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Meetings and Conferences

IMAGE CONVERTERS, LIGHT AMPLIFIERS AND THEIR APPLICATION IN SCIENCE AND TECHNOLOGY

(All-union Seminar, Session II, Moscow, June 15–16, 1970)

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THE All-union seminar at the VNIIOFI (The Physics Division of the All-union Scientific Research Institute) under the chairmanship of Professor B. M. Stepanov began its work in 1969. During the first session the problems of high-speed electron-optical photography were discussed.

The second session was devoted to the application of electron-optical image receivers in Astronomy. More than 20 papers were presented at this session. This was the first extensive scientific conference in our country at which the problems of astronomy, physics and electronics were so closely interwoven. Participating in the conference were scientists from VNIIOFI, the Alma-Ata, Byurakan, Crimean and Pulkovo Observatories, GAISh (the P. K. Shternberg State Astronomical Institute), PGI (the Polar Geophysics Institute) of the Kola branch of the U.S.S.R. Academy of Sciences, IAÉ (the I. V. Kurchatov Institute of Atomic Energy), LFTI (the A. F. Ioffe Physico-technical Institute, Leningrad) and others.

The opening address, delivered by Academician **E. K. Zavoĭskiĭ**, was devoted to the prospects of the study of the universe on the basis of the application of the latest methods of investigation. Information about the structure of the universe comes to us through electromagnetic radiation (in the radio-, optical, x-ray and γ-ray bands of the spectrum) and corpuscular radiation. In terms of the volume of information taken, optical and radio astronomy occupy the first place. But as experimental techniques develop, we can expect an evolution of astronomical investigations based on the reception of protons, neutrons, neutrinos, x- and γ-rays and gravitational waves. The information capacity of the channels of communication with the universe is determined by the fundamental laws of nature, but it also depends on the level of the technology employed in the fabrication of the scientific equipment. Advances in the construction of larger and larger telescopes and the appearance of diverse electron-optical image receivers have considerably extended the potentialities of optical astronomy. At present experimental astronomy has reached such a level that limitations in the investigations of distant objects are already connected with the fundamental uncertainty of the observational data when a small number of quanta are received. And even more important is the effect of the intrinsic noise and interference present in image receivers.

Academician E. K. Zavoĭskiĭ analyzed in detail the causes of the appearance of such noise (thermionic and field emissions, cathode bombardment by ions, the action of cosmic rays on the glass of the apparatus, residual radioactivity of the glass, etc.) and posed the problem of how they could be considerably reduced in the image converters (IC) used in astronomy. He also considered the possibility of using IC with maximum sensitivity in an astronomy based on the reception of x- and γ-rays, as well as relativistic particles.

The papers read at the seminar covered, in the main, three topics: 1) the basic problems of the application of image intensifiers in astronomy; 2) electron-optical equipment for telescopes and the experience gained in its use in astronomical investigations, and 3) new IC.

In a review report by **M. M. Butslov, E. K. Zavoĭskiĭ, G. E. Smolkin, and S. D. Fanchenko**, the history of the development of IC and their use in Astronomy were briefly discussed, the Soviet multistage IC of the UM-UMI series were described in detail, the main properties and advantages of these instruments were considered and the information characteristics of the photographic images obtained under conditions of great intensification of the image brightness were analyzed. Foreign developments in the field of IC and image brightness intensifiers were discussed in a report by **P. V. Shcheglov**, who focused his attention mainly on the single-chamber IC with contact photography (of the type of the Soviet FKT). Comparison of the potentialities of astronomical observations made with the multistage IC with direct image photography and those made with the multistage IC with a television system for registration was made by **V. V. Prokof'eva, G. E. Smolkin, and S. D. Fanchenko.** In a paper by **M. M. Butslov, V. A. Gornostaev, B. O. Karapetyan, A. A. Markov, G. E. Smolkin, and G. N. Sofiev**, and a paper by **A. N. Abramenko and V. V. Prokof'eva**, the advantages of using pulse multistage IC of the UMI type for investigating nonstationary astrophysical objects in the millisecond band (pulsars, etc.) were demonstrated. More details about the last two papers will be given below.

The advantages and disadvantages of modern IC as applied to the requirements of astrophysical observations were considered in the above-mentioned papers and in the discussions that followed them. The historical tendency towards the development of telescopy with image intensification was discussed in this connection.

Only twenty years have passed since A. A. Kalinyak, V. I. Krasovskiĭ and V. B. Nikonov first employed in astronomy the simplest IC (Dokl. Akad. Nauk SSSR 66, 25 (1949)) and obtained infrared photographs of a region of the galactic center. In 1950 V. T. Lukashenya and V. I. Krasovskiĭ developed a single-chamber IC with contact image photography (Dokl. Akad. Nauk SSSR 79, 241 (1951)) and investigated with its aid the infrared spectrum of the night sky. In these investigations the IC was used, in the main, for the conversion of images from the infrared into the visible region of the spectrum where the sensitivity of photographic materials is higher.

Fundamentally new horizons were opened by the construction in 1953 of multistage IC of so high a sensitivity that they were capable of registering individual light quanta [M. M. Butslov, UNF 6, 76 (1959); E. K. Zavoiskiĭ, M. M. Butslov, and G. E. Smolkin, Dokl. Akad. Nauk SSSR 111, 996 (1965) (Eng. Transl., Sov. Phys.-Doklady 1, 743 (1956)]. Multistage IC with maximum image brightness intensification were first used in astronomy in 1957 jointly by the Crimean Astrophysical Observatory and the I. V. Kurchatov Institute of Atomic Energy [M. M. Butslov, E. K. Zavoiskiĭ, A. A. Kalinyak, V. B. Nikonov, V. V. Prokof'eva, and G. E. Smolkin, Dokl. Akad. Nauk SSSR 121, 815 (1958) (Sov. Phys.-Doklady 3, 693 (1958))]. It was shown that the use of the multistage IC in stellar field and extra-galactic nebula photography on the MTM-500 telescope, allowed a reduction of the exposure time by a factor of 10^2—10^3. The same reduction in the exposure was obtained in nebula photography in a narrow spectral band on the ZTSh telescope [M. M. Butslov, I. M. Kopylov, V. B. Nikonov, A. B. Severnyi, and K. K. Chuvaev, Astron. Zh. 39, 315 (1962) (Sov. Astron.-AJ 6, 244 (1962))].

The results of these investigations received extensive international response and stimulated the development of multistage IC abroad. Over 35 astrophysical observatories of the world were equipped with this instrument in the second half of the sixties. About 50 more astronomical installations with multistage IC in the U.S.A. are right now in the adjustment stage. The use of the single-chamber IC with contact photography (the Soviet FKT instrument, limited mass production techniques for which were worked out in 1958, and a similar instrument constructed in the U.S.A. in 1960) is also slowly becoming widespread. Besides the various types of IC, television systems with electron-optical preamplification, as well as with precommutation amplification in which the principle of induced conduction is used, and electron-diffraction cameras in diverse forms are used in astronomy.

Recent international astronomical congresses have shown that the volume of valuable astrophysical information obtained on the basis of the use of IC and other image amplifiers is growing rapidly. Nevertheless the well-known prejudice against the use of multistage IC on telescopes still persists. This prejudice was perceptible at this seminar—for example, in the paper by P. V. Shcheglov in which he tried to get the astronomers inclined towards the use of mainly the FKT type of instruments. The basic question of the amount of useful intensification of image brightness which an IC provides was at the center of the discussion on the reports. Since one often comes across contradictory interpretations of this question, let us discuss in more detail the conclusions of the discussion.

The photographic plate, the IC, the television tube and electron diffraction cameras (the spectracon and the Lallemand camera) differ appreciably in their characteristics, but there exists for all of them a single concept of generalized quantum yield ϵ_{gen}. By definition $\epsilon_{gen} = (R_{out}/R_{in})$, where R_{in} and R_{out} are the ratios of useful signal to noise at the input and output points of the instrument. For images the quantity R characterizes that minimum optical contrast C_{min}, that is still distinguishable. If the luminous flux necessary for a resolved element of the image corresponds to the number of quanta N, then, it is obvious that $C_{min} = pR = p(\epsilon_{gen}N)^{-1/2}$, where p is the confidence coefficient (of the order of unity). It is clear from this formula that for a given value of the transmitted minimum contrast, the required number of primary light quanta is inversely proportional to ϵ_{gen}. This allows us to consider ϵ_{gen} as a universal measure of sensitivity of image receivers. Let us turn to the experimental data on the magnitude of the generalized quantum yield.

For photographic emulsions the quantity ϵ_{gen} strongly depends on the luminous flux. It is close to zero for $N < N_{thresh} \approx 10^3$—$10^4$ and attains values 10^{-3}--10^{-2} near N_{thresh}. The role of "noise" is played by the granularity of the photographic fog.

The generalized quantum yield of multistage IC of the UM-UMI type used in astronomy, (V. M. Sotnikov and S. D. Fanchenko, in: Diagnostika plazmy (Plasma Diagnostics), Vol. 2, M., Atomizdat, 1968, p. 145) may, in a sufficiently good approximation, be represented by a relation of the form $\epsilon_{gen} = \epsilon_{pc}[1 + \hat{n}_{noi}\tau/n_{sig})]$. For short exposures τ, when the number of image electrons n_{sig} in a resolved element of the image is much greater than the number of dark-emission electrons from the input photocathode, the generalized quantum yield of the instrument, as a whole, is none other than the quantum yield ϵ_{pc} of the input photocathode. In order to judge the sensitivity of IC in the case of prolonged exposures, we must have data about the intrinsic noise of these instruments.

The nature of the intrinsic noise of multistage IC was thoroughly investigated by E. K. Zavoiskiĭ, M. M. Butslov and G. E. Smolkin, [Dokl. Akad. Nauk SSSR 111, 996 (1956) (Sov. Phys.-Doklady 1, 743 (1956))], who discovered that the dark current from the input antimony-cesium photocathode contained two components: a single-electron component due to thermionic emission, and a multi-electron component due to the bombardment of the photocathode by ions of the alkali metals present in the tube of the instrument. When a cesium ion hits the photocathode, a bunch of, on the average, 7—10 electrons is emitted from a single point of the photocathode within a time $\Delta t \leq 10^{-11}$ sec with an initial energy spread of the order of 10 eV.

The experiments performed in this work revealed the following properties of the intrinsic noise of the IC. The single-electron component of the noise can completely be eliminated by means of an appropriate cooling of the input photocathode. However, cooling has no appreciable effect on the multi-electron component even when the temperature of liquid nitrogen is attained. The number $\hat{n}_{noi}$ of the multi-electron group emitted from a resolved element of the photocathode per second depends, first, on the degree of contamination of the internal surfaces of the IC by alkali metals and, second, on the accelerating potential difference V across the stage. This dependence may be used to select the most advantageous operating conditions for IC in astronomical observations. Indeed, for certain models of IC, the number $\hat{n}_{noi} \sim 10^{-1}$ for V = 12 kV. Reduction of V to 5–6 kV lowers $\hat{n}_{noi}$ to 10^{-4}. Some resultant reduction in the overall gain, is easily compensated for by the increase in gain and the number of subsequent stages of the instrument. It was precisely in such an optimum regime of power supply to the 1957 model of the IC that the background on the negatives of the above-mentioned joint work at the KrAO (the Crimean Astrophysical Observatory) and the IAÉ turned out, using minute-long exposures, to be almost two orders of magnitude lower than the background from the night sky.

As can be seen from the data cited, in modern IC of the UM-UMI type with a cooled input photocathode, $\epsilon_{gen} \simeq \epsilon_{pc}$ right up to exposures of the order of tens of minutes (without cooling—seconds and tens of seconds). Under these conditions a multistage IC can be considered as a completely noiseless image receiver. For prolonged exposures ϵ_{gen} becomes smaller than the quantum yield of the photocathode because of the intrinsic noise.

Those developing the IC for astronomical purposes are faced with the problem of a technological reduction of this noise to such a level that the exposure time in the noiseless regime reached many hours. Since the nature of the multi-electron component of the noise is known, this task is feasible, and encouraging results, about which more will be said below, have already been obtained on the wave to its solution. Of course a nonobservance of the normal operating conditions for the IC (breakdowns and corona discharges in the high-voltage insulation, unstable power supply, etc.) can be a source of additional "noise." It is clear that when putting each IC into operation all external noise sources of this sort can and should be completely eliminated.

Finally, a few words about the quantity ϵ_{gen} for electron diffraction cameras and television systems. All that has been said about ϵ_{gen} of the IC is applicable to the generalized quantum yield of the electron diffraction camera (the Lallemand camera, spectracon and others) provided the electrons emitted by the photocathode are counted under a microscope. As for the ordinary transmitting television tubes (the super-orthicon, vidicon etc.), ϵ_{gen} for them behaves, depending on the magnitude of the luminous flux, the same way as for photographic emulsions. The role of the unavoidable photographic fog in this case is played by the noise in the beam of electrons being counted.

The data cited on the generalized quantum yield allow the comparison of the basic potentialities of the principal methods of objective registration of images in astronomy: 1) photography, 2) television reception and recording of images (without preliminary intensification); 3) electron-optical image reception with subsequent photography or television recording.

Among the enumerated methods, the direct photographic method has the largest information capacity (a high resolving power, and an almost unlimited area of the field of view). The main disadvantage of photoemulsions is the existence of a sensitivity threshold below which an image cannot be recorded. Television systems with ordinary television tubes suffer from the same disadvantage. Furthermore, they are notably inferior to photographic plates in respect to resolving power and area of field of view, as well as to the amount of image distortion. An important advantage of the television method is the very fact that the observations are conducted at a distance from the telescope, as well as the possibility of easily changing the contrast characteristics of the recorder (the latter does not, of course, pertain to the magnitude of the minimum transmitted contrast, which is determined exclusively by the quantity $(N\epsilon_{gen})^{-1/2}$). Finally, we must remember that, in principle, a television signal can be directly fed into a computer for processing.

Taken separately, the IC occupies an intermediate position between the photographic plate and television in respect of resolving power and area of field of view. In a region of sufficiently high luminous flux it is in respect of the quantity ϵ_{gen} a multiple of ten times superior to the photographic plate. But the most important advantage of the IC with maximum gain over the two other methods is the nondependence of ϵ_{gen} on the magnitude of the luminous flux right up to the minimum values of illumination, when the image consists of the counted light quanta (photoelectrons). If we do not consider electron diffraction cameras, then the multistage IC is the first example of image receivers with limiting sensitivity which is capable of registering separately individual photons (photoelectrons). Photographic (or television) images obtained from the output screen of a multistage IC in the regime of maximum sensitivity acquires a uniquely granular character, determined by quantum fluctuations in the luminous flux at the entrance of the system. The unusual granularity of these images was, apparently, the cause of the well-known prejudice against IC with maximum gain, as if it were an instrument which inadmissibly damaged the quality of photographs. In reality, however, the quantity of images in this case is wholly determined by quantum fluctuations in the primary luminous flux under conditions of "poor" statistics of the photons producing the image. It is clear that on account of quantum fluctuations the magnitude of a signal consisting of N quanta cannot be established with an accuracy higher than $\sqrt{N}$. The question arises as to whether such images are necessary in astronomy. It turns out that they are. Let, for example, the spectrum of a variable star be observed. Let the characteristic variation time of the star be t_c and let during this time N = 500 light quanta fall on the part of the spectrum resolved by the instrument. For a quantum yield of 0.1, we obtain 50 primary photoelectrons. Consequently, an emission spectral line can be reliably recorded and its intensity measured with an accuracy of roughly 15%. A photographic plate and a television tube (without preamplification) generally cannot, in this case, give any image.

Calculations and experiments show that the condition for a photographic (television) registration of such threshold images is a preliminary intensification of their brightness by a factor of up to 10^3—10^4 with the aid of IC.

Of course, in these cases when it is necessary to transmit a small contrast in the image (for example, to detect a weak star against the background of the sky), and the phenomenon itself allows a continuous accumulation of signals, it is not rational to employ intensifications of 10^3—10^4. But the use of a cascade IC with a small number of stages (e.g. the UM or UMI-91, 92), or an IC with contact photography is all the same advantageous, since $(\epsilon_{\text{gen.photoem}}/\epsilon_{\text{gen.IC}}) \sim 10^{-1}$—$10^{-2}$ and the exposure time for obtaining photographic information with the same statistical accuracy can be shortened by a factor of a multiple of ten. Such is the usefulness of intensification by IC in the observation of stationary astronomical objects.

In any case, the threshold sensitivity and the information properties of a combined installation like an image brightness intensifier (IC) plus a recorder (a photographic plate or a transmitting television tube) is wholly determined by its first component—the brightness intensifier. The function of the brightness intensifier is to raise the useful signal above the sensitivity threshold of the recorder.

The papers of methodological character aroused great interest and allowed the participants of the seminar to exchange experiences in the use of IC on a telescopes. In a paper by **V. F. Esipov** and in another by **I. N. Zaĭdel', I. V. Volkov, V. F. Esipov, and P. V. Shcheglov**, the characteristics, results of tests and certain uses of the FKT-1 instrument with a multialkali photocathode were discussed. This IC with a photocontact registration has an effective field of view of diameter 10 mm and a resolving power of 25 lp/mm at the center of the field. The intrinsic noise of the photocathode at room temperature during an exposure time of three hours causes blackening of the photoemulsion, D = 0.3, when the highly sensitive A-600 photographic plate of Kodak 103a D (with a preliminary illumination before exposure) is used. The information gain for the blue region of the spectrum amounts to roughly 10. The instrument does not require a cumbersome outfit and is easy to install on the mobile part of a telescope. At present it is used at the GAISh, at the Leningrad State University Observatory, at the Observatory of the Tartu University of the Estonian SSR and at the Tashkent Observatory.

The use of the FKT in conjunction with the Fabry-Perot etalon made it possible to study the motion of a gas in a number of diffuse and fine-fibered nebulae, as well as to investigate the geocorona. With the aid of a diffraction spectrograph on the 125-cm telescope, a large quantity of the spectra of quasars and supernovae in different stages of brightness have been obtained and the profiles of lines at the centers of variable galaxies are being studied. The possibility of using the FKT for investigating weak astronomical objects is illustrated by the following example. On the 125-cm telescope the spectrum of a 17.5^{m} star is obtained with a dispersion of 250 Å/mm after a 1.5 hour exposure. Further increase of the exposure time is limited by the radiation of the night sky.

In papers presented by **É. K. Denisyuk, K. K. Chuvaev, P. Ya. Sukhoivanenko**, and **A. N. Abramenko** as well as in a paper by **R. E. Gershberg** and **K. K. Chuvaev**, the experience gained in the use on telescopes of the UM-92 three-chamber IC with magnetic image focusing under conditions of direct photography of the image from the output screen was recounted. These IC have an effective field of diameter 40 mm. The image from the screen is usually photographed on a highly sensitive photographic plate in a 1 : 1 scale with the help of an "Avrora-1" objective. The resolution on the photoplate under operating conditions is 10—15 lp/mm.

R. E. Gershberg and K. K. Chuvaev cite in their report data from observations of the spectra of rapid (lasting only a few minutes) outbursts from red dwarfs performed in 1965—1969 at the Crimean Astrophysical Observatory on the G. A. Shaĭn 2.6-meter telescope. Scores of the spectra of the outbursts have been obtained with time resolutions of up to several score seconds. Spectrophotometry of these spectra made it possible to obtain, for the first time, quantitative data about the process of the development of stellar outbursts of the given type and to establish an analogy between them and the chromospheric flares on the Sun. An extensive program of observation of the galaxies in narrow spectral bands is going on on the same telescope.

In Alma-Ata **É. K. Denisyuk** and his co-workers have obtained on the 70-cm telescope about 900 spectra of diffuse gaseous and planetary nebulae, and of elliptic galaxies; direct photographs of 47 elliptic galaxies have been taken and photometrically scanned. A UM-92 is also being used successfully at the PGI (the Polar Geophysics Institute) of the U.S.S.R. Academy of Sciences for the study of the monochromatic emissions of the aurarae polaris (report by **P. Ya. Sukhoivanenko**).

As É. K. Denisyuk and P. Ya. Sukhoivanenko noted in their papers, the use of the UM-92 has extraordinarily extended the possibilities of astronomical observations on telescopes of medium diameter.

It was discovered during the discussion of this group of papers that the level of the intrinsic noise of the UM-92 mentioned by the astronomers was 10—100 times higher than the level observed in laboratory tests of the same instruments. The increase in noise was traced to two causes. First, under the working conditions in the open air, the high-voltage insulation on the IC became damp, the protective layer of lacquer on the instrument itself cracked, etc. It turned out that in individual cases the reporters erroneously included the intensity of the resulting additional background in the figures characterizing the multi-electron component of the intrinsic noise of the IC. Secondly, in view of the fact that the intensification fell short of the level necessary for the attainment of a regime of maximum sensitivity, the UM-92 was often used in an overloaded duty, when the voltage on the input cascade was ~12 kV. This resulted in an extraordinarily sharp increase in the intensity of the really multi-electron component of the intrinsic noise. In such cases it is obviously necessary to use instead the UM-93 instruments or even the UM-95 and appreciably decrease the voltage on the cascades.

A. N. Abramenko and **V. V. Prokof'eva** elucidated in their reports the problems encountered in the application of the television technique with electron-optical preamplification to the photography of astronomical objects. As the transmitting television tube, they used the highly sensitive superorthicon (LI-211 or LI-214) with a UM-92 type multistage IC as brightness preamplifier, as well as the recently developed highly sensitive tube, which is an articulation of a superorthicon and one amplifying stage of an IC in the same vacuum tube. The generalized quantum yield of the television system was experimentally determined. It was 0.03 in the first case and 0.02 in the second for exposures lasting 2 minutes.

With the aid of the television technique the variation in the luminosity of more than 10 weak variable stars of rapidly varying brightness was studied.

In the above-mentioned paper by M. M. Butslov, V. A. Gornostaev et al., the question of the use of image brightness intensifiers for astronomical observations with short exposures, right up to the millisecond range, is considered. Examples of problems of this sort are the observation of the variations in the optical radiation of pulsars and other variable objects in white as well as in spectrally decomposed light, the elimination of the effect of atmospheric turbulence in the photography of planets, nebulae and double stars, the determination of the "instantaneous values" of the coordinates of moving bodies, etc.

Until very recently, the shortest exposure times in astronomy were obtained either with the aid of mechanical shutters or by using accelerating-voltage pulses for the IC. In the present paper an apparatus constructed on the basis of the pulse multistage IC of the UMI series, which were developed for high-speed photography, is shown. In the input chamber of such converters there are a compensated electronic shutter and two pairs of plates which deflect an image in mutually perpendicular directions. This makes it possible to obtain a continuous as well as multiframe scanning in time of the process under investigation. By its speed of response and convenience of exploitation the electron-optical shutter is superior to all known mechanical systems. For the control of the electronic image of an IC, frame and continuous sweep oscillators have been developed which make possible exposures of from 2 to 100 sec. The resolving power with respect to a field of view of diameter 20 mm then attains a value from 40–50 lp/mm for a single-chamber converter, 20–25 lp/mm for the UMI-92 and 10–15 lp/mm for the UMI-95.

A paper by **A. N. Abramenko** and **V. V. Prokof'eva** was devoted to the practical application of such type of apparatus in conjunction with the 70-cm telescope at the KrAO. The results of observations on the changes in the optical radiation of the pulsar NP 0532, which is at the center of the Crab nebula, are cited in this paper. The observations were made in March, 1970, with the aid of a television system in which the UMI-92 IC was used as a preamplifier of image brightness. A step voltage, ensuring a 16-frame time scanning of the image of the pulsar on the screen of the IC and television system, was supplied to the deflecting plates of the UMI-92. The duration of the sweep was, to a high degree of accuracy, equal to the period of the pulsar. The accumulation of luminous energy in each of the 16 intervals of variation of the pulsar brightness lasted thousands of pulsar periods. The construction of the sweep oscillator is similar to a previously published circuit [G. L. Levin, A. A. Markov, et al., Prib. i Tekh. Eksp. No. 6, 100 (1962) (Instruments and Experimental Techniques No. 6, 1164 (1963))]. The length of the period was determined with the aid of synchronized pulses from a PS-12 scalar coupled to a GSS-6 generator.

A communication on an electron-optical attachment to the AZT-8 and AZT-14 telescopes constructed on the basis of a UM-92 type IC, and on the results of tests made on it, was made by **A. A. Anoshkin, K. L. Mench**, and **G. G. Petrov**. They described in detail the construction of the attachment and the high voltage supply to the IC, and gave the characteristics of an auxiliary optical equipment used in the investigation.

A report made by **E. P. Semenov** and **V. V. Kuprevich** dealt with an investigation into the resolving power of electron lenses as the image diminished. With the aid of the frequency response and contrast characteristics, the authors considered how the individual units of the information transmission canal (photocathode, electron optics, luminescent screen, etc.) affect the resolving power of the system as a whole.

The results of an investigation into the possibility of reducing image distortion in multistage IC when a strong magnetic field is used were communicated in a paper presented by **M. M. Butslov, V. I. Komarov, G. E. Kosarev, O. V. Savchenko**, and **L. M. Soroko**.

M. M. Butslov presented a paper devoted to the analysis of the causes of the appearance of background luminescence of IC. They considered diverse effects, which make contributions to the intrinsic noise background: thermionic emission from the surfaces of the photocathode, bombardment of the photocathode by accelerated ions, electron emission of diverse character from the side walls and the mounting parts of the IC with the electrons hitting the field of view on the luminescent screen, etc. For IC, fabricated in the usual manner, the main contribution to the intrinsic noise of the best samples are made by only the first two effects. In many samples, however, an increased level of noise is observed which is connected with the last effect (localized field emission, etc.). It is shown in the paper that in all the indicated cases the main cause of the increase in the noise level is the entrance into the volume of the IC of the vapors of the alkali metals (K, Na, Cs) when the photocathode is being formed. The alkali metals not only bombard the photocathode, they also lower the work function and increase the probability of parasitic dark emission from the inner surfaces of the instrument. For an effective lowering of the noise level a method for the fabrication of IC with the aid of a manipulator has been suggested and tested. In this method the photocathode and the body of the instrument are fabricated in separate bulbs and then the photocathode is introduced into the IC tube under high vacuum. It is shown on the example of the series of IC with electrostatic image focusing that, for a nominal accelerating voltage of 15 kV, the use of the manipulator lowers the noise level by one-two orders of magnitude for an oxygen-cesium as well as for a multi-alkali photocathode.

M. M. Butslov, Yu. A. Karasev, S. V. Lipatov, B. M. Stepanov, V. N. Stozhkova, and **T. M. Fedorovskaya** presented a paper devoted to a detailed treatment of the characteristics of IC with electrostatic and magnetic focusing, fabricated with the aid of a manipulator, and to new models of IC with improved image quality.

A direct measurement of the brightness of the dark background of the single-chamber IC, fabricated with the aid of a manipulator, showed that for a two-hour exposure of an A-600 photoplate by the photocontact method, the blackening is 0.17 and 0.4 for sensitivities of a multi-alkali photocathode respectively equal to 100 and 150 μ A/lumen. This indicates the absence of other forms of noise besides the thermionic noise. For these measurements, single-chamber IC of the P8-Shch and M9-Shch types with luminescent screens on thin mica output windows (dimensions of the windows were, respectively, 5 × 40 and 5 × 50 mm) were fabricated. It is interesting to note that the visual resolving power in both cases was 50 1p/mm, while the photographic (in contact photography) resolving power was 33 1p/mm along the entire length of the slit output window of the M9-ShCh instrument.

Described in the report are the recently developed models M9-V, M9-2V and P8-2Shch of IC. IC of the type M9-V are fitted at the output end with a fiber-optic faceplate with an effective diameter of 40 mm. Its resolving power, measured by the photocontact method, turned out to be equal to 40 1p/mm, this quantity being determined mainly by the resolution of the fiber optics used.

An IC of the type M9-2v is manufactored in modular form. It has fiber-optic faceplates at the output as well as at the input end. The resolving power of such IC is 35 1p/mm.

For work in the ultraviolet part of the spectrum, in the vacuum ultraviolet and soft x-ray region, a P8-2Shch type IC with a mica input window of thickness about 10 μ has been developed. The photocathode is deposited on the inner surface of the window.

The receiver of short-wave radiation in this IC is the luminescent screen-convertor deposited on the cathode window on the exterior side. The thickness of the layer of the screen and the type of phosphor are determined by the characteristics of the short-wave radiation which is to be registered. The resolving power of such an IC is determined by the resolution of the phosphor-convertor.

The long and fruitful discussion of the problems of electron-optical Astronomy carried on at the seminar not only contributed to a clearer elucidation of the basic potentialities and prospects of the use of image intensifiers, it also made it possible to expose the problems of development and improvement of the IC. It is now time to develop for Astronomy diverse almost noiseless image amplifiers with small as well as extremely large amplification for high-quality images and uniform sensitivity over the field of view.

Translated by A. K. Agyei