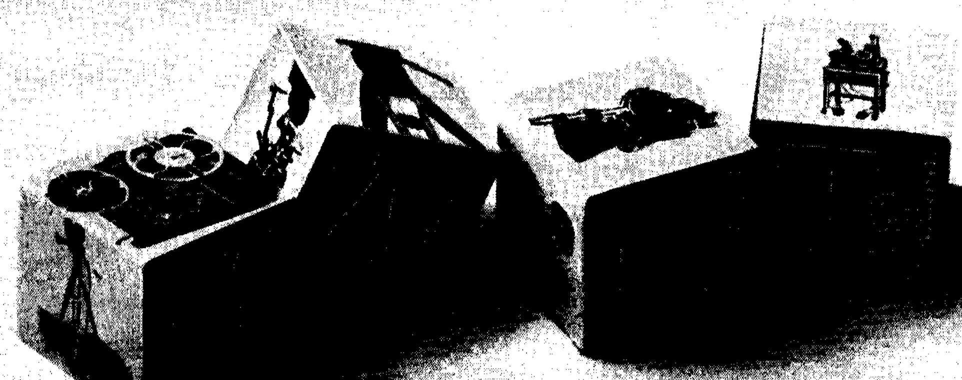

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50 kc/s and an image-tube pulsed and delayed to operate in the "optical radar" manner, producing spatial isolation of desired regions, selected by varying the flash to camera delays.

The repetitive source makes it possible to use the system as a direct-viewing device. Another paper from the Yoffe Institute presented by Dunaev, et al., "Optical Quantum Generator Applications for High-Speed Photography and Holography in Ballistic Investigations" (83) shows that Q-switched lasers are now generally used for schlieren studies. Illustrations showed the use of a hologram to perform additional experiments in retrospect (i. e., with optical systems not used in the original experiment).

Papers 39, 40 and 41 show that there is keen interest in image-dissection systems in the USSR especially at NIKFI and the Leningrad Institute of Kine-Engineering. Akimakina, Ivanov and Komar (39) described new lenticular plates of high relative aperture having pitch spacings of 60 μm, apertures of $f/2$ and spatial resolutions up to 400 lines/mm. From Leningrad, Grebennikov (40) and Provornov and colleagues (41) discussed improvements to raster cameras, in particular, Models RKS-2, RKS-11 and RKS-21, with considerable technical detail and thoroughness.

Papers presented at the Applications Session included "Certain Possibilities and Outlooks Related to Optical Methods Applied in Gas Dynamics" (105) by Bolotzerkovsky, of the Lebedev Institute, in which he pointed out that some theoretical approach is necessary to convert photographic records into quantitative results; he carried out such interpretations for projectiles of various shapes such as conical, spherical and flat-nosed cylinders.

"Flame Propagation in Electric Fields" by Salamandra (106) describes studies using the Toepler method. Schlieren were visible at 3,000 frames/s. A number of still examples were shown and a color film.

A paper on cathodo-luminescence (58) from the Power-Scientific-Research Institute was not presented at the Congress. The final paper presented by the USSR delegation (113) described a cinematographic study of colliery mechanisms at speeds between 1,000 and 4,000 frames/s. The paper, presented by M. N. Negodaev, Research and Designing Institute of Hydraulic Mining-Wniigidrougoel, was illustrated by film, showing that high-speed techniques everywhere are applied in an endless variety of tasks.

A special (one-paper) session on Terminology deserves particular mention. Prof. Dubovik spoke on behalf of Prof. Sakharov of NIKFI, who has prepared for consideration, discussion and amendment a *Dictionary of Terminology for High-Speed Photography in English, French, German and Russian* (97). It is arranged in an order based on the English terms or phrases and contains 850 such entries, each entry in all four languages with some additional cross-references. This is an immense and valuable work. It is inevitable that there will be differences of opinion on details and disagreement on meanings both within and between languages (probably more often than not, about choice of terms in the disputants own tongue) but this great contribution by Sakharov will be appreciated.

The USSR always produces valuable contributions at these Congresses and 1968 will go down as a new peak in both quality and quantity.

THE TECHNICAL PAPERS PROGRAM

There follows the complete listing of the papers in sequence as published in the *Proceedings of the 8th International Congress on High-Speed Photography:*

Invited Lecture: Prof. *J. D. McGee* (United Kingdom), Photoelectronic Image Devices — A Reveiw

SHUTTERS

1 *A. V. Krause, W. P. Raffan* (United Kingdom), Electron Tubes for Fast Shuttering

2 *R. W. Smith* (United Kingdom), Recent Developments of the High-Speed Image-Intensifier Framing Camera

3 *M. B. Prudence, R. A. Colmer* (United Kingdom), New Developments in the Telford Image Converter Camera

4 *A. E. Huston, S. Majumdar* (United Kingdom), The Imacon — A New Image Converter Camera

5 *K. A. F. Haynes* (United Kingdom), Functional Influences on the Design of a Modern Image Converter Camera

6 *T. H. Bulpitt* (USA), Image Converter Camera System for Single Photoelectron Recording

7 *N. G. Basov, Yu. A. Drozhbin, V. V. Nikitin, A. S. Semenov, B. M. Stepanov, V. A. Yakovlev* (USSR), Investigation of Ultrashort Light Pulses Employing Time-Base Image Converter Tube

8 *V. V. Korobkin, M. Ya. Schelev* (USSR), Image-Converter Camera for Using Over Wide Time Intervals

9 *L. V. Gavganen, L. M. Diamant, A. M. Iskoldsky, Y. E. Nesterikhin, V. M. Fedorov* (USSR), Nanosecond Image Converter Framing Camera Types

10 *V. V. Vorobyev, A. M. Iskoldski, E. P. Krugliakov, Y. E. Nesterikhin, M. Ya. Schelev* (USSR), Multiframe Image Converter Registration of the Process of Ruby Laser Giant Pulse Formation

11 *L. Guyot, D. Kaplan, M. Domalain, P. Laharrague, M. Durant* (France), Tubes intensificateurs d'images et cameras electroniques fentes et à images integrales multiples à haute sensibilitié—applications

12 *D. R. Charles, G. Wendt, F. le Carvennec* (France), Meshless Shutter Tube With Nine Images Double Deflection Capability

13 *G. Eschard, R. Polaert* (France), Tube obturateur pour photographie ultra-rapide

14 *H. Bacchi, J. Marilleau* (France), Dispositifs de prise de vues ultra-rapides à temps de pose compris entre 5 et 500 ns

15 *E. Laviron, H. Bacchi* (France), Caméra à image intégrale de 1 μs de durée d'ouverture

16 *M. Blanchet* (France), Dispositif pour la détermination de la constante de Kerr des liquides. Propriétés de nouveaux liquides électro-optiques. Installation de remplissage de cellules de Kerr

17 *G. Pfund* (Germany), Ein Beitrag zur Entwicklung magneto-optischer Verschlüsse mit Öffnungszeiten um 10^{-7} S

18 *F. Früngel, D. Ebeling, J. F. Suarez* (Germany), Fast Electrically Actuated Optical Shutters

19 *W. H. Allan* (USA), High-Speed Drum Shutter for Ribbon-Frame Camera

20 *W. H. Allan* (USA), Foil-Shutter, Multiple-Lens Camera

21 *J. M. Webster, R. Thomas* (United Kingdom), Electro-Mechanical Uncapping Shutter

22 *K. Chan* (USA), A Unique Capping Shutter

23 *K. Chan* (USA), A High-Speed 70mm Drum Camera

Invited Lecture: Dr. *Walter Siegmund* (USA), Fiber Optics

STREAK CAMERAS

24 *J. Leygonie, J. Cl. Bergon* (France), Problèmes actuels d'utilisation des caméras à fente à miroir tournant dans l'étude des compressions extrèmes par ondes de choc

25 *F. Chabannes* (France), Mesure de la résolution temporelle des caméras à fente à l'aide de diodes lasers pulsées

26 *K. C. Seddon* (Australia), The Barr and Stroud CP6 Rotating Mirror Streak Camera Determination of Writing Speed

FRAMING CAMERAS

27 *H. Lukanow* (France), Eine Bildreihenkamera als ballistischer Phototheodolit

28 *M. Koreeda, T. Yamamoto* (Japan), Development of Rotating-Prism High-Speed Camera Incorporated With Registration Sprocket and Rotating Disc Shutter

29 *A. S. Dubovik* (USSR), General Theory of Mirror Image Scanning in Matrix Form

30 *A. S. Dubovik, A. B. Granigg* (USSR), Continuously Operating Mirror Scanning System in High-Speed Photographic Cameras

31 *A. S. Dubovik, P. V. Kevlishvily, G. I. Belinskaya, G .P. Iyushin*