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Surveys of Foreign Scientific and Technical Literature

TRACKING OF MISSILES AND SPACE VEHICLES

Stuart Hibben

Aerospace Technology Division
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FOREWORD

This is the twenty-sixth report reviewing Soviet Developments in tracking of missiles and space vehicles. The material has been taken from Soviet open literature available to the Aerospace Technology Division and the Library of Congress. The bulk of the report covers the period from December, 1965 through August, 1966; in addition, articles dating back to June, 1964 have been included which relate to the following three topics: precision frequency measurements, precision angular displacement measurements, and precision analog-digital data conversion.

The 81 abstracts are arranged alphabetically by author within the eleven categories shown in the Table of Contents. A bibliography is presented at the end of the report.

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TRACKING OF MISSILES AND SPACE VEHICLES

1. Tracking Facilities and Institutions

Ill, Marton. Hungary's role in satellite tracking. Magyar Tudomany, no. 5, May 1966, 299-305.

Tracking activities in Hungary are directed by the Astronomers' Committee of the Hungarian Academy of Sciences and by the Earth Satellite Tracking Subcommittee, and are supported by the Soviet Academy of Sciences. Four satellite tracking stations operate in Hungary: No. 1111 Budapest; No. 1112 Szombathely; No. 1113 Baja; and No. 1114 Miskolc. They work in connection with the following computer centers: COSMOS, Moscow; Computer Center of the Academy of Sciences of the German Democratic Republic, Potsdam; Computing Center of the Polish Academy of Sciences, Warsaw; Space Research Center Satellite Orbits Group, Slough (Great Britain); Smithsonian Astrophysical Observatory, Cambridge (USA); and the Independent Tracking Coordination Program, Washington.

All four stations employ the optical tracking method, but only Baja is equipped for photographic tracking. The expense and scarcity of measuring instruments are still problems. Instruments used for optical tracking need to have a field of view of at least 8 to 10° and highly accurate timing. Many of the instruments used in Hungary had to be altered to meet qualifications. For timing accuracy Miskolc uses a continually running stop watch, the reading of which is photographed during measurements. With this method precision of 0.1—0.2 sec can be achieved. In Budapest and Baja an electromagnetic chronograph records time through synchronized contact with the photographic equipment used for position determination; the error is less than 0.05 sec. Baja also has a glow-discharge lamp chronograph with no moving parts. The chronograph registers time on film and permits measurements accurate to 0.1 msec. In Szombathely a frequency reference gage accurate to 10^{-8} and a digital time-interval meter accurate to 0.1 msec are used.

All four stations use adapted TZK-type telescopes for optical tracking. They have a field of view of 8° and about 8.5 magnitude. The instruments were equipped with a photographic registering device for greater precision. The determination of satellite positions with these instruments reaches an accuracy of 3 to 6 min, which fulfills the requirements of COSPAR.

Previously Baja used a domestic camera of f 1:5.6 speed and a 50-cm focal length for photographic tracking. This camera has only limited use, and in 1964 the Soviet Academy of Sciences gave Baja a NAFA-3c/25 type camera with 1:2.5 speed, 25-cm focal length, a field of view of 40 to 50°, and an error of 4 to 6 sec. Accurate timing is achieved by a Rohde Schwartz transistorized quartz watch with a chronograph. However, the NAFA camera has a relatively small magnitude (3—3.5). At present a photoelectric (nearly monochromatic) spectrophotometer is being built at Szombathely which will permit 2-channel photometry.

Budapest, Miskolc, and Baja participate in the INTEROBS program; the Baja tracking station also takes part in synchronous photographic observation of the Echo satellites. A total of 7986 position determinations were made in Hungary during 1965, 1442 of these by photographic tracking.

Baja initiated the INTEROBS program a few years ago and at present serves as its coordination center. The main objective of this program refers to determinations of the sudden density change taking place in the upper atmosphere. Because Hungarian scientists are so deeply involved in this program, Hungary was chosen for an international meeting on the use of satellites in scientific research held 14—18 October 1965. Hungarian scientists E. Illes and I. Almar were able to demonstrate on a satellite 60,053 sudden changes in acceleration which they related to changes in solar activity. The other subject of great interest at the meeting was the application of photographic tracking, especially in geodesy. The satellite geodetic method was organized during 1963—1964, with the Baja tracking station participating. The first analyses of the results were presented at the meeting and were considered encouraging. It is expected that the error in position determination will not exceed 10 m in 3000 km. So far Hungarian scientists have contributed only observations, not analyses, to the geodesy program. A Hungarian astrogeodetic work group is to be formed in the near future.

Photometry is considered a neglected field in satellite tracking; only two papers were read on the subject. It was revealed that photometric observations have established a connection between the rotating periods of satellites and solar activity. During the meeting a representative of the Zeiss Works announced that the new SBG 420.500.760 satellite-tracking telescope will be introduced in October 1966. It is expected that the error in observations will be reduced to 1"—2".

Masevich, A. G. International School for satellite observers. IN: Akademiya nauk SSSR. Vestnik, no. 1, 1966, 106-107.

The Astronomical Council of the Academy of Sciences USSR, in cooperation with the Tashkent Astronomical Observatory, has organized an international school in Tashkent for satellite observers. The course lasted from 7 to 15 September 1965, in accordance with the plan of mutual cooperation between the academies of sciences of the socialist countries on the problem: "Scientific research through satellite observation." Participating in the studies were 40 young specialist from Bulgaria, Hungary, East Germany, Mongolia, Czechoslovakia, Poland, and the Soviet Union. Lectures and practical exercises were conducted by scientists of the Astronomical Council of the Institute of Theoretical Astronomy, the Main Astronomical Observatory (Pulkovo) of the Academy of Sciences USSR, and the Tashkent Observatory of the Uzbek Academy of Sciences.

The first series of lectures dealt with the use of the data of exact photographic observations of satellites for the solution of important scientific problems. The lecture on space triangulation, a new branch of geodesy engendered by the creation of satellites, was given by D. Ye. Shchegolev (Pulkovo Observatory). He outlined the most recent results of synchronous photographic observations conducted in the USSR and the countries cooperating with it, as well as the USA and France; he also sketched the future prospects of this new branch of science. G. A. Chebotarev (Institute of Theoretical Astronomy) discussed the use of exact photographic observations of satellites for obtaining a more accurate theory of the Earth's figure. The students were acquainted with newly determined values of coefficients of high-order members in analyzing the gravity potential, which were obtained on the basis of long series of observations of numerous satellites.

A. G. Masevich (Astronomic Council) dealt with the study of the density of the atmosphere at various altitudes according to the results of the exact photographic observations of satellites. He paid particular attention to periodic and sudden fluctuations of the density of the atmosphere connected with solar activity. The lecture included a survey of the works of Soviet, British, American, and German scientists in this field from data of observations of more than 50 satellites.

The second series of lectures, dealing with the methodology of exact photographic observations of satellites, was begun with a survey of the means of observation. A. M. Lozinskiy (Astronomic Council) told about special cameras used in the Soviet Union and abroad for photographing satellites and demonstrated a modernized NAFA-3-c camera equipped with a programming device. His second lecture dealt with special aspects of satellite observations and how they differ from star and planet observations. He related the experience of the Zvenigorod Station of the Astronomical Council and gave the audience a number of practical suggestions. B. V. Yasevich gave a lecture on the ways and means of ensuring that the observation stations have moments of exact time.

The third series of lectures included topics on the astronomical processing of negatives. The existing methods of the photographic astrometry were described by A. P. Deytch (Pulkovo Observatory). His second lecture dealt with stellar catalogs, which provide the celestial coordinates for comparison stars. Many of the existing catalogs were demonstrated, including the atlas with enumerated stars, recently published in the USSR, which was compiled by the Soviet Geodetic Service especially for facilitating the processing of satellite photos. A. A. Kiselev (Pulkovo Observatory) discussed the peculiar features of the astrometric processing of satellite photographs and the possibilities of more exact determination of satellite position, by taking into account some deficiencies of the cameras.

Finally, in the last series of lectures, staff members of the Institute of Theoretical Astronomy analyzed the problems of computing the elements of satellite orbits according to observations (Yu. V. Batrakov), of the ephemerides of satellites according to the elements of their orbits determined by electronic computers (A. S. Sochilina), and ephemerides of satellites at the stations by using tables (I. I. Belozemtsev).

Practical exercises were conducted every day along with the lectures. The students made observations in groups of 5 or 6 under the guidance of an experienced teacher. They received time radio signals, photographed the satellites, processed the photographs, identified the stars, made measurements, fixed the continuous-action cameras, computed moments of observation and satellite coordinates. The weather was clear, and the bright Echo balloon satellite passed high in the cloudless Tashkent sky regularly, twice in 24 hours, during the evening twilight, thus creating the most favorable conditions for the novice observers.

Medvedev, P. Space communications systems. Aviatsiya i kosmonavtika, no. 6, 1966, 66-69.

There are four basic kinds of space communications systems: ground-to-space, space-to-space, ground-to-ground, and global communication systems. Basic features of each are considered with particular reference to communication satellites and global systems of communication. Radio frequencies in the 100- to 10,000 Mcps (wavelength from 3 m to 3 cm) range are recommended; even better quality of transmission can be obtained in the 1000—10,000 Mcps communications "window". In considering global systems which would provide worldwide communications by means of relay satellites, preference is given to a three-satellite arrangement, i.e., three active stationary relay satellites launched into a circular orbit 35,800 km above the equator (see Fig. 1). Soviet experience with communication satellites is discussed. It is said that the USSR had launched three Molniya-1 type communication satellites into high elliptic orbit (see Fig. 2). These satellites provided nine hours of continuous communications for the entire territory of the USSR during the first orbit, and three hours between the European USSR and North and Central America during the second orbit. The satellite was equipped with a relay for transmitting radio and TV programs, command and control systems, an orientation system, and orbit-correcting equipment, and solar batteries and chemical sources provided the electric power. The onboard relay equipment of the Molniya-1 is controlled from the ground. On command from the ground it transmits one TV program or is switched to multichannel two-way telephone, telephoto and telegraphic communications. Ground stations have special antennas, powerful transmitters, and highly sensitive receiving equipment, as well as special equipment for increasing the density of multichannel telephone service. The satellite is equipped with a highly directional antenna, and its operation has good technical qualities. Soviet experts consider the Molniya-1 type satellite, with its ultralong-range communications capability, a prototype of a future worldwide comprehensive communications system.

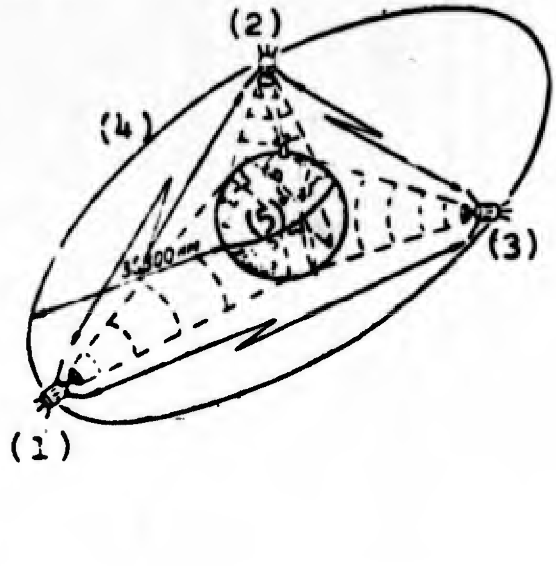


Fig. 1. Global communication system

1 - Artificial Earth Satellite-1; 2 - AES-2; 3 - AES-3; 4 - circular orbit; 5 - equator.

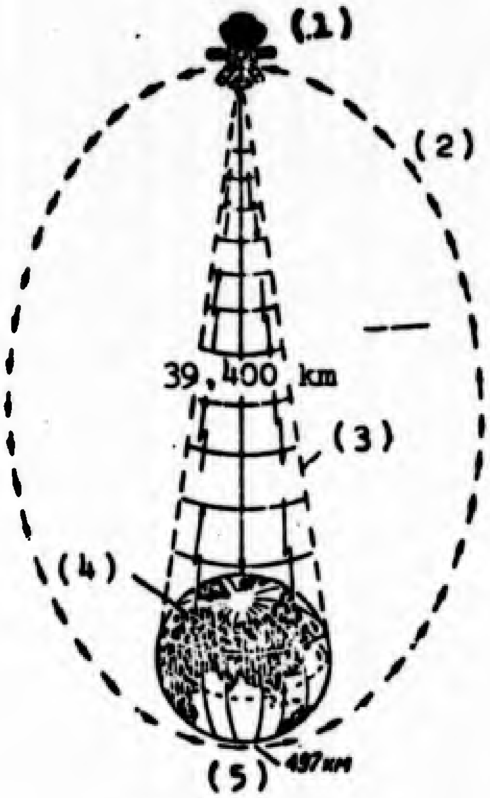


Fig. 2. Communication by means of Molniya-1 satellite

1 - Molniya-1 satellite; 2 - elliptic orbit; 3 - conical space-to-ground radiobeam; 4 - zone of radio communication; 5 - perigee 497 km.

2. Tracking Equipment and Techniques

Abele, M. K. A three-axis automatic photographic camera for satellite tracking. Nablyudeniya iskusstvennykh sputnikov Zemli, no. 1, 1957-1962. Moscow, 1962. Byulleten' stantsiy opticheskogo nablyudeniya iskusstvennykh sputnikov Zemli; spetsial'nyy vypusk, 55-61.

The article describes in detail a camera (f = 75 cm, D/f = 1:3.5, field of view 4 x 5°) for tracking satellites, especially those of low optical density. A method of compensating for the speed of the satellite by movement of the photographic plate is used to keep the image on the same spot long enough to obtain sufficient exposure. The three-axis system of the Baker-Nunn camera was utilized, with certain modifications, to eliminate the need for an accurate ephemeris. The system consists of a guiding telescope which is linked to the camera. Both instruments have similar but separate mountings for rotational movement about the three axes. The guiding telescope serves to correct the angular tracking speed of the system. The main feature of the arrangement is an oscillating film frame which moves in the direction of the satellite image and is synchronized with the movement of the guiding telescope. The motions of the frame, the camera rotation, and the shutter operations are performed by means of an electronic programming device. The frame, which carries a 60-mm film, is rendered immovable with respect to the image for the time of exposure. If the rotational velocity of the camera is not the same as that of the satellite, a hand correction can be made. The "Uran-16" objective of the camera is capable of photographing stars up to 10.4 stellar magnitude with a 1-sec exposure. Up to 17 photographs can be made during one passage of the satellite. Each photograph contains 4 to 6 images. The camera was first installed in July 1961, and regular observations were started in August. The American "Midas-3" and the "Echo-1" satellites, among others, were tracked with the camera. The accuracy of satellite coordinates determined on the basis of positions of the reference stars was found to be ±0.5 to 1".

Afraymovich, E. L. A system for automatic multichannel processing and recording, with a general purpose digital computer, of experimental information from studies of nonuniform properties of the ionosphere. Geomagnetizm i aeronomiya, v. 6, no. 4, 1966, 767-772.

A system for automatic processing and recording of data obtained from pulsed radar studies of the ionosphere is described. The system consists of a data processing unit, a magnetic tape recorder, and an input circuit for a general purpose digital computer. The processing unit gates the received radar echo pulses, then shapes, pulse-width modulates and finally pulse-frequency modulates the signal before applying it to the input of a serial magnetic tape recorder. The recorder output is fed to the computer memory through an input circuit consisting of a pulse shaper and an eight stage gated buffer register. The output of each gate is connected to the computer input. The system features low noise, effective computer input rates on the order of 1000 numbers/sec, practically unlimited effective memory, and can work with any general purpose digital computer with speeds not lower than 2 to 5 thousand operations/sec. An improved version of this equipment was used in 1965 for processing ionospheric data from 200 observational sessions with satisfactory results. It can also be used for automatic registration and processing of random process data with an upper frequency not over 100 kc. In general the design enables much more rapid data processing because data is recorded on magnetic rather than punched tape, and also because improved algorithms have greatly reduced the demand on working storage capacity.

Aref'yeva, A. V., V. N. Korpusov, I. A. Lysenko, A. D. Orlyanskiy, A. N. Ryabchikov, and N. F. Shuvarikova. Results of a study of the wind regime in the meteor zone by the radar method. Geomagnetizm i aeronomiya, v. 6, no. 4, 1966, 703-706.

The method and results are presented of a study of wind circulation in the upper atmosphere conducted during the first half of 1964 near Moscow (56°N). The wind circulation was measured by radar tracking of meteor trail drifts at altitudes of 85—110 km.

The radar equipment used in the measurements had a coherent pulse output modulating a 33-Mc carrier. The pulse duration, repetition frequency, and power were 10 μsec, 500 cps, and approximately 100 kw, respectively. A form of coding was used in which every fifth pulse was distinct. A two stack transmitting antenna consisting of four 5-element Yagi antennas was employed. The receiver antenna had only one 5-element section. The receiver sensitivity thus achieved was 2—3 μv at a signal-to-noise ratio of two. The display and recording equipment was triggered by the received pulses and was protected from spurious noise by 1) utilization of the coincidence of two consecutive marker pulses for correlating purposes, 2) pre-selection by repetition frequency discrimination, and 3) spurious signal suppression using a special detuned noise receiver. The displayed frames were filmed. Each frame contained information on the distance from the point of reflection of the transmitted pulse, the meteor echo diffraction pattern, the Doppler shift pattern, the date and time, and the antenna direction.

The horizontal component of the unit velocity of meteor trail movement was obtained from direct readings of the radial trail velocity components as recorded by the Doppler shifts. The direction of meteor trail movements was determined from the Doppler shift phase difference obtained at the outputs of two phase detectors in which the reference signals were approximately in quadrature.

The drift velocity readings had considerable fluctuations and, for this reason, were averaged on an hourly basis. The averages were used to study diurnal wind pattern changes. In order to secure meaningful averages using the equipment at hand (based on at least 50 measurements/hr), measurements were made alternately, first in the NS and then in the EW directions. The results obtained at the same time of day but for different days were combined. Thus, about 7000—9000 individual readings were recorded during one 5—7 day measurement session.

On the basis of the observation results, it was established that the magnitude and direction of winds varied from day to day and from month to month. The experimental curves of wind velocities were analyzed by Fourier series, i.e., they were reduced to a constant component and three harmonics (corresponding to 24-, 12-, and 8-hour variations). The second harmonic was predominant. The velocities of the zonal wind components attained maximum values of 20—30 m/sec in April and June. These velocities were lowest during January and March (1—5 m/sec); during February and May they were 12—15 m/sec. The direction varied from easterly during February and March to westerly during the April—May period, and again to easterly in June. The meridian wind components were directed to the south during every month except March. The magnitudes of these components varied from 5 to 18 m/sec; the maximum was observed in March.

Comparison of these results with the published data from similar studies at Manchester and Khar'kov established that similarities exist in the monthly variations and that in all three cases the wind velocities decrease during spring and summer. The curves of the meridian wind components exhibit certain similarities, but the zonal component curves show closer agreement. The data are different when the relative magnitudes of the wind velocities for the three locations are considered. Both wind components at Manchester were weaker than those studied in the USSR. This is attributed to the different times of observation with respect to the 11-year solar activity cycle.

Bakharev, A. M. Telescopic studies of meteors as a method for processing data on the upper atmosphere; and tasks during the IQSY. IN: Akademiya nauk SSSR. Mezhduvedomstvennyy geofizicheskiy komitet. Issledovaniye meteorov, no. 1, 1966, 147-151.

Telemeteors are weak meteors which can be observed only by telescope. The study of these meteors is associated with studies of the physical properties of meteoric showers entering the terrestrial atmosphere. There are showers consisting only of telemeteors, but these showers are connected with streams of big meteors and radiants, whose orbits are known. Telemeteors can be observed and recorded with wide-scope telescopes. The average count for individual telemeteors is two per hour. If meteoric showers are included, the number of meteors during one hour increases. The quantity of meteoric matter entering the Earth's atmosphere during one year was estimated at about 50 thousand tons. This quantity is less than that determined from satellite data. The appearance of meteors at night is variable, with a minimum at midnight. Relative heights from flash H_1 to extinction H_2 were computed from the ratio H_1/H_2 and represented in a table. The ratio attained minimum value soon after midnight. The yearly telemeteor rate shows maxima in June and December during solstices.

Batrakov, Yu. V. Determination of the relative position of observation stations using artificial earth satellites. Astronomicheskiy zhurnal, v. 42, no. 1, 1965, 195-202.

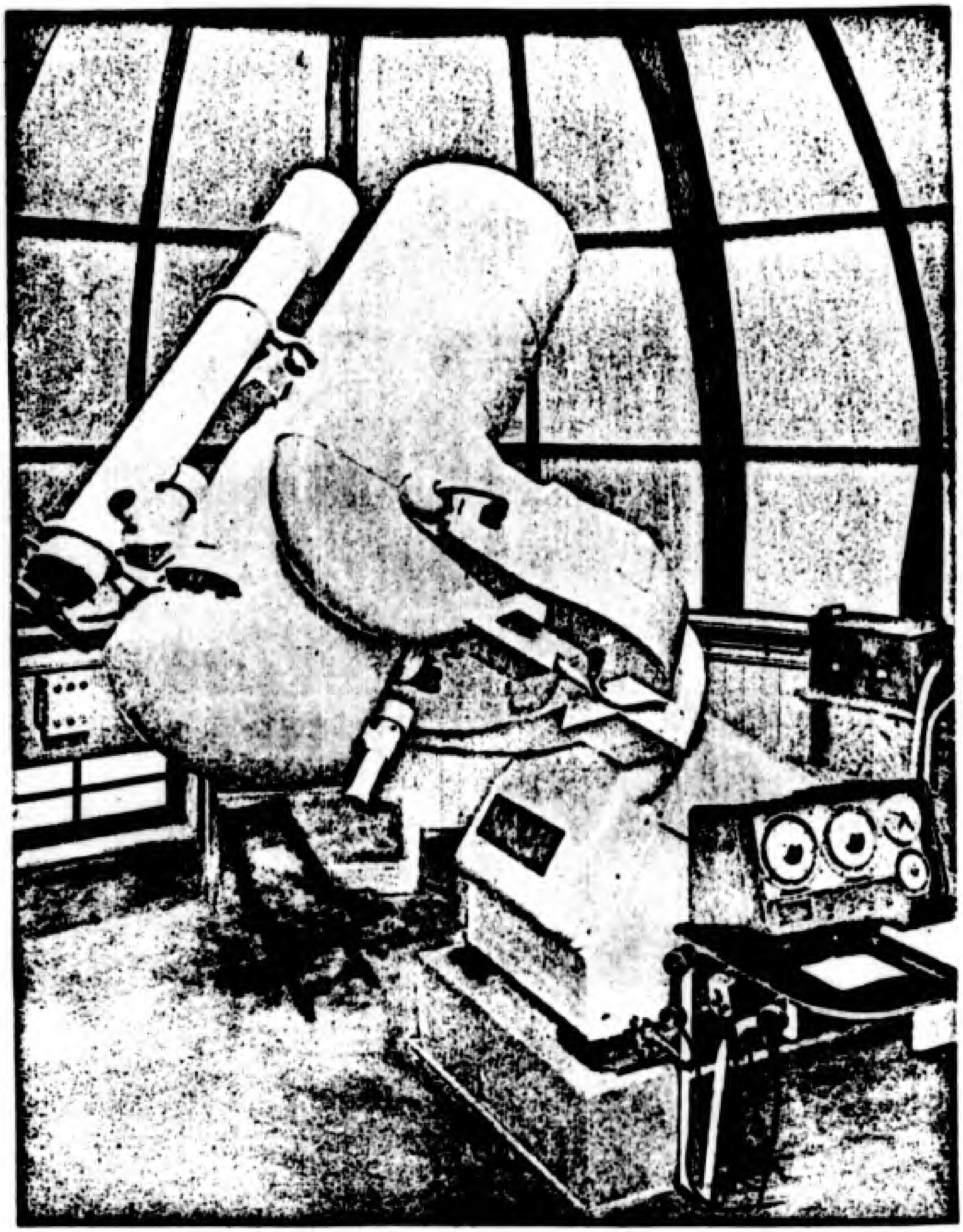
The purpose of this paper was to call attention to some possible uses of simultaneous or almost simultaneous observations of satellites in the determination of the relative position of stations at a considerable distance from one another on the earth's surface. In addition, together with the possibilities of using simultaneous observations of α, δ, and ρ, the paper discusses the possibilities arising from the use of observations of $\dot{\alpha}$, $\dot{\delta}$, and $\dot{\rho}$, and also observations containing time errors. Also considered is the problem of the use of nonsimultaneous observations. In determining the relative position of stations, it is assumed that observations can give not only the angular coordinates α and δ, but also the topocentric distances ρ and the first derivatives of these values $\dot{\alpha}$, $\dot{\delta}$ and $\dot{\rho}$. Technically, α and δ can be determined from measurements of satellite photographs and ρ and $\dot{\rho}$ by direct radiotechnical measurements; in addition, $\dot{\alpha}$ and $\dot{\delta}$ are determined by differentiation of the polynomials representing changes of α and δ with time. It is noted that, although $\dot{\alpha}$ and $\dot{\delta}$ are obtained from α and δ, in certain cases they can yield additional information which is lost if only α and δ are used. An example is the case when the arcs of an orbit overlapping in a small segment are observed from two stations. In this case, observations in the nonoverlapping segments are lost if only simultaneous observations of α and δ are used, but they give additional information if α and δ are used to form $\dot{\alpha}$ and $\dot{\delta}$. In the case of the use of nonsimultaneous observations (with precise recording of time), it is shown that it is possible to determine the interval of time in which it is possible to use nonsimultaneous observations. Finally, it is shown that an expression can be derived for determining the relative position of stations using observations with time errors.

Genkina, L. M., N. N. Denisyuk, and E. S. Yeroshevich. Photographic observations of the entrance of the Echo-2 satellite into the earth's shadow. Astronomicheskiy zhurnal, v. 17, no. 5, 1965, 1117-1119.

A photographic study of the entrance of the Echo-2 satellite into the earth's shadow was made in April 1964 to determine atmospheric effects on the brightness of the satellite. The study was made at the Institute of Astrophysics of the Academy of Sciences Kazakh SSR, with a D. D. Maskutov meniscus telescope system which has a focal length of 120 cm, a diameter of 50 cm, a 5° field of view and rotation rates of 1/6 or 1/3 deg/sec. The satellite was photographed at intervals of 0.5 sec, without any filters, on Ilford Zenith plates mounted on a plane-parallel variable plane having a displacement perpendicular to the satellite path, and located at the focal plane of the telescope. A chronograph synchronized with six Moscow radio stations was used to record the start and finish times for each plate with an accuracy of 0.1 sec; the accuracy of the intermediate steps was 0.01 sec. The satellite was photographed before and during its entrance into the earth's shadow, and then reference stars were photographed for comparison purposes. Satellite brightness for each segment of the trace was found through standard photometric methods (from the width of the photographic trace) with an accuracy of ± 0.2 stellar magnitude. In two nights 21 negatives were taken: 13 of known stars, five of the satellite before entering the earth's shadow and three of the satellite after entry. There were significant differences in results between the two nights. For example, after entering the earth's shadow the satellite brightness decreased respectively by four and two stellar magnitudes in five seconds during orbits on April 1 and April 5. These variations are attributed to differences in aerosol, ozone and refractive properties of the atmosphere. The relationship $D = a\omega^n + b$ for constant brightness was established, where D is the width of the photographic trace; ω is satellite speed, and a, b and n are constants which depend on satellite speed.

Hu, Ning-sheng (5170/1380/3932). Catadioptric telescope of the Purple Mountain Observatory. T'ien wen hsueh pao (Acta astronomica sinica), v. 13, no. 2, 1965, 219-222.

The Nanking Astronomical Instrument Plant of the Purple Mountain Observatory, Chinese Academy of Sciences, in cooperation with the Second Nanking Machine Tool Plant, Nanking Diesel Engine Maintenance Plant, Nanking Boiler Plant, Nanking Ch'and-chiang Machine Plant and other organizations, designed and constructed a 430/600/800 catadioptric telescope for the Purple Mountain Observatory in April 1965 (see figure). The telescope has an aperture of 430 mm, and a focal length of 800 mm providing a focal ratio of 1.9. The diameter of the film is 110 mm corresponding to a field of 7°.6. The main tube of the instrument with one guiding telescope and three finders is supported on a fork-type mounting. Three speeds are available for moving the telescope—slewing at 4°.3 per second, setting at 1' per second, and guiding at 2" per second. The precision worm gear on the end of the polar axis is driven by means of a synchronous motor controlled by a quartz crystal clock of the observatory. All position indications are transmitted by synchros. In front of the correction mirror, there is a hand-control-box to enable the observer to remove the telescope, to make exposures, and to exchange the film-holders. Measurements of several films give about 30—40 microns for the image diameters of faint stars everywhere in the field.

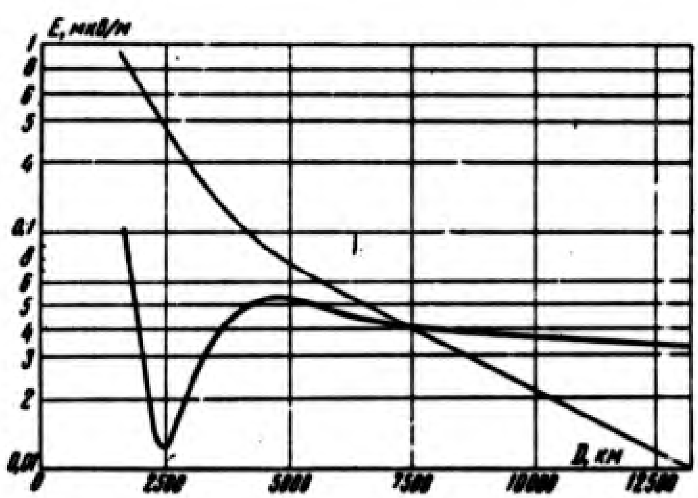


Catadioptric telescope of the
Purple Mountain Observatory

GRAPHIC NOT REPRODUCIBLE

Kazantsev, A. N., and D. S. Lukin. Field intensity of short radio waves emitted by an artificial earth satellite. Kosmicheskiye issledovaniya, v. 4, no. 2, 1966, 238-241.

A study is made of the dependence of the field intensity of short radio waves emitted by an artificial earth satellite on distance, under various propagation conditions and parameters of the ionosphere. Formulas are derived for calculating the focusing factor for the emission (without consideration of the magnetic field) and for the total absorption coefficient factor for the radio beam path. A Strela-M computer was used for the calculations. Some results are given in the figure, which shows received signal intensity vs. distance from the transmitting satellite. Three zones can be seen: 1) a sharp decay of signal out to approximately 2500 km from the satellite; 2) a zone of increased strength, 2500—5000 km, attributed to the fact that the scattering angle with the F-layer is increasingly less with distance; 3) a zone of gradually decreasing signal, 5000—15,000 or 18,000 km; here there is evidently no further Earth-ionosphere reflections of the signal, and scattering effects predominate. Also it was noted that in this furthest zone, field strength does not decay as the inverse of range, but rather more slowly.



Signal intensity vs distance

Kokurin, Yu. L., and Yu. A. Kovura. Measuring irregular refraction of radio waves in the ionosphere by means of signals from artificial Earth satellites. Radiotekhnika i elektronika, v. 11, no. 3, 1966, 439-444.

A theoretical method of isolation of the interference curve free from polarization fading is set forth; information about irregular refraction is obtained by determining the angular position of characteristic points on this curve. The experimental study included interferometer reception of a 30-Mc signal from a "Mayak" transmitter aboard the "Electron-2" satellite. A horizontal half-wave dipole with a reflector and an R-250 superheterodyne receiver were used; the receiver passband was 4—5 kc. After detection, the signal was applied to a balanced d-c amplifier and recorded on tape. The same equipment was used in a second receiver 2 km away. The antennas of both interferometers were so positioned that within azimuth angles of 100—250° the signal was reflected only by the sea surface. Analysis of signal variations due to atmospheric inhomogeneities, recorded in March 1964, are included.

Krotikov, V. D., V. P. Lastochkin, and K. S. Stankevich. Measurement of the absorption of decimeter radio waves in the atmosphere. IVUZ. Radiofizika, v. 8, no. 5, 1965, 1044.

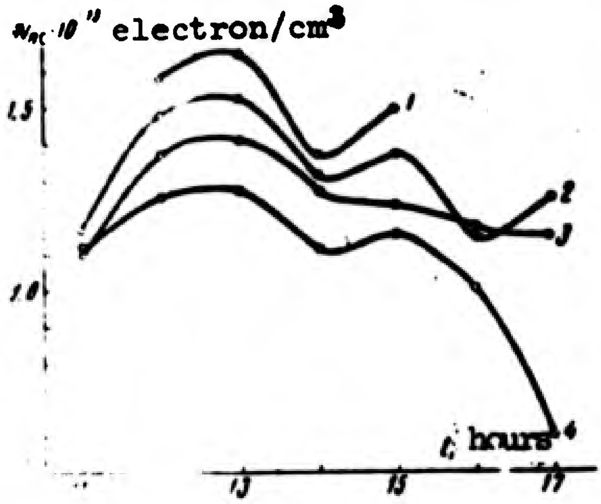
The vertical distribution of the temperature of the intrinsic radiation of the atmosphere was measured at wavelengths 16.3, 18.9, 21, and 30.6 cm at elevations from 5 to 30°. The antenna beamwidths at the halfppower points were respectively 24', 30', 35', and 40'. The brightness temperatures of the atmosphere were determined by comparing the antenna temperatures for signals from the atmosphere with the discrete source Cassiopaeia-A. The total absorption at the zenith could be determined from the measured and theoretical values of the antenna temperature as a function of the elevation angle. The total absorption in the zenith direction was found to be 0.066 db $\pm$15% for all temperatures, corresponding to a temperature at zenith of 4.1K for the radio emission from the atmosphere.

Mityakov, N. A., E. Ye. Mityakova, and V. A. Cherepovitskiy. Results of a study of the distribution of electron concentration in the ionosphere by a method of ground reception of radio signals from Electron-1. Kosmicheskiye issledovaniya, v. 4, no. 2, 1966, 249-256.

The total electron concentration in the ionosphere above the maximum of the F layer was determined from ground reception of signals of Electron-1 transmitted at 20.005 and 30.0075 Mc. Observations were made during February—March 1964 at Gorky and in the Crimea with equipment capable of recording the phase difference of coherent-frequency signals. Standard PKCh-3 equipment, described earlier by Ya. L. Al'pert et al., was employed in the Crimea, while special equipment capable of recording signal amplitudes and phase differences at coherent frequencies of 20, 30, 40, and 90 Mc was developed for use at Gorky. Standard R-250 M receivers were employed. Signals from a coherent reference heterodyne were also fed to the receivers. In the presence of satellite signals, low-frequency beats were generated at the output of the receivers. After passing through narrow-band filters, the low-frequency signals were fed to a phase meter, where they were brought to a single frequency of 9 kc. On the basis of recorded phase differences, total electron concentration was determined to altitude z_c of the satellite from the following formula:

$$N_{nc} = \int_0^{z_c} N dz$$

where N_{nc} is the vertical profile of the ionosphere passing through a point at which radio beams intersect with the maximum of the F layer. Curves showing the diurnal variation of N_{nc} for various intervals of geographic latitudes are given in the figure. The total electron concentration was found to increase in the southward direction.



Diurnal variation of the electron concentration for various geographic latitudes

1 - 51—53°; 2 - 53—55°; 3 - 55—57°; 4 - 57—60°.

Prokopchuk, S. I., and V. P. Karnaukhov. A system for measuring radiowave attenuation and drifts in the ionosphere. IN: Akademiya nauk SSSR. Sibirskoye otdeleniye. Sibirskiy institut zemnogo magnetizma, ionosfery i rasprostraneniya radiovoln. Issledovaniya po geomagnetizmu i aeronomii (Studies in geomagnetism and aeronomy). Moscow, Izd-vo Nauka, 1966, 88-90.

A system for measuring and recording the attenuation of radiowaves and the horizontal drift of small inhomogeneities in the ionosphere is briefly described. The system consists of a variable power output transmitter with a maximum pulse power of 20 kw, two modified R-250M receivers (with the AVC and ladder i-f filters removed) operating with three antennas. One receiver is used for measuring the attenuation factor;it normally uses a three beam umbrella-type antenna. The other receiver measures the drifts and is normally tied to two inverted L antennas in a space diversity configuration. Any receiver may be connected to any antenna by virtue of an electronic commutator. The recording of drift or attenuation is done with the aid of 13L037 display tubes whose images, and a special mask with time data, are continuously filmed with a "Konvas" movie camera. During the registration of drifts the x-sweep is automatically removed, and the reflected pulses are applied to the z-axis of the CRO. The additional system data are as follows: transmitted pulse duration, 100 μsec; pulse repetition frequency, 50 cps; receiver sensitivity, 3 μv; bandwidth, 17 kc; film transport speed when recording attenuation, 26.8 mm/sec and 160 mm/sec for drift.

Rizvanov, N. G. Use of a long-focus horizontal telescope with coelostat for positional observations of the moon by the photographic method. IN: Akademiya nauk SSSR. Astronomicheskiy sovet. Komissiya priborostroyeniya. Soveshchaniye. Kazan, 1964. Novaya tekhnika v astronomii (New techniques in astronomy); materialy soveshchaniya, no. 2. Moscow, Izd-vo Nauka, 1965, 56-57.

In order to study the rotation and the figure of the moon, a horizontal telescope was constructed in 1949 at the Astronomical Observatory imeni V. P. Engel'gardt (Kazan University). The telescope has an immovable objective (D = 200 mm, F = 8000 mm), a coelostat, a clock mechanism worked by weights, and an additional mirror. When making positional observations of the moon with the horizontal telescope, many difficulties arise in obtaining clear pictures of the surrounding 9—10^m stars. Due to diffraction and atmospheric turbulence, the diameter of the photographic images of stars reaches 0.5—1.0 mm, when the lens opening is 1:40. Additional absorption of light occurs on the two mirrors. Therefore, in order to obtain contrast in pictures of the stars, the time of photographing the star field has to be increased to 3—10 min. It must be noted that the results obtained by this method may contain large random errors due to the atmospheric turbulence and the periodic errors of the clock mechanism. However, the measurement and the analysis of several pictures of the moon with the stars, obtained with the horizontal telescope in 1963, have shown that, with good pictures of stars, the accuracy of plate reduction was entirely satisfactory.

Vasil'yev, V. I. Certain problems associated with automatic fault indicators for digital telemetry systems. Priborostroyeniye, no. 6, 1966, 6-8.

Two variants of automatic fault locating units for digital telemetry systems are introduced. Theoretical investigation carried out by the author shows that the optimum number of reliability tests needed for the controlled unit, including the probability of random failures during two clock periods, is two. Based on this, the first circuit has two inputs 1 and 1' connected to the control and controlled circuits. The coincidence or noncoincidence gate outputs set flip-flop T_1 or T_2 and open gates K_1 or K_2, allowing the signals indicating correct or faulty unit performance to reach their respective outputs. In the second variant, the same input signals are first applied to blocking generators BG_3 or BG_4, AND or NAND gates, ferrite-transistor flip-flops FF_1 or FF_2, FF_3 or FF_5, which in turn set flip-flops FF_4 or FF_6. FF_1 or FF_2 are reset by the synchronization pulses at this time. If during the second clock period the state of the telemetry system remains the same, the final outputs from Tp_1 or Tp_2 pulse transformers will indicate correct or faulty equipment performance, respectively. These units assure a minimum down time for telemetry systems. The author further determines the probable information loss caused by a sudden failure of one of w sub-systems each with a different failure rate.

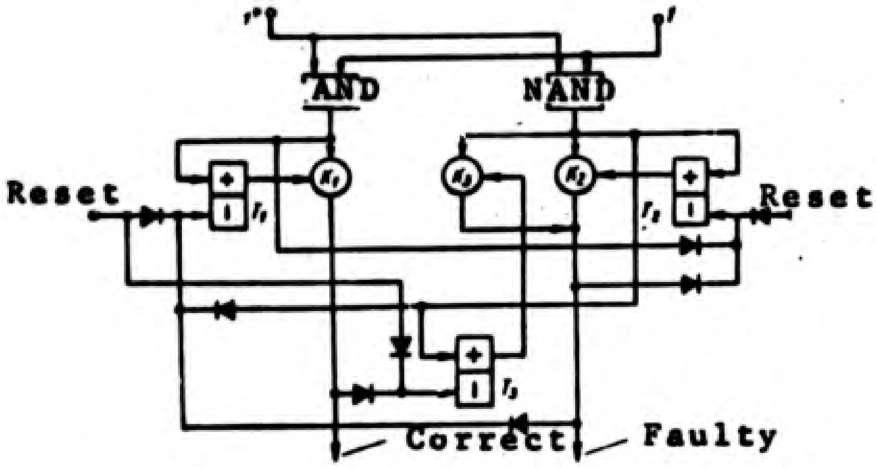


Fig. 1. Failure indicator (variant 1)

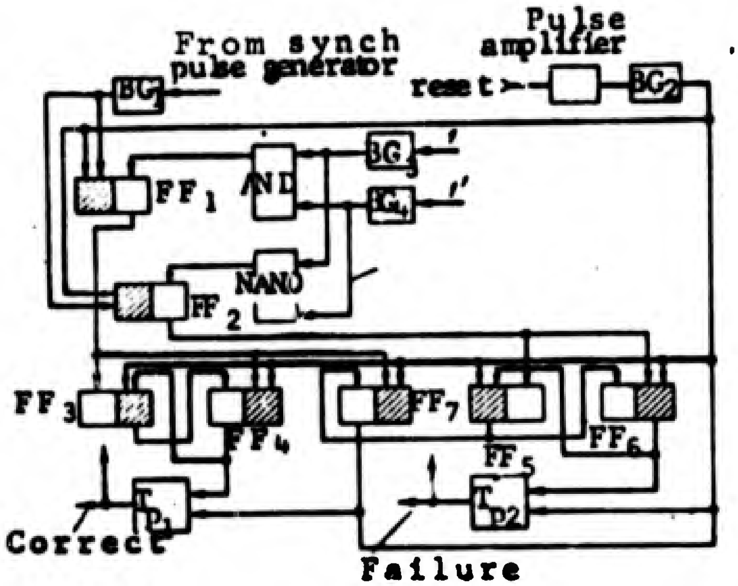


Fig. 2. Failure indicator (variant 2)

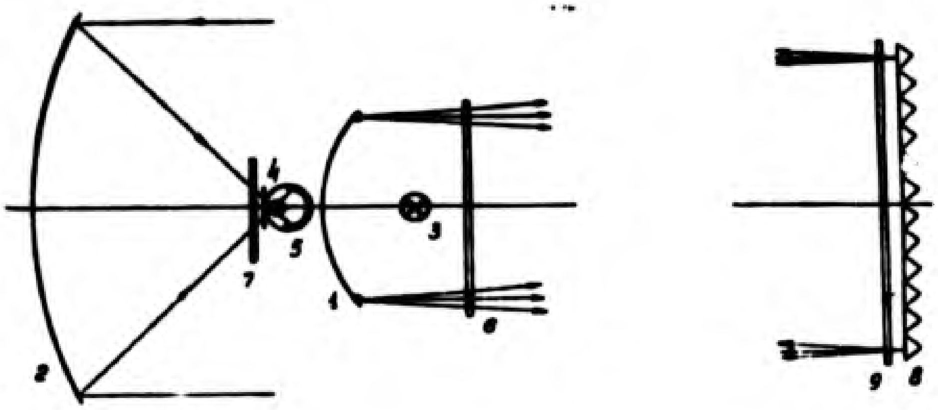
3. Precision Baseline Establishment

Golosov, V. V., D. V. Gordeyev, Ye. P. Ostapchenko, V. A. Perebyakin, and V. F. Khomaza. Possible use of gas lasers in high-precision measurements of distances. Geodeziya i kartografiya, no. 5, 1966, 9-15.

The authors describe experiments in which the light source of a precision optical range finder (SG-2M) was replaced by a small gas laser. The purpose was to increase the accuracy of distance measurements with such a range finder and to permit its use under daylight conditions. The gas was a mixture of helium and neon operating at 6328 Å and delivering not less than 1 mw. The measurements were made of distances of the order of 3 km in sunlight and during twilight. In daylight, when the ordinary light source could not be used, the rms measurement accuracy was ±2.4 mm, and in twilight, ±1.3 mm. Equipping the range finder with a laser approximately doubled the maximum distance measurable at night. The requirements that must be satisfied by the laser are specified, and it is found that the LG-55 developed by one of the MEP SSSR enterprises is the most suitable for this purpose. The dimensions of the laser are listed. It is concluded that the development of optical range finders with gas lasers offers distinct advantages.

Kutev, Yu. M., and A. I. Sadykova. Range calculation of optical range finder systems with return reflectors made from a pyramidal-prism array. Priborostroyeniye, no. 8, 1966, 109-113.

In this paper equations are obtained that express the range limit of an optical ranging system as functions of transmitter, receiver and return reflector parameters, for the case where the return reflector is a plane array of pyramidal prisms. The transmitter-receiver of the system (see figure) consists of a light source (3), a diaphragm (4) and a light receiver (5) located along the focal axis of transmitting and receiving coaxial parabolic reflectors (1) and (2). The analysis shows that as range increases to 50 km or more, the detection range of the system is limited chiefly by a scattering of light in the return reflector. The degree of scattering is determined by the deviation from orthogonality of prism dihedral angles in the return reflector.



Optical ranging system

1 - Transmitting reflector; 2 - receiving reflector; 3 - light source; 4 - diaphragm; 5 - light receiver; 6 - light filter; 7 - light filter; 8 - return reflector; 9 - light filter.

Tlusty, Jaromir. Lasers and their application in geodesy. Geodeticky a kartograficky obzor, no. 3, 1966, 62-67.

There is a growing interest in the use of lasers among geodesists in Czechoslovakia. The purpose of this paper is to enumerate the lasers currently designed and manufactured in Czechoslovakia and their applications, together with background information on the world development of lasers. There was some delay in laser research in Czechoslovakia but all types of lasers are now being developed. The study of the application of gas and solid state lasers in geodesy and mine surveying, especially with regard to their application and modification in laser theodolites and shaft leveling devices, now is a part of the State research program, which, in turn, is a part of the wider studies of quantum properties of mass. Since it is anticipated that geodesists and communication engineers will continue to work on the same main problems in laser research, the cooperation of both groups is necessary. Following are descriptions and data on the main types of lasers designed in Czechoslovakia: 1) The gas-type laser — a quartz tube filled with helium-neon gas mixture and having two spherical mirrors covered with reflecting dielectric coatings (chiefly zinc sulfide and magnesium fluoride) — represents the basic design concept of Czechoslovak lasers. Combinations of either one plane mirror and one spherical mirror, or two spherical mirrors are being used. Power output of these models is essentially within the mw range. In the gas laser model designed by Engineer Doubek (Candidate of Sciences, Faculty Member of the Antonin Zapototsky Military Academy (VAAZ) in Brno) using an infra-red transducer, apparent longitudinal and transverse mode groupings were observed at the wavelength of 1.15 μm. In another model designed at the Instrument Research Institute of the Czechoslovak Academy of Sciences in Brno, an attempt was made to reduce the divergence of the beam by appropriate alignment of the optical system. The output angle was reduced to less than 30". This angle, however, is still much too large for geodetic purposes. 2) Solid state lasers. Most of these are based on the ruby crystal, glass, or other luminescent materials including solidified liquids. In most cases a xenon exciter is used, powered by a high frequency generator. Several designs are being used. In a model designed by Engineer Blabla from the RE Institute (URE) of the Czechoslovak Academy of Sciences, the reflector (mirror) chamber has the form of four ellipses with one common focus in which the ruby is set; there are four exciters in the other foci. Still another model has a spiral exciter mounted around the ruby rod in the center of the system. Other variants have been produced in Czechoslovakia and elsewhere. In all cases, the manufacturing requirements are very high, especially with regard to grinding and to the optical purity of the ruby; nonparallelism of the planes must not exceed more than a few angular seconds. The power output of solid state lasers is in the w-Mw range; the wavelength ranges from 0.6943 m to 2600 μm. Nitrogen-oxygen-, or air-cooling is required for operation in most cases. The beam divergence amounts to about 10 angular minutes in the absence of the optical system. 3) Diode lasers. The first models were built in Czechoslovakia in 1963. In most of them the diode is a gallium arsenide crystal prism. Operation of these lasers requires very low temperature, (optimum range 20—30 K). The divergence of the output beam is considerable, reaching 5° in the transverse direction. In applying lasers in geodesy and related fields electro-optical (pulsed-light) range finders have been used very widely, particularly in the United States, for military and navigation purposes. Among later models, only the Soviet GD-314 range finder exhibited at the Leipzig Fair in 1965 meets geodetic requirements. Its specifications were published in Nauka i zhizn', no. 5, 1965 (range 2000 m with an accuracy of ±2 cm). A gallium arsenide diode is the light source in this laser. The current areas of laser application in geodesy include direction determination in conjunction with a theodolite and level, tachymetric ranging and tracking of artificial satellites, and, conversely, measuring the earth's shape and size. In addition, Czechoslovakia has successfully used lasers in transmitter-target communications. The effect of atmospheric attenuation of laser-signal transmission became apparent in these experiments.

4. Slant Range and Range Rate Measurement

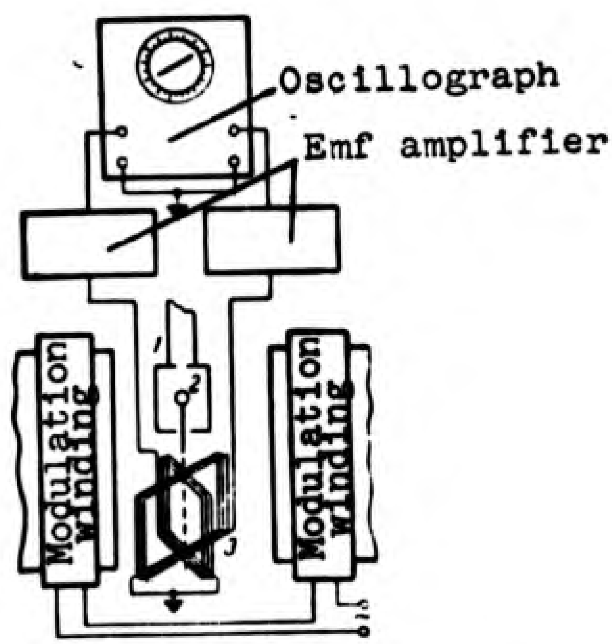
Kaverznev, K. M. Determining the location of a space vehicle. Kosmicheskiye issledovaniya, no. 2, 1966, 327-330.

A method for determining the coordinates of a space vehicle from measured distances between three widely separated points and the vehicle is described. A ranging device is used to measure distances between the three points, A, B and C, and the vehicle. The centroid of triangle ABC is found and, after correction is made for propagation distortion, the value of R is found, i.e., the slant range from the centroid of triangle ABC to the space vehicle. The rms error probability of H, the component of R perpendicular to the plane of triangle ABC, is a function of the rms error in the range measurement, the area of a triangle formed by paths between two adjacent measuring stations and the vehicle and the included side of triangle ABC, and the three distances between the centroid of triangle ABC and its apexes. The technique gives a fast and accurate solution of range of a space object, irrespective of the geometry involved.

5. Angle and Angular Rate Measurement

Bratashevskiy, Yu. A., and A. I. Otko. An induction goniometer for a radiospectrometer. Pribory i tekhnika eksperimenta, no. 4, 1965, 250.

An induction goniometer for measuring rotation angles of an object placed in a cavity resonator inside a cryostat is described. The device, designed to be used in spectrometry, has an accuracy of 1°. The transducer of the device (see figure) consists of two 1000 turn mutually perpendicular coils wound on a plastic core (diameter ~7.5 mm) connected along the axes of the test sample in a cavity resonator. Rotation of the sample results in an equal angular displacement of the coils and changes the emf induced in them. The device is calibrated so that the tilt angle of the Lissajous line on the oscillograph is equal to the displacement angle of the sample. The 1° angular accuracy can be improved by using an indicating device more accurate than the oscillograph, e.g., a bridge or a precise resolver.



Induction goniometer

1 - Waveguide with resonator;
2 - sample; 3 - transducer coils.

Kubrik, M. Sh. A television-based method of angle measurement. Izmeritel'naya tekhnika, no. 1, 1965, 17-20.

A television-computer system for measuring angles is described. The block diagram of the system is shown in Fig. 1. The object (1) is projected on the photocathode of a camera tube (3) with a two-line scan. Signals for vertical and horizontal deflection coils are generated in blocks (4) and (5). The current in the vertical deflection coil determines the distance between the lines (quantity a). After passing through the amplifier (6), the video signal reaches the commutator (7). From here all first lines are directed to the delay block (8), where the signal is delayed for the exact period of the line (Fig. 2, a and b). After amplification and differentiation in blocks (9) and (10), the positive pulses (from leading edges) of the first and second lines reach blocks (11) and (12), respectively, while negative pulses from trailing edges reach blocks (13) and (14) (Fig. 2, c, d). In block (11), a positive pulse is generated whose leading edge coincides with the beginning of the line and whose trailing edge coincides with the positive pulse of the first line (Fig. 2 e). In block (12), a negative pulse is generated whose leading edge also coincides with the beginning of the line but whose trailing edge coincides with the positive pulse of the second line (Fig. 2, f). Both pulses are directed into block (15), where they are integrated, producing pulse x (Fig. 2, g). The duration of this pulse determines the value of the interline difference, and its polarity, the sign of this difference. Pulse x_2 is similarly generated by block (16). These pulses are subsequently sent to the computer circuitry (17) for mathematical processing. Error can be as low as 0.5%.

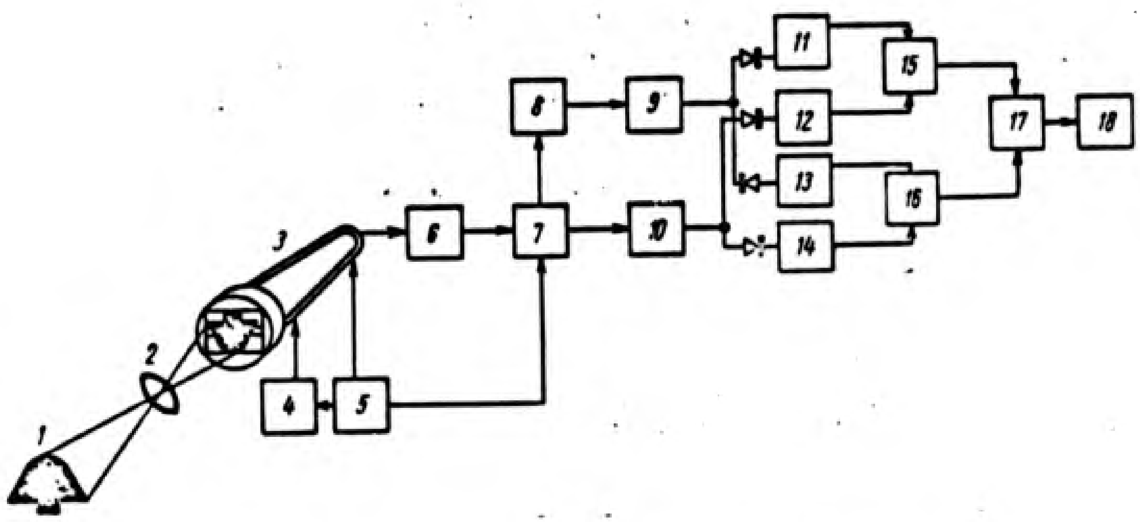


Fig. 1. Angle measuring system

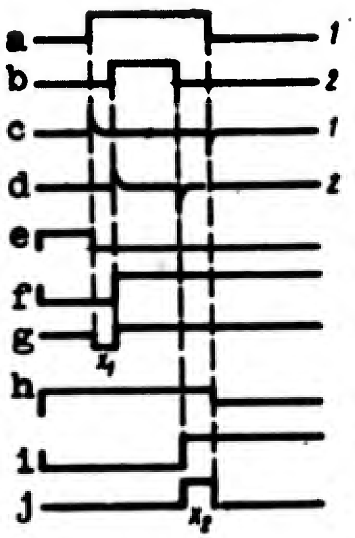


Fig. 2. Waveforms

Tokarev, F. "Vega" astronomic instrument and its practical accuracy. Morskoy flot, no. 11, 1965, 21-22.

The "Vega" multipurpose astronomical instrument is easy to handle and permits altitude h and azimuth A to be quickly determined; however, it has been seldom used in the merchant marine due to its insufficient accuracy. After 120 altitude and azimuth readings had been taken using the "Vega" instrument and the TBA-57 theodolite, an rms error of ≈ ±2.5' was revealed for h and an error of ≈ ±6.2' was revealed for A. These errors are much higher than those given in manuals, where a value of ±1.1' is given for h. About 81% of the measured errors were between 0.0' and ±3.0', and around 90% of A errors were between 0.0 and ±0.5°. The accuracy necessary for marine application can be obtained by increasing the diameter of the planisphere to 250 mm. This would also simplify interpolation and make it possible to use special aids such as found on geodetic instruments. To eliminate the effect of eccentricity, the mean values of two opposite limb measurements have to be considered. Greater accuracy can be obtained by using interferometers.

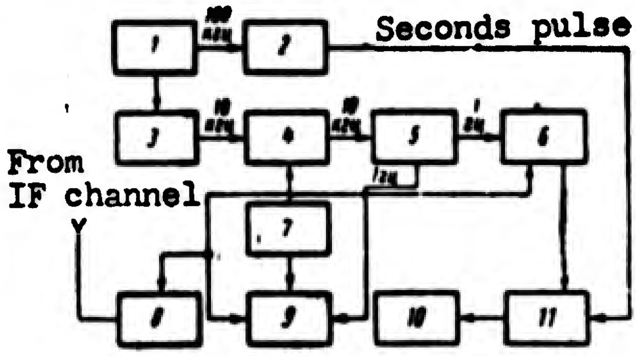
Zhidko, Yu. M. Optimum antenna arrays for determining the angular coordinates of a source. Radiotekhnika i elektronika, v. 9, no. 7, 1964, 1304-1308.

Based on L. E. Brennan's work, formulas which describe the case of two linear antenna arrays with their separate amplifiers are developed. Sum and difference signals $\Delta = A \pm A$ (where A is the amplifier output-signal amplitude) are formed. The exact target position is determined from the ratio of the difference signal to the sum signal. Assumptions: antenna noise is neglected; amplifier noise is distributed according to the normal law; the signal-to-noise ratio in the amplifier is considerably greater than 1.

6. Absolute Time Measurement

Fleyer, A. G., and Yu. A. Fedorov. Instrument for automatic reception of radio signals of exact time in seconds. Izmeritel'naya tekhnika, no. 2, 1966, 82-84.

The development of a device for automatic locking into exact time (seconds) radio signals is reported. The device includes (see figure) quartz-clock master oscillator 1, quartz-clock frequency divider 2, 1:10-ratio scaler 3, phase shifter 4, $1:10^4$-ratio scaler 5, follower stage 6, motor 7, radio receiver 8, signal-recognition device 9, digital printer 10, visual reading device 11. The time radio signal is recognized by the area of coincidence of the radio signal with a locally generated П-shaped gated pulse. The error of time signal reception is claimed to be about 20 or 30 μsec.



Synchronizer

London, G. Ye. A high-accuracy electronic chronograph. Pribory i tekhnika eksperimenta, no, 3, 1966, 138-140.

A high-accuracy electronic chronograph (error +0.02 μsec) for measuring time intervals between 2-msec pulses is described. The equipment consists of two oscilloscopes and a coupling device. An OK-17M oscilloscope with linear sweep serves as a visual electric-pulse indicator and for coarse reading, while an IV-13M type oscilloscope with spiral sweep is used for fine reading.

7. Frequency Measurement and Standards

Gavrish, P. P., Yu. N. Denisov, A. G. Komissarov, V. M. Lachinov, V. I. Prilipko, Yu. I. Sosov, and P. T. Shishlyannikov. Wide-range automatic electronic-counter frequency meter. Pribory i tekhnika eksperimenta, no. 2, 1965, 94-100.

An electronic frequency meter is described which is intended for measuring the frequency of sinusoidal or pulse signals within the 0.1—100-Mc range. Measurements can be made either automatically every 5—30 sec or randomly by pushbotton. The digital-type instrument operates from 0.05—1 v at its input, displays the results on decade tubes, and can also deliver a binary-decimal code suitable for computers. The frequency meter can be used not only for direct frequency measurement but also in conjunction with a nuclear magnetometer for precision measurement of magnetic field strength. A block diagram and circuit diagrams of the amplifier, a 1-Mc reference crystal oscillator, a cold-cathode-tube relaxation generator, frequency dividers, counter decades, an output-to-printer unit, and a clock-frequency decade unit are presented.

Khodzha-Akhmedov, Ch. L. Frequency dependence of absorption in the ionosphere at high latitudes. Geomagnetizm i aeronomiya, v. 6, no. 1, 1966, 80-86.

Experimental data are given for the frequency relationship of absorption in the ionosphere from analysis of riometer observations at high-latitude stations at Dikson, Cheluskin, and Hayes from September 1963 to April 1964. Riometers operating on 32 and 40 Mc were used at all these points with five-element Yagi antennas. In addition a riometer for frequencies of 35.1 and 48.3 Mc with a four-element Yagi antenna was used at the Dikson station as well as an instrument for measuring absorption by the pulse method at a frequency of 1.98 Mc. The antennas of all riometers were directed toward the North Pole. The results are given separately for auroral and Polar Cap absorption. A comparison of data from all instruments for auroral zone absorption shows that the frequency relationship for absorption conforms to the law

$$A_1/A_2 = [(f_2 + f_L)/(f_1 + f_L)]^n,$$

where A_1 is absorption at frequency f_1, A_2 is absorption at frequency f_2, and f_L is the gyromagnetic frequency. In most cases n = 1.5—1.7. The equivalent altitudes for the absorbing regions are basically at levels of approximately 50—70 km and higher. The altitudes of the absorbing regions (as well as the value of n) are independent of absorption intensity. The results of riometer measurements at two frequencies may be used at high absorption levels for conversion of the absorption to low frequencies. Polar Cap absorption was observed twice during this period: on 21 and 27 September 1963. (A number of strong solar chromospheric flares were observed on these and preceding days, causing magnetic disturbances in the ionosphere.) Both cases were used to determine the frequency relationship for this type of absorption. Recordings of galactic noise at this time were made at two frequencies only at the Cheluskin station. Curves are given showing an analysis of data for absorption at frequencies of 32 and 40 Mc as well as the ratio A_{32}/A_{40} as functions of local time. This same curve shows the height of the absorption layer in km. The altitudes of the absorption layer during the disturbance changed from approximately 46 to 80 km for both cases. Minimum values were observed at 1400 hours local time. The ratios A_{32}/A_{40} for absorption in the Polar Cap region on 21 and 27 September were approximately the same as for the case of auroral absorption. Since there were only two cases, no conclusions can be made on the frequency relationship of Polar Cap absorption.

Likhter, I. Ya. Cyclic variations of atmospheric noise intensity in the radio spectrum. Geomagnetizm i aeronomiya, v. 6, no. 4, 1966, 795-796.

Results of measurements of atmospheric noise intensity in the radio spectrum, made from 1958 to 1965 at many points on the Earth (Pretoria, Murmansk, Alma-Ata, Khabarovsk, etc.) are reported. The measurements were made daily at frequencies of 12, 27 and 51 kc and 2.5 mc. Readings for the morning minimum, afternoon maximum and night maximum were averaged for each of the four seasons of the year. On sites equipped with continuous-recording equipment readings of the nightly minimum were also obtained. Noise intensities at 12, 27 and 51 kc were found to be below their median values during high-activity periods of the sun (1959—1960), and above their median values during low-activity periods of the sun (1962—1964). The cycle began to repeat during 1965 when noise intensity approached its median value. The noise intensity curves for 2.5 mc were similar to the lower frequency curves, but were phase-delayed by one year from the latter. Cyclic variation of noise was seen to have a strong correlation with the level of thunderstorm activity present, which seems to verify the relation to solar activity.

Makrygin, A. M., and Ye. A. Ponomarev. The existence of anomalously near radio wave reflections from sporadic ionization zones associated with the aurora borealis. Geomagnetizm i aeronomiya, v. 6, no. 5, 1966, 936-937.

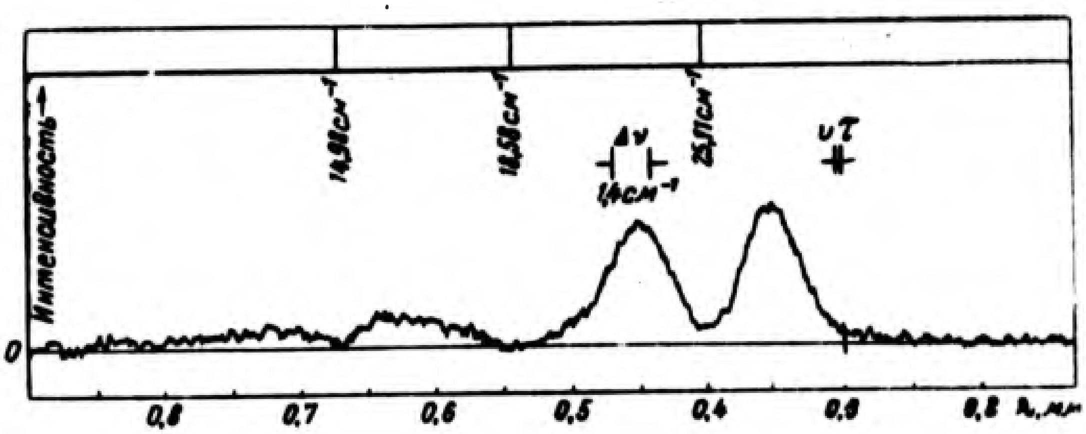
This paper describes instances of unusually short-range ionospheric radar reflections during relatively quiet geomagnetic periods. Five instances of reflection in the 200 to 300 km range were observed in Yakutsk during an ionospheric study in the spring of 1965. Photographs of the radar plan position indicator displays were taken and analyzed. Weak and diffuse secondary reflections in the same azimuths at 600 km ranges were also observed in some cases, but they could not be linked with geomagnetic or ionospheric disturbances. Occurrence of these short-range reflections cannot be attributed to distorting effects of ionospheric fluxes on the geometry of local magnetic fields, nor can they be attributed to refractive bending of the radar beam, since the electron density in the E layer was low in every case. Evidently, an unusually low aspect sensitivity existed in these cases.

Miler, M. Propagation of optic waves in the atmosphere. Jemna mechanika a optika, no. 10, 1965, 313-317.

Atmospheric properties are studied as related to the propagation of optic waves, damping, noise, and damping variation at different spectral bands, in order to determine the possible application of short-wave lasers for communications. The effects of the varying composition of the Earth's atmosphere on the propagation of coherent light beams from cw gas and semiconductor lasers are also considered. Selective absorption, heat and luminescent radiation, dispersion, and external radiation are described briefly and the present knowledge of atmospheric temperatures, chemical composition, and particles in suspension is summarized. It is concluded that the atmosphere is completely impenetrable to wavelengths longer than 14 μ, although penetrable areas at unknown higher bands can exist. Eight penetrable wavelength bands ("infrared windows"), with extrapolated widths for thin layers of the atmosphere, are tabulated. Wave scattering is analyzed briefly, based on the size of particles suspended in the atmosphere. The analysis is based on the supposition that a coherent laser beam is projected through a homogeneous atmosphere, in which absorption or scattering cause attenuation. It does not include effects of air mass currents, atmospheric turbulence, or nonhomogeneous fields caused by variable optic density. Nonhomogeneity causes refraction of light waves, which increases with altitude and produces "terrestrial refraction." Thus, a laser beam may be deflected concavely toward the earth when lower air layers are cooler than upper layers, or convexly when lower layers are warmer than those above. Atmospheric turbulence may deflect a laser beam and cause it to strike the receiver mirror at less than a vertical angle of incidence, which would require a broader receiver plate; or, only part of the beam cross section may fall in the receiver aperture, requiring a wider slot, which increases phase differentials. Turbulence may even alter the beam cross section and cause intensity fluctuation, or may deflect individual rays within the beam and blur its focus. It is concluded that, although laser communications have a great future, lasers cannot yet be employed through the open atmosphere. Atmospheric conditions above the more densely populated temperate zones of the earth make its use questionable in the near future.

Ryadov, V. Ya., and G. A. Sharonov. An experimental study of transparence of earth's atmosphere to waves in the sub-millimeter band. Radiotekhnika i elektronika, no. 6, 1966, 1037-1045.

Absorption of radiation in the sub-millimeter band due to water vapor in the atmosphere was measured. The measurements made in the window regions of the ground layer at wavelengths of 0.2, 0.29, 0.36, 0.45, 0.73 and 0.87 mm, were conducted from August to October 1963 at the Gor'kiy State University im. N. I. Lobachevskiy. The measuring equipment consisted of a radiation source, in the form of a mercury-quartz lamp placed in the focal plane of a parabolic reflector (diameter, 900 mm; focal length, 364 mm), and a radiotelescope receiver. The receiver had an optical monochromator with diffraction gratings to limit the input bandwidth; gratings with periods of 0.5, 1, and 2 mm were used as dispersing elements. Three sources were used simultaneously. Measurement accuracies were found to increase with separation of source and receiver; the optimum distances used, at which tolerable signal/noise ratios were still available, were 25 m for $\lambda = 0.2$ and 0.29 mm; 150 m for $\lambda = 0.36$ and 0.45 mm, and 250 m for $\lambda = 0.73$ and 0.87 mm. Before measuring absorption, absolute humidity measurements were made at a height of 2 m, the approximate height of the source and the receiver. A linear relationship between the received field intensity and absolute humidity, at a given wavelength, was found for absolute humidities from 3 to 11 g/m^3. Significant differences exist between measured and calculated values of absorption; a possible cause for this may be the difference between the actual spectral line widths of water vapor and those used in the calculations. In the figure is a spectral response from the 150 m-distant source, showing windows at approximately 0.35 and 0.45 mm.



Spectral density of ground level signals received from mercury-vapor source 150 m distant. Humidity = 6.69 g/m3.

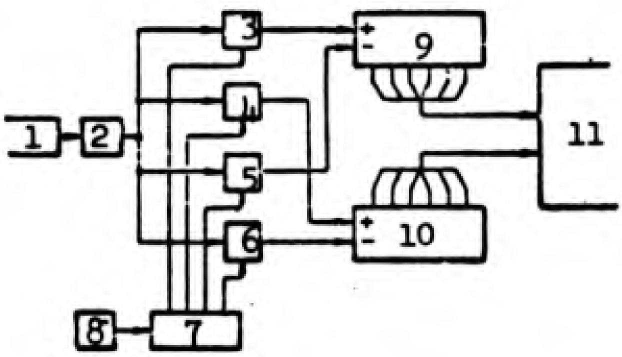
Savin, Yu. K. Some problems in the investigation of the magneto-ionic effect and polarization of ionosphere-reflected waves. Vsesoyuznaya nauchnaya sessiya, posvyashchennaya Dnyu radio. 22d, 1966. Sektsiya rasprostraneniya radiovoln. Doklady. Moscow, 1966, 27-28.

The polarization of ionosphere-reflected waves was experimentally studied at the frequencies (short-wave band) where the reflected signal contained only one magneto-ionic component. The receiver used two horizontal dipoles installed at right angles; the dipole signals were applied to a 2-channel indicator and a fading-duration analyzer. These experiments helped to determine the frequency band in which the strongest polarization fading of signals occurred. It is found that the shorter the tolerable signal-absence time, the greater advantage the 2-perpendicular-dipole reception has as compared to single-dipole reception; with a tolerable signal-absence time of 0.1—0.01%, the power gain is 20—25 times.

8. Relative Time or Delay Time Measurement

Drabkin, R. L. Device for signal separation and phase measurement. Radiotekhnika, v. 20, no. 7, 1965, 31-40.

A description is given of a device (see figure) designed for converting an output signal into a binary code and for smoothing information on the phase of the signal. The unit serves as an intermediate link between an i.f. amplifier and a digital computer. From amplifier 1 the signal is fed to pulse shaper 2, which generates a pulse when the voltage at the amplifier output crosses the zero level. Four gates (3-6), controlled by switch 7, separate the irregular pulse sequence corresponding to the zero phase moments of the signal-noise mixture at the amplifier output into equal time intervals. The period and frequency phase of the switch are determined by reference oscillator 8. The pulses are then transmitted from the gates to reversible counters 9 and 10. The phase of the received signal and the signal-to-noise ratio at the receiver input can be evaluated on the basis of pulses registered by the counters; the statistical error can be determined on the basis of the signal-to-noise ratio. In addition to the description of the operation of the device, the article treats the basic design relationships involved, including systematic, static, and dynamic error, and indicator self-adjustment. The device is recommended primarily for use with low signal-to-noise ratios, but can be used with higher ratios if larger errors can be tolerated.



Signal separation and phase measurement device

1 - If amplifier; 2 - pulse shaper; 3, 4, 5, 6 - gates; 7 - switch; 8 - reference oscillator; 9, 10 - reversible counters; 11 - digital computer.

Kokurin, Yu. L., V. V. Kurbasov, V. F. Lobanov, V. M. Mozhzherin, A. N. Sukhanovskiy, and N. S. Chernykh. Measuring the distance to the moon by an optical method. Zhurnal eksperimental'noy i teoreticheskoy fiziki. Pis'ma v redaktsiyu. Prilozheniye, v. 3, no. 5, 1966, 219-223.

A description is given of the experimental measurement of the distance to the moon by means of an optical locator. A schematic of the locator is shown in Fig. 1. Ruby laser 1 and photomultiplier 2 are fixed rigidly in the Coude focus of telescope 3. A tunable interference filter 4 is placed in front of the photomultiplier and behind diaphragm 5. Mirror 6 can be automatically switched from receiving to transmitting operations. Photomultiplier output amplifier and pulse shaper 7 follow 2, and the measurement of the time intervals between the emission and reflection (from the moon) of laser pulses is made by counter 8, which is activated by that portion of the laser pulse directed to the photomultiplier. The laser operated at 6943 Å, with a pulse energy and duration of 5—7 j and $5 \cdot 10^{-8}$ sec, respectively. The diameter of the main telescope mirror was 2.6 m and its focal length 10^4 m; the beam diameter was 13 mm, and the divergence of the beam reflected from the telescope mirror was ≃3 sec of arc. The filter passband was 10 Å, and the instrumental error in the measurement of time $\pm 10^{-7}$ sec. The observation of the lunar surface was confined to an area located at the bottom of the Flammarion crater with the selenographic coordinates of λ—3°.57 and φ—2°.98. The results of observations are shown in Fig. 2 as a frequency distribution of the quantity $t_E - t_T$ in 10-μsec class intervals (t_E and t_T are the experimental and calculated times, respectively, required by a signal to complete the round trip). The signal-to-noise ratio was ~5 and the mean of the useful signal was found to be distributed within the 15—20 μsec class boundary, with a standard deviation of 1.2×10^{-6} sec. The total error is positioning the distribution center was $\simeq 1.3 \times 10^{-6}$ sec, which corresponds to ≃200 m error in the measurement of lunar distance.

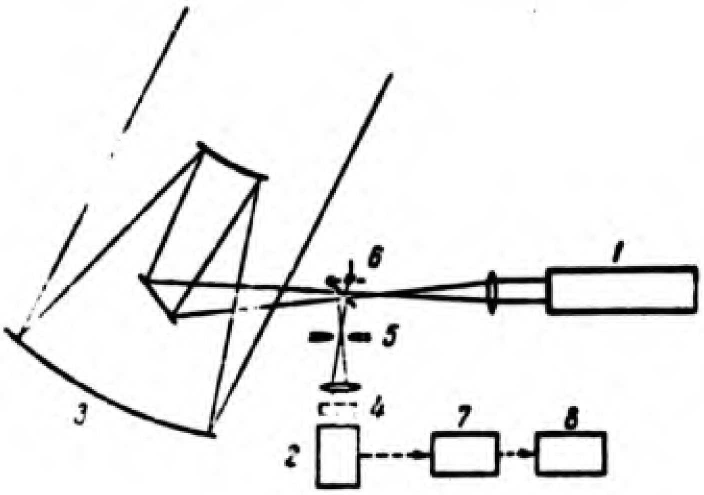


Fig. 1. Schematic of the locator

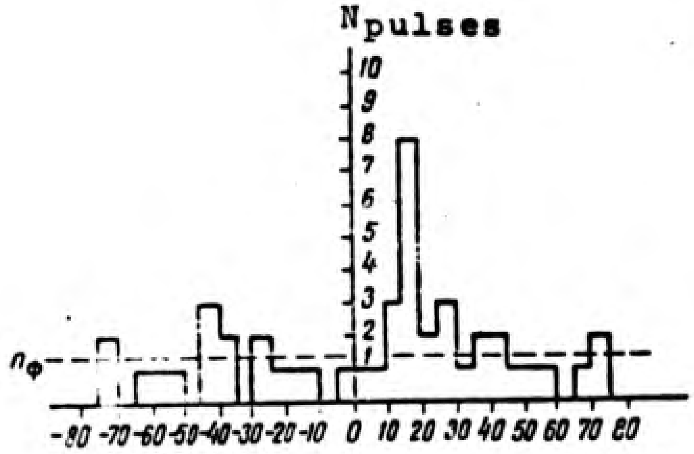


Fig. 2. Results of measurements

Koltik, Ye. D., B. D. Taube, and A. A. Kulemin. The F-200 phasometric device. Izmeritel'naya tekhnika, no. 8, 1965, 25-27.

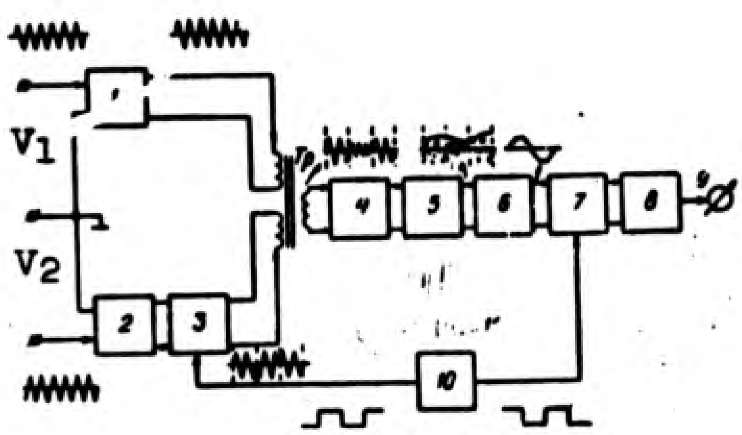
Research done at the VNIIM im. D. I. Mendeleyeva on precise methods of reproducing phase shifts between two variables showed that for an accuracy of ±(0.1—0.05°) the frequency range of phase calibrators with cathode-ray tubes can be expanded to 200—300 kc without frequency conversion. The basic circuit of the proposed F-200 phasometric device is given and its operation is described. The device can be used not only for calibrating or checking phase meters within 0.1—0.05°, but also for testing passive and active electric networks. In the presence of a frequency converter, the input voltages can be converted to an audio frequency range.

Malykh, L. Ya., N. I. Malykh, N. F. Perepelkin, and Ye. S. Yampol'skiy. Velocity phasemeter for 8-mm band. Pribory i tekhnika eksperimenta, no. 2, 1964, 93-95.

A velocity superheterodyne phasemeter operating on the 8-mm wavelength is briefly described. It is intended for (a) measuring the time-average density of plasma by the phase of a signal passing through the plasma and (b) observing movements of the critical-density plasma surface by the phase of the reflected signal. The phasemeter error is 7° plus 1.5° or less due to discrepancies associated with the distance between the meter and the plasma outfit. Minimum readable phase shift, ~ 10°; max permissible rate of change of the measurand, 0.2 πrad/microsec; information about the measurand is delivered every two microsec. A block diagram, a circuit diagram of the intersifier-pulse shaper, and a circuit diagram of the sawtooth-voltage shaper are supplied.

Skripnik, Yu. A., and V. I. Skripnik. A single-channel quadrature phase indicator with phase switching. IN: L'vov. Politekhnicheskiy institut. Kontrol'no-izmeritel'naya tekhnika (Control and measurement techniques) no. 2. L'vov, Izd-vo L'vov Univ., 1966, 47-52.

A portable quadrature phase meter with phase switching is described. The input voltages V_1 and V_2 are applied to blocks 1 and 2 (see figure) which provide a high-impedance and low-capacitance input to the meter. One of the voltages (V_2) goes through a 180° phase switcher whose switching frequency is controlled by a square wave generator (10). The two voltages are then added in transformer T_p. The resultant output is an amplitude-modulated signal with the index of



Block diagram of a quadrature phase meter modulation proportional to the deviation from quadrature i.e., the phase difference of the two applied voltages. The resultant signal is amplified, applied to a square-law detector (5), amplified by a low-frequency amplifier (6), applied to a detector (7) synchronized to the switching frequency, and fed through an integrator (8) to a highly-sensitive indicator (9). The characteristics of the meter are: input frequency range, from 1 Kc to 1.5 Mc; input voltage, 3—30 v; fine and coarse scales of ±30' and 5°; quadrature indication error (with maximum nonlinear distortion of 2%), 6', 30', and 90' for frequencies of 1 to 200 kc, 200—500 kc, and 500 kc to 1.5 Mc, respectively; minimum input impedance, 0.5 M ; threshold sensitivity, not less than 1°. The weight of the meter does not exceed 6 kg.

Zborovskiy, A. A., Yu. A. Skomorovskiy, and V. P. Sushkov. Measuring the relaxation time (about 1 nanosecond) of recombination radiation of a semiconductor source. Pribory i tekhnika eksperimenta, no. 5, 1965, 224-227.

A theoretical and experimental method for measuring the relaxation times of recombination radiation on the order of 10^{-9} seconds is described. The method consists of determining the phase shift φ between radiation and the current through a semiconductor source of recombination radiation. The effective relaxation time is defined by

$$\tau_{eff} = \tan \varphi / 2\pi f_p,$$

where the operating frequency f_p = 4770 kc. The circuit for measuring τ_{eff} is described in detail. It consists of a high-frequency generator, an electrooptical KDP cell, a phase shifter, amplifiers, and two semiconductor sources of recombination radiation. Total error in the circuit amounts to 8×10^{-10} sec in τ_{eff}. The theoretical analysis is based on the p-n junction diffusion theory. The behavior of minority carriers is determined from the kinetic equations. An expression is derived for the number of radiated photons. It is shown that τ_{eff} determines the upper limiting modulation frequency of recombination radiation as well as the lifetime of electrons and holes.

9. Velocity of Light Determination

Basov, N. G., R. V. Ambartsumyan, V. S. Zuyev, P. G. Kryukov, and V. S. Letokhov. Velocity of propagation of a powerful light pulse in a medium with population inversion. IN: Akademiya nauk SSSR. Doklady, v. 165, no. 1, 1965, 58-60.

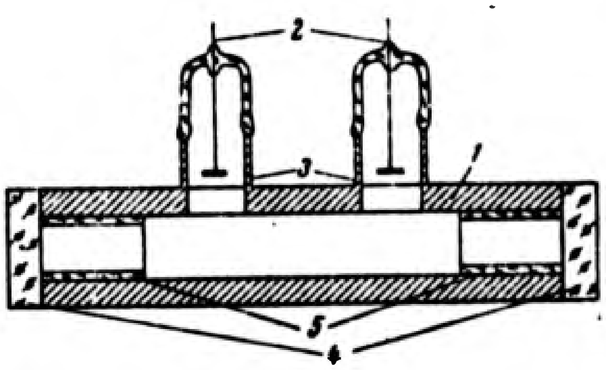
The article is a brief advance report of a comprehensive work to be published separately. It was shown that the leading edge of a powerful light pulse does not change materially while propagating within a medium with inverse population. In the case of a ruby medium with usual parameters, the velocity of the pulse maximum on reaching its stationary value was shown to be 17×10^{10} cm/sec, which greatly exceeds the velocity of light. This fact, however, does not contradict the causality principle, since such a propagation takes place as the result of the deformation of the initially weak leading edge, and can continue only to the point of zero intensity which always propagates with the velocity of light in the medium. An amplifier composed of two ruby rods 24 cm long was used for experimental study of the problem. The end faces of the rods were cut at the Brewster angle. The total gain for a weak signal was about 50. Both input and output pulses were recorded by the same coaxial photocell arrangements, but the output pulse was made to travel an additional distance so that it reached the photocell 56×10^{-9} sec after the input pulse. The parameters of the input pulse were as follows: energy 1.3 j, pulse width 16×10^{-9} sec. A comparison of oscillograms of weak and strong pulses revealed that no appreciable shortening of the pulse occurred, and that only the time interval between the input and output pulse shortened as the pulse strength increased. The shift in the time interval in this case was 9×10^{-9} sec, which agrees with the theoretical considerations presented above. It follows that amplification of the exponentially growing leading edge of the pulse results not in a shorter pulse, but in an additional shift of the pulse peak. To shorten the pulse, it is necessary to increase the steepness of theleading edge by cutting it off with a shutter, by nonlinear absorption, etc. It is noted further that the shift of the pulse peak with velocity exceeding the velocity of light is accompanied by the shift of the boundary of inverse population and can lead to the emergence of a number of new effects such as that of Cherenkov radiation.

Chebotayev, V. P. Accurate measurement of light velocity by means of an Ne-H_2 laser. Radiotekhnika i elektronika, v. 11, no. 9, 1966, 1712-1714.

A proposal is made for using a neon-hydrogen laser in a hollow cathode (see Fig. 1) to measure light velocity. The accuracy is determined by the precision with which the beat frequency and the difference in the generation wavelengths can be measured. The latter can be measured by means of a passive interferometer with a known length and with

$$\Delta\lambda = \frac{2L}{q_1} - \frac{2L}{q_2},$$

where q_1 and q_2 are half-wave numbers at two different wavelengths. The pulsed discharge was excited in steel tube 1 (outside diameter, 40 mm; inside 18 mm) which served as a hollow cathode. Two anodes 2 were soldered through Kovar seals 3. The tube ends were parallel within $\pm 1''$ and their surface roughness was approximately 0.01 μ. The cavity consisted of plane glass mirrors 4 (effective diameter, 1 cm) which also sealed the system. The cavity length and active discharge interval were 26 and 16 cm, respectively. Glass inserts 5 were used to protect the mirrors from being sputtered by the cathode material during discharge. Laser action occurred at 11,143 Å due to the $2s_4$—$2p_8$ transition. The photomultiplier output was fed into the vertical amplifier of an oscillograph. The sweep time was equal to the time necessary to change the resonator wavelength to one-half the generation wavelength and was determined by the rate of change of the laser temperature. The method for measuring wavelength difference can also be used for making accurate measurements of generation wavelengths.



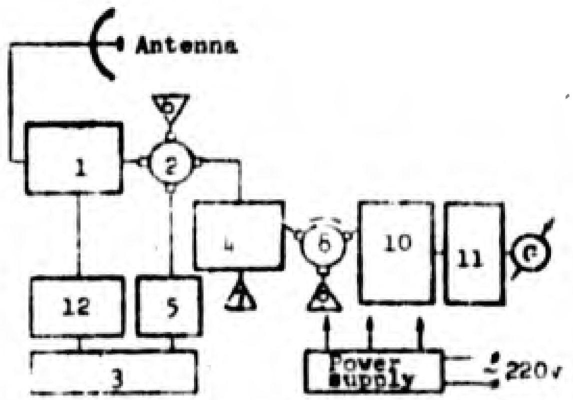
Laser schematic

1 - Discharge tube; 2 - anodes; 3 - Kovar seals; 4 - mirrors; 5 - glass inserts.

10. Radio Astronomy

Aynbinder, I. M., L. K. Soloshek, and A. V. Zakharov. Modulating radiometer with parametric converter input. Pribory i tekhnika eksperimenta, no. 5, 1965, 120-123.

A low-noise radiometer intended for the study of weak radio emission from the Moon and Jupiter at 70.25 cm is described. The block diagram of the radiometer is shown in the figure. The antenna switch employs DGTs-27 diodes whose capacitances are compensated by inductances. In the off position, the transmission loss through the switch is 18 db; in the on position, it is 0.2—0.3 db; VSWR = 1.21:1. It has a 3-db bandwidth of 15%, and switching time is 15—20% of the modulating period. The ferrite directional coupler (8) is a Y-circulator with 1.6-db transmission loss in the forward direction and 17.3 db in the backward direction; VSWR = 1.12:1. In order to provide maximum sensitivity, additive noise is applied through the attenuator (12) to the antenna arm, balancing the temperature of the arms. The parametric amplifier design assures maximum sensitivity by maximizing the ratio of its noise temperature to the bandwidth, keeping the generation factor low (0.5—0.6). The parametric converter converts the input signal to the i.f. range with the aid of a klystron oscillator with a 9228-Mc pump frequency. An additional 398-Mc BFO and a balanced mixer form the output signal. Converter noise temperature is 150K with 15-Mc bandwidth; however, in order to assure proper coupling with coupler 8, the converter temperature (allowing for losses in the coupler) is 300K.

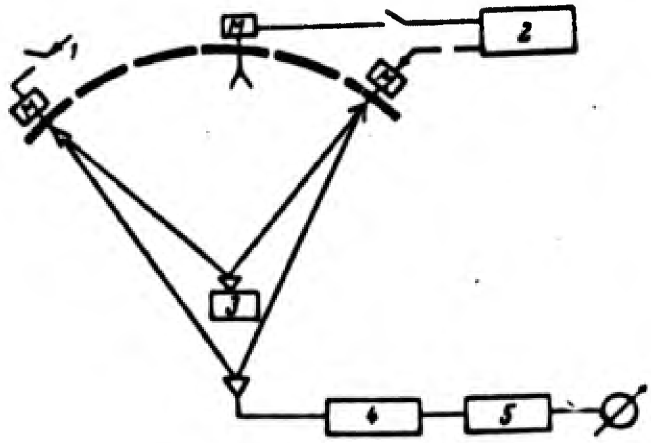


Modulation radiometer

1 - Directional coupler; 2 - 3-way switch; 3 - noise generator; 4 - antenna switch; 5 - divider; 6 and 7 - cold noise temperature reference; 8 - ferrite coupler; 9 - balancing load; 10 - parametric amplifier; 11 - standard P-5-9 i.f. and lf amplifier.

Braude, B. V., N. A. Yesepkina, V. Yu. Petrun'kin, S. E. Khaykin, and V. N. Umetskiy. Application of methods for correction of the surfaces of optical telescopes to tuning of highly directional radio telescopes. Radiotekhnika i elektronika, v. 11, no. 8, 1966, 1499-1503.

A modified version of the so-called shadow method of tuning is proposed. The shadow method in its original form is used for correcting the surface of optical reflectors, but it does not assure the required accuracy and reliability when applied to large, highly directional radio telescopes. The modification consists of providing ways of producing converging waves near the antenna and of localizing errors on the mirror surface. The principles of localizing surface errors and of determining the shape of the reflecting antenna surface, based on the modulation of signals reflected from various sections of the antenna, are briefly described. In this procedure (see figure) the reflecting surface is made of comparatively small movable (adjustable) elements. One or more slightly directional modulated reradiators (small dielectric or slot antennas with shf modulators) are mounted on each element. A generator is placed at one of the antenna focal points and a receiver with a detector and filter tuned to frequency Ω at the other. With such an arrangement, equal paths are obtained between the first and the second focal points. The modulated signal is produced by one of the reradiators, and a reference signal is produced by the sum field reflected from all of the antenna elements. Phase measurements with an accuracy of 0.5° at $\lambda = 3$ cm were made by the modulation method under laboratory conditions. In general, the tuning of a highly directional radio telescope should proceed as follows: 1) The antenna is first focused for a short distance to obtain a converging wave front; 2) the reflector surface is then checked and corrected by the modulation method; 3) the antenna radiation pattern is checked by placing a generator at one focal point and measuring the field distribution near the other focal point. The distribution should coincide with the antenna radiation pattern in the far zone. When the measured antenna radiation pattern (field distribution near the focal point) is found to be in good agreement with the calculated one, the antenna should be focused to infinity, i.e., a plane wave should be obtained from the radio telescope. The operation of the system is then checked against cosmic radio sources which have small angular dimensions, compared to the width of the radiation pattern.

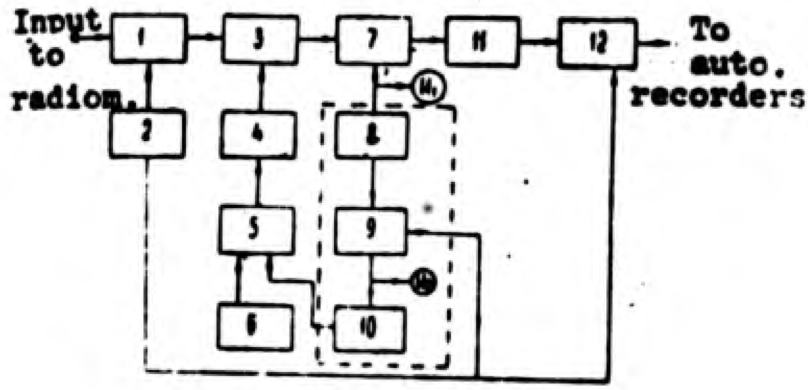


Shadow method tuning arrangement

1 - From generation of Ω-frequency signals; 2 - Ω-frequency modulating generator; 3 - ω-frequency signal generator; 4 - detector; 5 - Ω-frequency signal amplifier.

Gershteyn, L. I. Centimeter-band radiometer with elimination of the effects of spurious signals by automatic frequency control of the heterodyne. IVUZ. Radiofizika, v. 8, no. 4, 1965, 771-774.

The author shows that automatic control of the heterodyne frequency, such that the mixer-current component at the modulation frequency is kept at zero, eliminates completely the spurious-signal component due to unequal reflection of the heterodyne power from the input and from the modulator, and at the same time suppresses the component due to unequal reflection of the noise at the receiver-channel frequency. A block diagram of such a radiometer is shown in the figure. It covers a range from 11.1 to 17.5 Gc, and is adjustable by simply varying the heterodyne frequency. The output drift is 1—10 deg/hr, and its sensitivity (at a time constant of 1 second) is from 2° to 4° over the entire range. The use of this design obviates the need for rectifiers and double bridges.

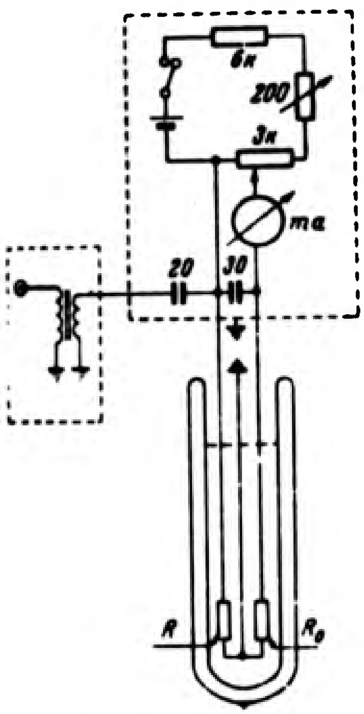


Block diagram of radiometer

1 - Mechanical waveguide modulator; 2 - modulation frequency generator; 3 - directional coupler; 4 - heterodyne; 5 - heterodyne power supply; 6 - power supply manual control; 7 - single crystal mixer; 8 - amplifier for modulation frequency; 9 - phase detector; 10 - automatic frequency control filter; 11 - i-f amplifier; 12 - low frequency block of radiometer; И_1 - mixer current indicator; И_2 - afc system indicator. The units enclosed by the dashed line pertain only to the afc system.

Karlova, Ye. K., and N. V. Karlov. Millimeter-band receiver based on an InSb photoconductor. Pribory i tekhnika eksperimenta, no. 2, 1966, 191-194.

The design and performance of a low-noise millimeter-wave receiver based on an InSb detector are described. The InSb element, which at liquid He temperature acts as a photoresistor to incident millimeter rf, was n-type, with a rated carrier mobility of 3 x 10^5 $cm^2/v \cdot sec$, and was cut from a single crystal to dimensions of 4 x 1 x 1 mm. At an operating temperature of 4.2K, detector resistance was in the range of 130—150 ohms. The crystal, together with a carbon ballast resistor, was mounted in a 3.2-mm diameter waveguide, which was fed by a klystron via a tapered polyethylene insert in the guide, and the assembly was immersed in the He cryostat (see figure). Special efforts were taken to shield the crystal and receiver circuitry because of the great sensitivity and bandpass of the InSb element. The incoming signal was dual-modulated: at 72 cps by oscillation of a slot attenuator in the guide and at 3 kc by modulation of the klystron supply voltage. By also using synchronous detection and low-noise receiver components, the authors obtained reception considerably better than that of usual (type D-407) crystal diodes, under the same test conditions. The relative improvement in sensitivity of the InSb element varied from 20 db at $\lambda = 4$ mm to 3 db at $\lambda = 0.6$ mm; by lowering the He temperature to 1.8K, these gains could be improved another 3—5 db. The stability and zero drift of this receiver were considered very good, with consistency of data maintained over several months of operation, provided the copper leads to the crystal were not resoldered. However, the InSb element was found to lose its sensitivity several months after being removed from the receiver. The authors conclude that their receiver is comparable in sensitivity to some of the best present superhet types in the millimeter band, and they suggest that it can be used in radiospectroscopy and radioastronomy.



Photoresistor supply mounting

R_0 - InSb resistor; R - ballast resistor.

Kaydanovskiy, N. L., and N. A. Smirnova. Limitations on the resolving power of radio telescopes and radio interferometers imposed by the conditions of propagation of radiowaves in outer space and in the atmosphere. Radiotekhnika i elektronika, v. 10, no. 9, 1965, 1574-1582.

A theoretical analysis of limits of resolution based on Western and Soviet published data brings about these conclusions: (1) In the millimeter band, where the limitation is imposed by the troposphere, the maximum antenna resolution is equal to a few angular seconds and depends on the elevation. (2) The centimeter and shorter decimeter bands, where only the scattering in the interplanetary medium matters, are the optimal bands for solid antennas; the resolution can be as high as 0.01—0.001 sec for observations in the plane of the ecliptic, and even higher in other directions. (3) In the longer decimeter and meter bands, the resolution is no better than 10 sec. (4) The resolution of a 2-antenna interferometer is unlimited for wavelengths under 15 cm for observations made in the ecliptic plane, and under 3 m for observations directed toward the ecliptic pole. (5) The resolution of an interferometer at wavelengths over 50 cm in the ecliptic plane (or over 10 m toward the ecliptic pole) is limited by $\sqrt{\overline{\sigma^2}}$ (expansion of the point source due to the interplanetary medium). (6) In the intermediate band (15—50 cm for the ecliptic plane, 3—10 m for the ecliptic pole), the resolution is limited by $\Delta\theta$, i.e., $0 < \Delta\theta < \sqrt{\overline{\sigma^2}}$.

Kokourov, V. D. Experimental study of a pulse signal spectrum reflected from the ionosphere. Geomagnetizm i aeronomiya, v. 6, no. 5, 1966, 933-934.

A study of spectral characteristics of rectangular pulses reflected from the ionosphere is described. The study, made with pulses 120 μsec in duration, used a manually-controlled radiotelescope with a linear receiver characteristic out to 30 kc. Fourier transforms of reflected signals were calculated by computer at 0.5 kc intervals. Reflected signal bandwidth, defined as the frequency between 0 cps and the first amplitude null of the Fourier transform, was found to be very close to the calculated (8.2 kc measured, 8.33 calculated). Pulses reflected from the F2 layer on 19 April 1965 were very distorted: leading and trailing edges were sloping and the peak was flat. The received Fourier spectrum revealed this distortion since its bandwidth was reduced by a factor of 1.4 with respect to that of the transmitted signal.

Makrygin, A. M., and Ye. A. Ponomarev. Some results of auroral radar observations during the IQSY Geophysical Quiet Sun period. Geomagnetizm i aeronomiya, v. 6, no. 4, 1966, 786-788.

Radar observations of the aurora borealis were made in Yakutsk during the International Quiet Sun Year. The observations began on July 29, 1963 and were made daily at fifteen minute intervals starting at 1700 and ending at 0800 the next day. A pulsed radar equipped with a movie camera, an amplitude recorder, a noise suppressing system and a goniometer were used. The radar characteristics were: receiver sensitivity, 3×10^{-15} v; transmitted power, 90 kw; pulse duration, 8 μsec; carrier frequency, 73 mc; repetition rate, 50 kc; antenna type, 78 element two-story yagi in two sections; antenna rotation rate, 3 rpm; half-width of the antenna pattern in the horizontal plane, 11°; radiation pattern in the vertical plane, three lobes with maxima at 6.5, 16 and 24° with 2/3 of the radiated power in the lowest lobe. Results are given for each of the four seasons. Maximum and minimum reflection distances were 1200 and 200 km; 90% of the reflections were between 600 and 1000 km. Maximum eastern and western azimuths were 70° and 300°; more than 80% of the reflections were ±40° and about 60% were ±20° from the magnetic median. Significant seasonal changes in the reflections were measured.

Martirosyan, R. M., A. M. Prokhorov, and R. L. Sorochenko. Radio spectrometer for 21-cm wavelength with paramagnetic amplifier. IVUZ. Radiofizika, v. 8, no. 4, 1965, 699-703.

The authors describe a spectrometer intended for the investigation of the hydrogen line, using a paramagnetic amplifier with two coupled 1420-Mc quarter-wave strip resonators. Ruby with 0.04% Cr^{3+} concentration was used as the active medium. An external field of 2000 oe was produced by a superconducting solenoid with winding of pure niobium. The gain of the amplifier when working with a radiometer was 16—18 db at a bandwidth of 7—8 Mc. The gain drift after 30 minutes of operation did not exceed 2—3%. A block diagram of the radiospectrometer is shown in the figure. Modulation was by switching the input of the paramagnetic amplifier from the antenna to a dummy resistor equal to the wave resistance of the coaxial line. The amplifier was switched to the radiometer circuit with the aid of a circulator with 0.2 and 20 db loss in the forward and backward directions, backed up by a ferrite gate for better decoupling. The stabilization and calibration of the equipment are briefly described. Tests have demonstrated the ability of the apparatus to disclose fine details in the radio line profile.

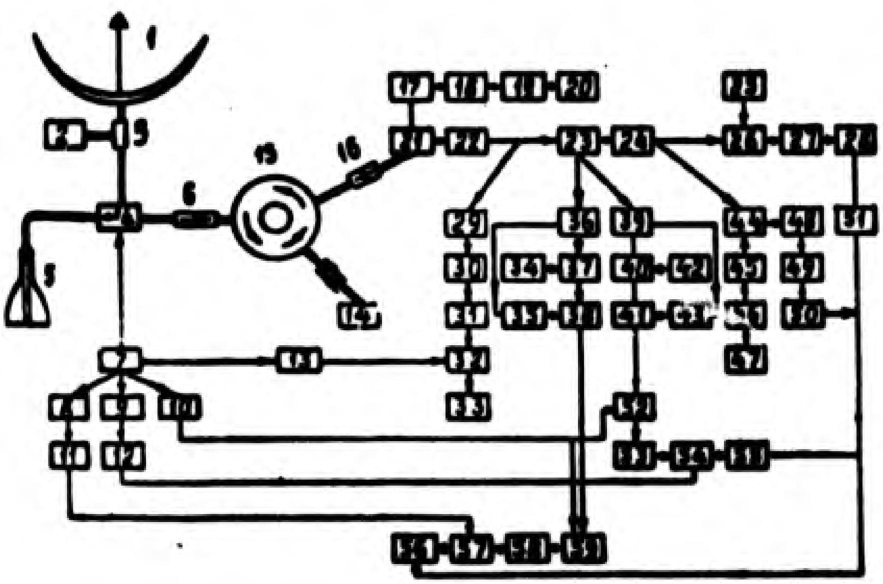
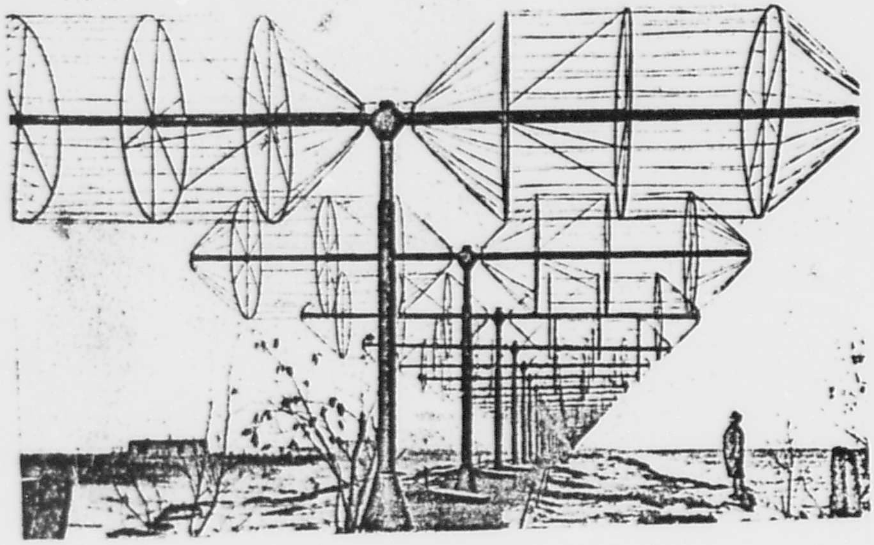


Fig. 1. Radiospectrometer block diagram

1 - Antenna; 2 - noise gen.; 3 - directional coupler; 4 - modulator; 5 - Dewar with dummy load; 6,16 - ferrite gates; 7 - modulation freq. gen. ; 8.,9,13 - phase shifters; 10,11, 12 - pulse shapers; 14 - quant. paramag. ampl.; 15 - circulator; 17 - freq. quadrupler; 18 - 108x freq. multiplier; 19 - buffer; 20 - first heterodyne gen.; 21 - first mixer; 22 - if ampl.; 23 - second mixer; 24 - contin. tuning heterod.; 25 - 1000 kcs timer gen.; 26 - mixer; 27 - 250-kcs ampl.; 28 - detector; 29, 30 - suppl. ampl. and broadband output detector; 31, 32, 33 - modul. freq. ampl, synch. detector, and broadb. output recorder; 24, 42 - 3d heterod. of narrow band outputs; 36,39 - 2d if amplif.; 35, 43 - agc; 37, 40 - 3d mixers; 38, 41 - quartz filters; 44 - 10 kcs timing pulse mixer; 45 - harmonics group ampl.; 46 - narrow pulse shaper; 47 - 20 kcs gen.; 48 - 5 kcs ampl.; 49 - detector; 51 - timing relay; 52,59 - narrow band chann. detect.; 53,58 - modul. freq. ampl.; 54, 47 - synch. det.; 55, 56 - narrow band channel recorders.

New radiotelescope in the Ukraine. IN: Akademiya nauk SSSR. Vestnik, no. 4, 1966, 116.

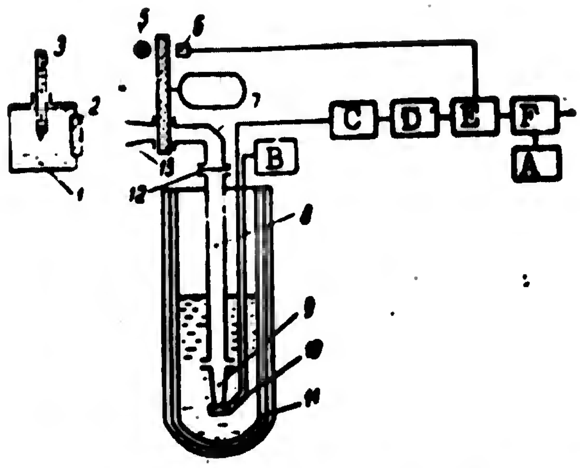
The Radioastronomical Observatory of the Institute of Radio Physics and Electronics, Academy of Sciences UkrSSR, is nearing completion of a unique decameter radiotelescope, claimed to be one of the largest of its kind in the world. The giant instrument (see figure) occupies an area in excess of 150,000 m^2. It consists of over 2000 T-shaped antenna exciters, and will be capable of receiving signals from sources 10 billion light years away. The control building has already been completed. A digital computer instead of conventional mechanical methods will be used to control the beam because of the great size of the radiotelescope.



Radiotelescope

Popov, Ye. I. Radiometers for the submillimeter band using indium antimonide detectors. IVUZ. Radiofizika, v. 8, no. 5, 1965, 862-869.

The author analyzes several methodological and design problems involved in the construction of submillimeter-band radiometers based on volume effects in semiconductor detectors. Comparison of the fluctuation sensitivity (per unit solid angle and per unit antenna area) of radiometers operating with different types of detectors shows that for large objects, such as Sun or the Moon, better results can be expected from thermal detectors (preferably operating at very low temperature) than from superheterodyne or crystal-detector receivers. This conclusion was checked by constructing a radiometer breadboard operating with a horn antenna having a beamwidth of 15° at half-power points, and with an n-type InSb receiver at liquid helium temperature. The radiometer was found to have a sensitivity of 0.05K and accumulation time of 1 sec, in good agreement with the theoretical estimates. It is pointed out in the conclusion that the further increase in the detector sensitivity and decrease in the transmission-line losses can improve the sensitivity to a possible (1—3) x 10^{-3}K. The tuning range of such a radiometer can be broadened by using an interference type modulator.



Block diagram of the radiometer

1 - Hot water; 2 - teflon window; 3 - thermometer; 4 - mechanical modulator; 5 - modulator disk; 6 - RC circuit; 7 - quasi-optical mirror; 8 - German silver tube; 9 - conical junction; 10 - crystal; 11 - nitrogen jacket; 12 - photosensitive black paper; 13 - antenna horn

A - Automatic recorder; B - bias; C - low frequency preamplifier; D - low frequency amplifier; E - phase detector; F - dc amplifier.

Tovmasyan, G. M. Annular radio telescope with a high resolving power. Byurakan. Observatoriya. Soobshcheniya, no. 36, 1964, 79-85.

A new radio telescope system is described, consisting of two annular mirror telescopes with very high effective resolving power. The main mirror is a narrow spherical ring of large diameter. The normal to the ring forms a small angle with the horizon. The ring consists of individual elements. The second mirror is moved on the focal line of the main mirror, and has a diameter equal to half that of the main mirror. This telescope can examine the sky in a declination belt equal to $180° - 2\phi$, where ϕ is the geographical latitude of the mirror's location. Because of its low position, the correcting mirror may be moved around the ring of the main mirror on a carriage. The ring of the main mirror can be illuminated by a restricted area of the correcting mirror and thus a very narrow horizontal directivity diagram may be obtained. Both coordinates of the discrete radio emission source can be measured by examining the region of sky twice on corresponding azimuths. A radio emission source can be observed for two hours with a telescope whose diameter is one kilometer and which is located at 40° latitude when the source is at the southern border of the belt scanned, and for one hour if the source is at the northern border. Such a high resolving power telescope is less expensive to construct than the ordinary one. A maser with cooler can be added to this telescope. This telescope may be used before construction is complete.

Yakovlev, O. I., A. I. Yefimov, and K. M. Shvachkin. Attenuation of radio waves in interplanetary space and in the vicinity of the Sun. Radiotekhnika i elektronika, v. 11, no. 4, 1966, 617-622.

A study of attenuation of meter-band radio waves in interplanetary space and in the vicinity of the Sun is discussed. A method of precise measurements of radio emission from radio source Taurus-A was employed. The measurements were made from March through December 1964 at 184 Mc and various values of angle ψ. The bandwidth of the antenna radiation pattern permitted measurements at $\psi \geq 5°$. On the basis of the measurements, the following conclusions were reached: 1) There is no attenuation (within limits of $\pm 5\%$) in the propagation of radio waves with a continuous spectrum at the 1.6-m band for a distance of 3×10^8 km when the energy beam propagates at a distance of 2.5×10^7 km from the Sun. 2) Little attenuation was observed during the propagation of radio waves with a continuous spectrum at the 11-, 3.5-, and 1.6-m bands through all the interplanetary space within the Earth's orbit when the beam propagates at a distance of 1.3×10^7 km from the Sun. 3) During the propagation of monochromatic radio waves at the meter band in interplanetary space and in the vicinity of the sun a change in the spectrum could be observed which corresponds to the apparent attenuation during reception by a narrow-band receiver.

Yesepkina, N. A., N. L. Kaydanovskiy, D. V. Korol'kov, B. G. Kuznetsov, and S. E. Khaykin. Effects of atmosphere on characteristics of small radio telescopes. Radiotekhnika i elektronika, v. 11, no. 8, 1966, 1405-1412.

A study is conducted of atmospheric effects on the performance of a high-resolution radio telescope antenna with a variable profile. Factors influencing the antenna dimensions, such as wavefront phase distortions, existence of a gradient of index of refraction, and radio wave absorption in the ground layer of the atmosphere are considered. It is noted that phase distortion can be minimized if the average radius of curvature of the reflector is much greater than the height of irregularities in the atmosphere. By assuming a 10^{-4} relative accuracy of the antenna reflecting surface and mean atmospheric conditions, antenna gain was calculated for various azimuth angles. Nearly optimal performance conditions were found for the vertical dimensions of a reflector equal to $0.5 \times 10^3\ \lambda$, and horizontal dimensions of an antenna chosen to make the attenuation equal to 30%. With such a choice of dimensions, the effective area of the antenna is 2×10^5, 1.3×10^4, 0.9×10^3 m^2 for $\lambda = 10$, 3 and 1 cm, respectively.

Zhevakin, S. A., and A. P. Naumov. Some problems in calculating and measuring the absorption of millimeter and submillimeter waves in atmospheric water vapor. IVUZ. Radiofizika, v. 8, no. 6, 1965, 1100-1109.

Theoretical values of the absorption factor γ for a range of 10 μ—32 cm were reported in recent of the authors' works (e.g., Rad. i elektronika, no. 9, p. 1327, 1964); measured values of γ were 1.5—2 times higher than the theoretical for the 2—8-mm band and for the submillimeter band. The present article examines the temperature of solar radiation attenuated by the Earth's atmosphere, the absorption factor of atmospheric water vapor, and the temperature of atmospheric radiation. It is preferable to measure the absorption in the submillimeter range by solar radiation than by atmospheric radiation, despite the fact that the solar-radiation method is applicable only when the antenna solar temperature is rather high and substantially varies with the zenith distance. Possible causes of the above discrepancy are briefly discussed in the light of current (1963-65) Western publications.

Zhoravlev, V. S., A. A. Petrovskiy, and B. P. Pogrebnyy. General-purpose radio telescope with antenna diameter of 15 m. Astronomicheskiy zhurnal, v. 43, no. 1, 1966, 220-226.

The RT-15 radio telescope for observation of celestial bodies and artificial Earth satellites at frequency ranges up to 3000 MHz is described. Two such telescopes have been in operation at Zimenki since 1962 and were used in a series of experiments on a radio communication link established between Zimenki and Jodrell Bank via the Echo-II satellite. A photograph of the RT-15 is shown in the figure.

The telescope together with its steering mechanism weighs 120 metric tons. Its height measured from the base of a steel-reinforced foundation is 30 meters. The solid foundation does not allow the telescope to sway more than 5" in winds up to 25 m/sec. The backlash effect and elastic deformations of the rotating mechanisms do not exceed 1.5' and are compensated by feedback systems. The dish antenna may be rotated from -3° to 183° with respect to two mutually perpendicular axes. The error in establishing the perpendicularity of the axes did not exceed ±30", and the error in aligning one of the axes in a particular direction was kept within ±20".

The antenna system consists of two reflecting mirrors: a 15-m diameter parabolic reflector with the active surface machined to an accuracy of ±0.75 mm and a coaxially mounted hyperbolic counter-reflector (not shown in the figure) placed at a distance of 4.69 m from the apex of the first mirror. The power source for steering consists of two motors for each axis: the MI-32T (0.37 kw), which by means of a 240,000:1 reducer tracks slowly moving celestial objects, and theMI-52T (7 kw) with a 10,800:1 reducer which allows the telescope to follow fast moving objects such as artificial Earth satellites.

The position of the telescopes may be controlled in three modes from a control unit located nearby. The automatic tracking mode directs the dish according to a previously prepared program punched on standard 35-mm tape. Discrete error signals arise when the data representing the desired telescope direction disagree with the data on the actual direction from the synchro angle indicators, which give a discrete signal for every 12"-change in direction. The error signals are applied to the feedback loop of the tracking system. When fast-moving objects are being tracked, velocity feedback is also used.

To reduce the amount of program input data, the desired velocity is computed by linear interpolation of rate of change of position data entered on punched tape. Strong velocity feedback introduces an undesirable constant-error component due to nonlinearities of the tachometers and temperature compensating elements. This error is compensated with the aid of a unit which regulates tachometer characteristics. The system is synchronized by the master clock — a quartz crystal with a 21-bit frequency divider.

The second control mode is for visual tracking and is done manually by varying the position or velocity of telescope rotation or both by semiautomatic means. The tracking accuracy depends on the operator's ability to keep the image of the tracked object on the intersection of the cross-hairs on the TV receiving screen. The image on the screen originates from a TV transmitter coupled to an optical telescope installed on the reflector. The TV link uses the standard PTU-3 industrial TV system. The objects for this mode of tracking must be brighter than 6th magnitude.

The third mode is tracking of celestial bodies with the use of tabulated data from previous observations. Angle or velocity tracking is done manually by entering the angle and velocity data from tables into the system every 2, 4, or 16 minutes, depending on the desired accuracy.

The characteristics of each tracking mode are given in the accompanying table. The two radio telescopes may also be utilized as an interferometer or as backups for each other.

Tracking mode data

Operating mode	Velocity	Acceleration	Velocity range	Tracking error
Rapid movement				
Automatic tracking	1.5°/sec	0.1°/sec^2	—	24—36"
Visual tracking	1.8°/sec	0.15°/sec^2	150	—
Realignment	2.0°/sec	0.15°/sec^2	150	—
Slow movement				
Automatic tracking	80"/sec	5.10^{-2}"/sec^2	—	24—36"
Visual tracking	80"/sec	3"/sec^2	150	30"
Tracking with data tables	80"/sec	—	300	60"*

*At top speed using 2-min tracking intervals.

The RT-15 radio telescope

GRAPHIC NOT REPRODUCIBLE

11. Technological Advances

Abesadze, T. B., N. L. Melikadze, M. V. Chkheidze, and V. I. Shekriladze. High-current converter of low-voltage levels into a code. Nauchno-tekhnicheskaya konferentsiya po sredstvam promyshlennoy telemekhaniki. Moscow, 1963. Promyshlennaya telemekhanika (Industrial telemechanics); materialy konferentsii. Moscow, Izd-vo Energiya, 1966, 249-252.

In view of the sensitivity of low-voltage levels to extraneous noise and the concomitant need for the use of amplification in each individual channel, the authors have developed a converter in which the level is measured by a deflecting-beam instrument, and in which the beam deflection is converted into a digital signal by means of a light-sensitive instrument (see figure). The accuracy of such a converter depends both on the accuracy of the meter employed and on the minimum distance which separates two neighboring light-sensitive elements. If several light-sensitive elements are installed at each scale division, and if these elements are suitably arranged in columns, it is possible to code the results of the conversion in accordance with a prescribed law. A standard meter with sensitivity of several millivolts per scale division can be used. If an electrodynamic meter is used, it is possible to obtain in discrete code the amplitude of sinusoidal oscillations at any instant of time, something which cannot be done with any other converter without the use of a rectifier. The code mask is placed on the surface of the focusing member of the instrument, and the scale can be printed photographically.

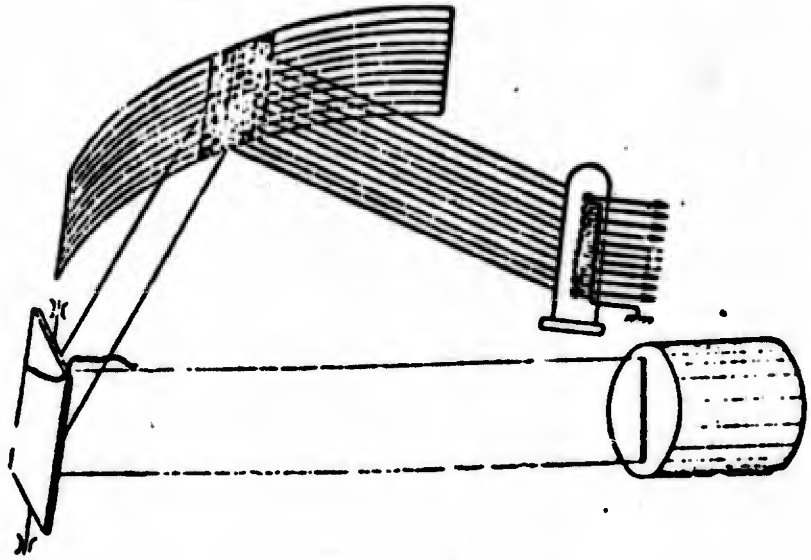


Diagram of converter with focusing mirror

Methods of eliminating the scale nonlinearity have been developed. The use of fiber optics can improve the resolution and the accuracy. Different types of optical fibers, with length of 30 cm, were tried. Types FEU-27 and FEU-31 photomultipliers were tested, and the latter turned out to be more sensitive. A scale of 100 divisions (10 binary digits) with measurement accuracy 0.1% calls for the use of an optical mask of 0.136 x 0.6 mm area, and a maximum width of the light beam of 136 µ. The actual width chosen was 80 µ. A signal of the order of 0.5 volts was obtained in all digits.

Aleksandrin, V. I. Application of the adaptability principle to a voltage-to-digital time-code converter. Priborostroyeniye, no. 4, 1965, 7-8.

A theoretical design is proposed for an adaptive voltage-to-digital converter which would substantially reduce conversion time without reducing accuracy. With this design, the character of the input voltage (waveform, magnitude) automatically controls the usually fixed parameters of conversion speed and degree of quantization. The block diagram of the system (see Fig. 1) resembles the conventional voltage-to-digital converter, in which the pulse generator has access to the counter input for the interval between the start of the ramp voltage and the time when the ramp voltage is equal to the input voltage.

The principle of operation of the adaptive converter is as follows: When the instantaneous value of the difference between the input voltage U_x and the current value of the ramp voltage $U_n(\Delta U(t)) = U_x(t) - U_n(t)$ is greater than some value ΔU_i, the logic circuit (LC) sets the switching elements S_1 and S_2 into position i. This action increases the ramp slope by a factor of 2^i; i.e., it decreases the time necessary for the ramp to change by ΔU. As a consequence, the number of pulses passing through the gate tends to decrease. However, the pulse count is kept at the same level by switching element S_2, which directs the pulses to the (i + 1)st counter flip-flop and in effect multiplies the number of pulses by 2^i.

The design assumes a simplified form for reasonable values of i. Thus, if the ramp slope is increased tenfold for $\Delta U(t) \geq 0.02\ U_{x(max)}$ and the pulse line is switched concurrently to the next-to-last stage of the decade counter, then only two switching actions are necessary, and the conversion time may be reduced by a factor of 8. A comparison of standard and adaptive coding of a ramp voltage is shown in Fig. 2.

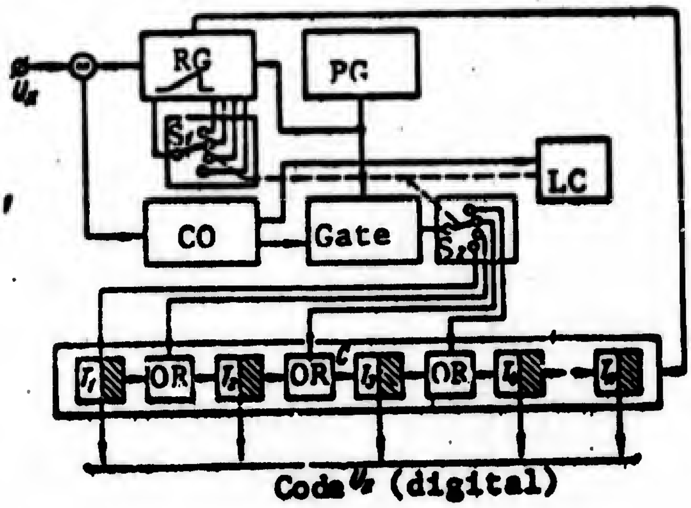


Fig. 1. Block diagram of adaptive converter

T - Flip-flops; S_1, S_2 - switching elements; LC - logic circuit; PG - pulse generator; RG - ramp gen-; erator; CO - comparator circuit.

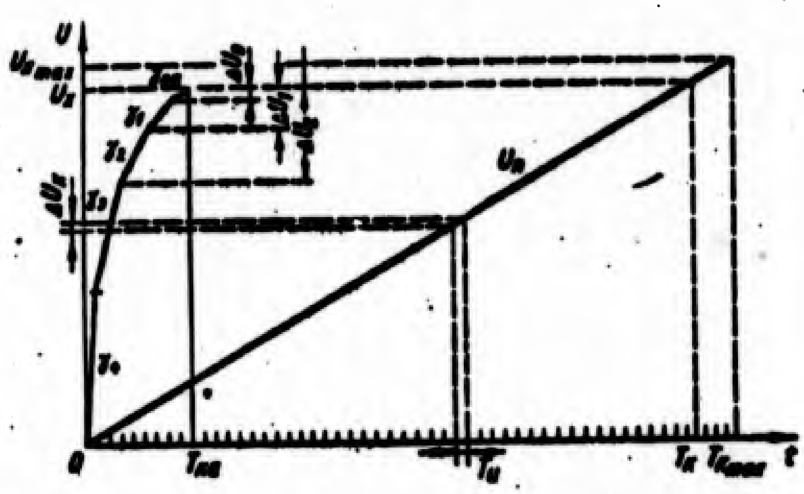


Fig. 2. Comparison of standard and adaptive coding of ramp voltage

T_{ka} - Time to code U_x by adaptive conversion;
T_k - time to code U_x by standard conversion;
γ - changed slopes for various driving signals.

An, V. A., L. A. Geller, and B. N. Kazak. Experiment in using analog-digital conversion for recording variations in Earth's magnetic field. Geomagnetizm i aeronomiya, v. 5, no. 5, 1966, 896-900.

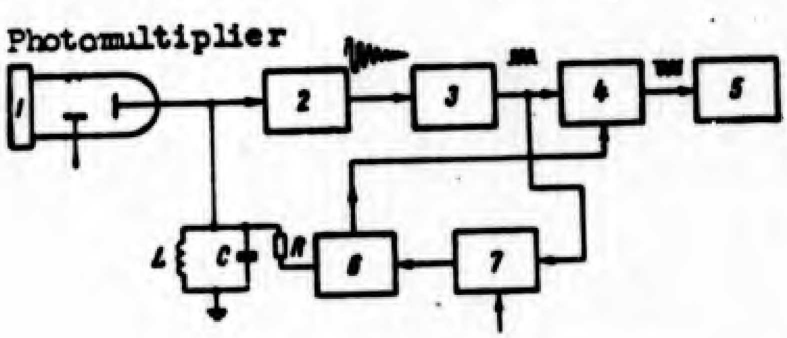
Results are described of recording low frequency (up to 10 hz) microvariations in Earth's magnetic field, performed in November and December, 1963, at the Lovozero Station, Murmansk Oblast. Orthogonal E and H components of the field were separately measured and, after being encoded in 11-bit binary form, were tape recorded for computer analysis. Subsequent D/A conversion was also provided for visual readout of variations on a loop oscillograph. By increasing the encoder commutating rate from 50 to 100 hz, the authors achieved a conversion accuracy of not worse than ±5%. The recording and analytical techniques are claimed to be the first of their type applied to studies of the Earth's magnetic field.

Butayev, G. M., and N. I. Shchedrov. Angle-to-code contactless converter with ferrite sensing elements. Priborostroyeniye, no. 5, 1965, 27-28.

The development is reported of a new angle-to-Gray-code converter in which the on-off switching is effected by copper-foil segments passing through the gap of a very sensitive ferrite core. The sensing element comprises a transistor and a 3-winding ferrite-core transformer connected to form a non-sinusoidal-wave oscillator. Insertion and withdrawal of the copper segment results in starting and stopping the oscillations, with the oscillator functioning as a low-resistance switch. One sensing element is required for every digit of the converter. A wire-saving time-sequence 50-cps-supplied circuit is envisaged for transmitting many-digit signals to a receiver. An experimental model of the converter was tested for over 1 year in actual operation at the Dzerzhinskiy Metallurgical Plant.

Gadalov, A. N., I. D. Rapoport, and Yu. V. Mineyev. Telemetering of pulses from a scintillating cosmic ray detector over a wide dynamic range. Geomagnetizm i aeronomiya, v. 6, no. 4, 1966, 762-766.

A relatively simple system for measuring amplitude of pulses from a scintillation cosmic ray detector in the dynamic range of $\sim 2 \cdot 10^4$ is described. This range is attained by means of an analog-to-numeric conversion directly at the output of a photomultiplier. The basic concept of the system is illustrated in the figure. An oscillatory circuit, tuned to $f \sim 1$ Mc (so that $1/f \gg \tau_\ell$ where τ_ℓ is the luminescence time), is coupled to the anode circuit of the photomultiplier which registers scintillations ($\tau_\ell \sim 10^{-9}$ sec). A photomultiplier current pulse charges the capacitor of the tank circuit and produces a packet of damped oscillations with an initial amplitude (U_o) proportional to the current pulse. The oscillations are damped and then passed on to an amplitude discriminator (threshold, U_t) which forms a packet of standard pulses whose number $N = k \ln (U_o/U_t)$. In the presence of an external control signal and through an anticoincidence circuit (1), these pulses are sent to an output counter whose readings are in turn transmitted to a registration channel. In the absence of the control signal, the circuit oscillations are damped by the first pulse that arrives from the discriminator through another anticoincidence circuit (2). In this case, the packet of pulses is not damped. Thus, a selection is made of registered pulses. The minimum value of the registered scintillation pulses is determined by the input circuit noise. The circuit sensitivity (U_t), which is made to exceed several times the noise level, is $\sim 300\,\mu$v. The maximum value of registered scintillation pulses of ~ 7 v is limited by the permissible amplitude at the input of the transistorized circuits. The power supply required for the entire system does not exceed 100 Mw.



Detector block diagram

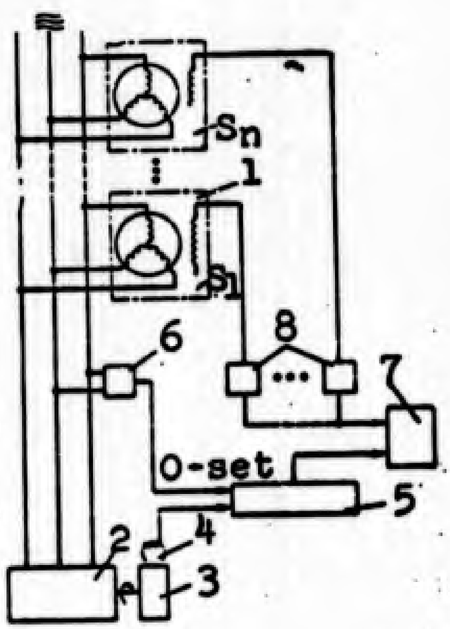
1 - Scintillator; 2 - amplifier; 3 - discriminator; 4 - anticoincidence circuit (1); 5 - counter; 6 - damping circuit; 7 - anticoincidence circuit (2).

Glazov, M. N. Converter of voltage to shaft rotation angle and digital code. Izvestiya vysshikh uchebnykh zavedeniy. Priborostroyeniye, v. 8, no. 5, 1965, 75-79.

An experimental shaft encoder is described which is designed for analog-digital conversion in a feedback control circuit. The feedback signal is developed in the usual fashion by a stepped output motor, which positions the encoder shaft via a reducer. The experimental encoder used is a linear potentiometer with ±160° rotatability; encoder output is displayed on two decatron counters. For an error signal developed by the system within the limits of ±250 mv, the statistical encoder error is not worse than 1%. Error threshold sensitivities of 10 mv and less are stated to be attainable, and satisfactory operation is maintained at power supply voltage and frequency deviations of ±15%.

Gorokhov, L. P. Multichannel angle-code converter. Priborostroyeniye, no. 9, 1965, 29.

A multichannel angle-to-code converter is described. The converter (see figure) does not utilize the usual parallel-to-serial conversion nor a large quantity of pulse generators. Synchros S_1, ...S_n are powered by generator 2. Pulse generator 3, driven by the power generator shaft, gives out a fixed number of pulses to sensor 4 for every 360° of rotation of the common shaft. The pulses from sensor 4 are applied to



Multichannel converter

counter 5, which is reset by shaper 6 for each 180° change of phase of the generated voltage. Gate 7 allows shaper 8 in conjunction with the counter to enter the digital equivalent of an angle of turn of a synchro into the computer. The system takes on an even simpler form if the computer memory consists of a magnetic drum; in this case, the drum rotation and power generator 2 are synchronized.

Grebenshchikov, V. N., and V. O. Krichke. Register with analog-digital converter. Priborostroyeniye, no. 9, 1965, 10-12.

A description is given of a system capable of sensing negative slowly varying voltages between 0 and 15 v, converting them into a two-digit decimal number between 0 and 99 with an accuracy of 1%, and printing the results on the EUM-23 typewriter, all in 2 sec. The system uses relays to accomplish the logical functions needed in the comparison of the analog sample to the reference voltages. The conversion from binary to decimal numbers needed for the printout is also done by the same 16 relays. The system is comparatively slow but it has the advantage over other systems of the same type in that if one or more relays malfunctions or the comparator circuit fails, the typewriter will not print.

Ivanov, A. A. Time-digital-code converter for nanosecond range. Pribory i tekhnika eksperimenta, no. 1, 1966, 111-114.

As the existing analog time-pulse-height-time converters are inadequate for the purposes of modern experimental physics, a new non-analog converter has been developed. It uses the well-known principle of measuring a time interval by counting the number of pulses whose repetition rate is exactly known. A repetition rate of 200 Mc has been selected, which gives a time resolution of 5 nsec. The tunnel-diode counter capacity is 2^8, i.e., the maximum measurable time interval is 1.28 microsec. The differential nonlinearity of the converter is $\pm 0.4\%$ or lower. The converter has been used under laboratory conditions for about 6 months. Reducing its resolution time to 1 nsec is held possible. A principal circuit of the converter is explained.

Ivanov, Ye. S., Yu. A. Belanov, and V. N. Brodovskiy. Angle-to-digit converter. Class 42, No. 165594. Byulleten' izobreteniy i tovarnykh znakov, no. 19, 1964, 48-49.

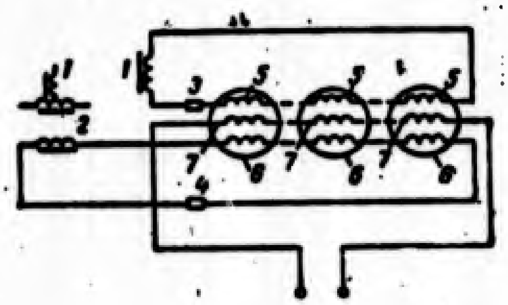
This Author Certificate introduces an angle-to-digit converter by which the phase-measurement method can be applied to a rotary converter. In order to utilize industrial sources of rotary fields, the converter is provided with a pulse generator based on three-coil, ferrite-core transformers (see figure). In a variant designed to ensure a required degree of conversion accuracy, the converter contains m transformers which are equal in number to 2^{n-1}, where n is the number of bits. In a second variant, a sequence of pulses is produced which have opposite polarities. The primary winding of the k transformer contains a number of turns equal to $W_{1K} = W_0 \cdot \cos \gamma K$, and a number of secondary turns equal to $W_{2K} = W_0 \cdot \sin \gamma K$, where W_0 is the number of turns determined by the dimensions of the core, and γK is a phase angle equal in the first and second quadrants to

$$\frac{360^\circ}{2^{n-1}}(K-1)$$

and in the third and fourth quadrants to

$$180^\circ + \frac{360^\circ}{2^n} + \frac{360^\circ}{2^{n-1}}(K-1),$$

where K = 0, 1, 2...m/2. In a final variant, the transformer output windings are connected to a d-c magnetizing source in order to reduce the number of transformers.



Circuit diagram of an angle-to-digit converter

1, 2 - Transformers; 3, 4 - resistors; 5 - primary transformer windings; 6 - secondary transformer windings; 7 - transformer output windings.

Karyshev, Ye. N. A method for conversion of an analog signal. Class 42, No. 174842. Byulleten' izobreteniy i tovarnykh znakov, no. 18, 1965, 90.

This Author Certificate introduces a method for converting an analog signal into the quantized or sign function necessary for calculating a distribution law or normalized correlation function on a photoelectronic polar correlator. The process of recording the quantized or sign function on photographic film is speeded up and automated by quantizing the analog input signal according to level and converting the signal for each quantum into a train of rectangular pulses with a duration equal to the time that the signal remains in the given quantum. The resultant pulse train is used for controlling neon lamps which expose the photographic film.

Kneppo, P. L., A. A. Mozheyko, and V. F. Semenov. High-speed transistorized voltage-to-code converters. Priborostroyeniye, no. 8, 1965, 12-14.

A description is given of two analog-to-digital converters with ranges of 9.999 v and 10.2375 v and resolving capabilities of 1 mv and 2.5 mv, respectively. Conversion speeds are 3 μsec and 0.15 μsec; absolute error is $\pm(0.02\% U_x + 1)$ and $\pm(0.05\% U_x + 2.5)$, where U_x is the analog voltage to be converted.

Both models operate on the principle of successive comparisons. The 16 or 12 flip-flops (depending on the model) generate a voltage U_y, which is compared with U_x; the outcome of the comparison changes the flip-flop states, which in turn generate another U_y, which is again compared with U_x. The process continues until U_y does not differ from U_x by more than the lowest order binary digit, or the sensitivity of the differential amplifier which is used as a comparator block. The differential amplifiers in the two models have a drift of 50 μv/C and 100 μv/C with common mode rejection capabilities of 50,000 and 10,000 (voltage ratio). The first converter is designed for operation in the temperature range of 15—35C, and the second, in the range of -20 to +4C. Tolerable power line voltage unbalance is ±10% for both models.

Kondalev, A. I., Ye. A. Semeshko, and P. M. Siverskiy. Analog-to-digital converter for magnetic-tape signal coding and entry into digital computer. Avtomatika i priborostroyeniye, no. 4, 1965: 23-25.

The Institute of Cybernetics of the Academy of Sciences USSR has developed a printed-circuit transistorized A/D converter with the following characteristics: analog input range, from -2.54 to +2.54 v; digital word length, 7 bits for input signals at 200 cps—18 kc and 8 bits for signals at 0—200 cps; sampling rate, variable from 500 kc up to fractions of cps; input resistance, 100 kohm; threshold sensitivity, 10 mv; conversion time, 0.5—1 μsec; power consumption, 100 w; and operating temperature range 18—30C. The principle of operation is as follows: A null circuit continuously compares the input analog U(t) and quantized reference voltage U_{ref} and in case of nonagreement sends pulses to one of two inputs of the reversible counter. The counter in turn changes the reference voltage in the direction of diminishing nonagreement. The counter contents (representing the digital equivalent of the analog input) always vary to follow the analog voltage and stop only if $|U(t) - U_{ref}| < 10$ mv. The counter may be sampled at a rate suitable for subsequent information recording on magnetic tape, perforator, punched card unit, or direct computer input.

Leytman, M. B. Converters for telemetry systems using magnetic elements. IN: Akademiya nauk SSSR. Institut avtomatiki i telemekhaniki. Magnitnyye tsifrovyye elementy (Magnetic digital elements). Moskva, Izd-vo Nauka, 1965. 147-155.

Two circuits are described: 1) a pulse width modulator (see Fig. 1); and 2) a pulse repetition frequency-to-voltage converter (see Fig. 2). In the first, the transistor normally cut-off by back bias U_B receives a start pulse U_{start} and U_{in} at its base. The collector current linearly increases until the transistor saturation region is entered. The latter is a function of base current or U_{in}. For a circuit utilizing an E-42 steel core 3 cm^2 in cross-section and a P26 transistor the input-output characteristic is a train of pulses whose duration varies by 10 msec/volt. The ratio of maximum to minimum pulse duration for this circuit is 733. In the second circuit, the transistor is normally cut-off by U_B and the core is in state $-B_s$. The start pulse saturates the transistor and switches the core into state $+B_s$. The core returns to the initial state by the action of bias current I_1. Thus, the duration of output pulses and their amplitude remain constant while the repetition frequency follows the repetition frequency of start pulses. The average value of the output waveshape is proportional to the repetition frequency. The actual model for a maximum frequency of 80 cps was built using 50NP alloy for the transformer core. The relative error for the temperature range extending from 20 to 45°C was less than 0.5%, and when compensation was included, the error was reduced to 0.1%.

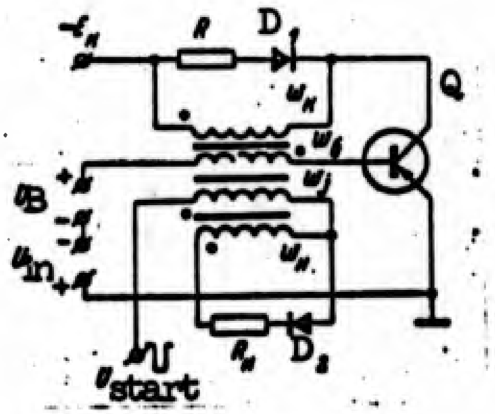


Fig. 1. Diagram of pulse width modulator

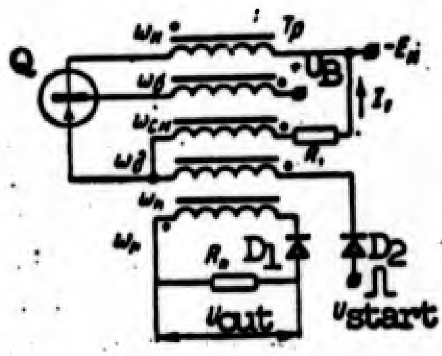


Fig. 2. Frequency measurement circuit

Luchenitsev, I. A., D. A. Fridshtand, and N. I. Shchedrov. Transistorized digital converter. Avtomatika i priborostroyeniye, no. 2, 1965, 39-41.

A direct analog-to-digital converter with a conversion time of 10 msec and a maximum permissible error of $\leq 1.5\%$ is described. It is designed to achieve the simplicity, economy, and reliability necessary for sampling systems that require individual converters for each channel. The converter is temperature stabilized, has a built-in memory unit, and can be readily integrated into a digital computer system.

The converter operates as follows: Upon an external command a sawtooth voltage is generated by an RC circuit with $\pm 0.1\%$ linearity. Concurrently, a control flip-flop triggers on, connecting a 100-kc pulse generator to a binary counter.

The count continues until the sawtooth voltage reaches the level of the voltage being converted. At this point a hybrid comparator-blocking oscillator resets the control flip-flop, which in turn stops the count. The counter reading is thus proportional to the input voltage.

The converter has the following characteristics: input voltage range, 0—2.5 v; resolution, 2.5 mw; conversion time, 10 msec; input impedance, 1 Mohm; inherent conversion error at 20 ±3C, ±0.5%, with an increment of ±0.3% for every ten degrees of temperature change.

Lumbovskaya, T. N. Calculation by successive approximations of the trajectory of multistage rockets guided by the beam-rider method. Issledovaniya po dinamike poleta (Research on flight dynamics), no. 1. Moscow, Izd-vo Mashinostroyeniye, 1965, 237-256.

It is shown that the problem of determining the trajectory of a rocket guided to a moving target by the beam-rider method can be reduced to the simultaneous solution of a system of nonlinear differential equations describing the motion of the rocket and the kinematic equations of the guidance method. The author stresses that solving such a system by numerical methods is a laborious task and that the obtained solution does not show a general principle of the motion of the rocket and of the target because it depends on initial conditions of motion and the aerodynamic and structural parameters of the rocket. A grapho-analytic method based on the method of successive approximations is propcsed for determining the trajectory of a multistage rocket guided to a target. By linearizing the kinematic equation of the beam-rider method and integrating, the following expression for determining the trajectory of the rocket is derived:

$$\varepsilon = \frac{V_c}{H_c} \cdot \frac{\sin^2 \beta}{V} \left(\frac{H_0 \cdot r_{c0}}{H_c} + \int_0^t V dt \right).$$

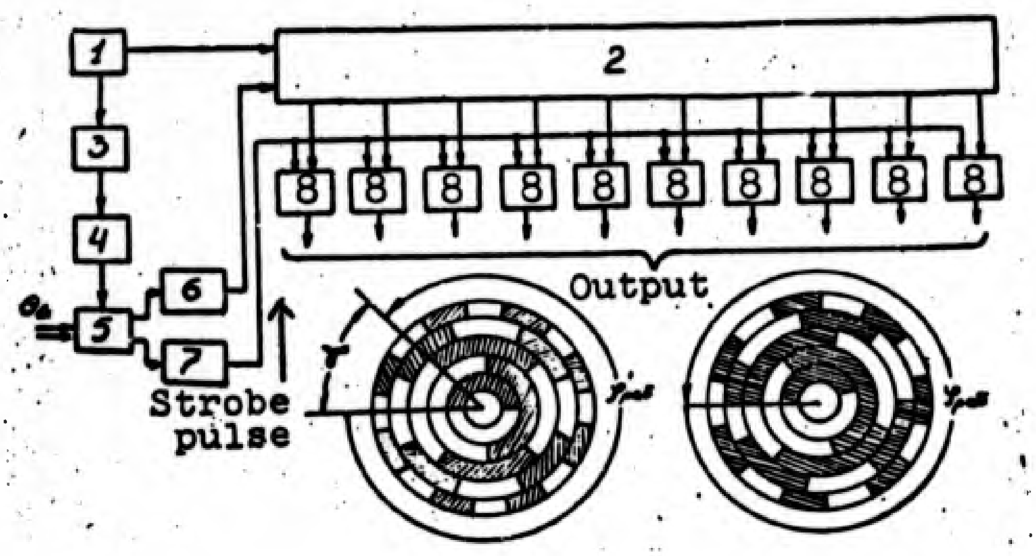
where ε is the lead angle (the angle between the radius vector and the velocity vector of the rocket); V_c is the velocity of the target; H_c is the altitude of the target; β is the angle between the radius vector and the horizontal plane; H_0, r_{c0}, and V are the altitude of the rocket, its distance from the guidance system, and the velocity of the rocket at the initial instant of guidance, respectively. Expression (1) contains the function V(t) and, therefore, the problem of calculating the trajectory can be solved in quadratures, when the law of variation of velocity in time is known. Assuming that variation of the velocity in time is linear, the first approximation to the solution of the problem is derived. The methods of graphical integration are used for determining flight parameters. On the basis of first approximation formulas, an algorithm for successive approximation of trajectory parameters is presented. It is noted that in order to calculate the parameters for each stage of a rocket, it is sufficient to confine oneself to second-approximation formulas; third-approximation results are very close to or even coincide with the results of the second approximation.

Marlenskiy, A. D. Orientation on interplanetary flights with devices based on the use of rigidly connected telescopes aimed in opposite directions. Kosmicheskiye issledovaniya, no. 2, 1966, 330-332.

This paper describes orientation of spaceships in interplanetary space and determination of their orbital elements by means of a device that uses rigidly connected telescopes aimed in opposite directions. On manned flights, a number of automatic as well as measuring and control devices can be constructed by aiming one of the telescopes (T_1) at the sun and with the other (T_2) observing stars in the opposite half of the galaxy. To keep telescope T_1 pointed toward the sun would require a low-power motor capable of providing angular accelerations on the order of 10^{-4}"/sec^2. In this configuration telescope T_2 can be pre-programmed to observe some of the visible stars that fall in its field of view (1—2° wide) and compare the observed angles with those stored in the program memory. Another configuration that uses two pairs of telescopes, one directed toward the sun and the stars and the other directed toward the earth and the stars, makes possible the calculation of the helio- and geocentric radii-vectors of the spaceship from simple geometric relationships.

Pautov, V. I., B. N. Saveliyev, and V. P. Skuridin. Contactless shaft-position to code converter with parallel readout. Izvestiya vysshikh uchebnykh zavedeniy. Priborostroyeniye, v. 8, no. 6, 1965, 68-72.

A position-to-code converter operating on the principle of intermediate phase shift is described. The code wheel is maxked according to the Gray code, and angular displacements may be coded in degrees, radius, or the graduations of any other angular scale. A block diagram of the converter is shown in the figure. The strobe pulse is applied to the left inputs of the AND gates, which are controlled by the code scanner at the right inputs. Coincidence produces a binary coded output. The frequency scaler together with the code scanner may be set to give an output in discrete units equal to $\Delta\varphi = 360°/2$ k, where k is the ratio of clock pulse repetition frequency to the pulse repetition frequency of the highest order track of the code wheel. The same reduction factor may be obtained by eliminating section γ (see figure) from the code wheel. Practical considerations limit the number of bits of the converter output to 12-13; attainable linearity is ±1 angular minute.



Position-to-oode converter

1 - System clock; 2 - code scanner; 3 - frequency scaler; 4 - filter tuned to phase-shifter power frequency; 5 - induction-type phase shifter; 6, 7 - strobe pulse generators; 8 - AND gates.

Perov, G. I., and Yu. V. Rodionov. A variant of a transistorized analog-to-digital converter. IN: Akademiya nauk SSSR. Sibirskoye otdeleniye. Avtomaticheskiy kontrol' i metody elektricheskikh izmereniy, tom 2 (Automatic control and methods of electrical measurements, v. 2). Novosibirsk, 1964. 48-55.

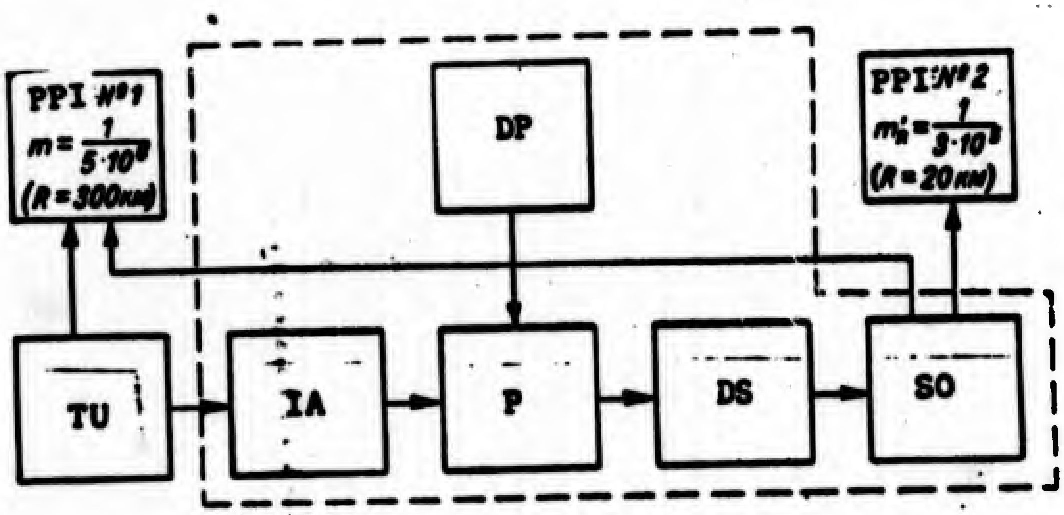
An experimental analog-to-digital converter intended for use as an input to a digital computer is described. It has the following characteristics: analog input-voltage range, 0—10 v; conversion accuracy, ±0.5%; conversion time, 50 μsec; seven channel input; input impedance, 3 kohm.

The converter works on the principle of successive comparisons. The threshold comparator circuit consists of a d-c-coupled amplifier with a very low input impedance. Three currents (I_x, current proportional to the input voltage; I_k, corrective current; and one or more reference currents) are summed at the input to the amplifier. The output is either greater or less than the preset threshold level. The output accordingly affects the logic elements of the circuit which in turn adjust the reference current for the next comparison. This sequence continues until the unknown current is determined with an accuracy corresponding to the lowest reference current.

The states of the gated flip-flops, which determine the reference currents, are a digital equivalent of the analog input voltage. The corrective current I_k is automatically adjusted periodically to eliminate zero drift. The test models performed satisfactorily in an ambient temperature range of 10—35C.

Petrushevskiy, V. A. A device for detailed study of radio echoes from clouds and precipitation. Leningrad. Glavnaya geofizicheskaya observatoriya. Trudy, no. 159, 1964. Voprosy radiometeorologii (Problems in radiometeorology), 89-93.

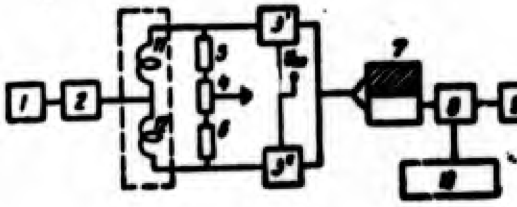
The author describes a unit for improving the definition of a radar echo pattern on a PPI which makes it possible to determine the direction and rate of motion of the blip with more speed and accuracy. A block diagram of the unit is shown in the figure. The device uses two P-displays: coarse (PPI No. 1) and fine (PPI No. 2). Any section in the range of the coarse PPI may be examined on the fine PPI in large scale (from 3:106 to 6:107, which corresponds to ranges from 20 to 100 km). A pulse from trigger unit TU starts scanning of PPI No. 1 and is fed to the delay unit which consists of an inverter amplifier IA, phantastron P, differentiation stage DS and squegging oscillator SO. Scanning of PPI No. 2 is triggered by the delayed pulse. The delay time is regulated by delay potentiometer DP which is graduated with respect to range. A schematic diagram of the delay unit is given. The azimuthal distortions which arise during operation of the instrument are analyzed.



Display block diagram

Skobelev, O. P. Pulse-time analog-to-digital converter. Byulleten' izobreteniy i tovarnykh znakov, no. 24, 1965, 105.

A pulse-time analog-to-digital converter (see figure) is introduced. To simplify the device and increase its accuracy, the output of a square-wave generator in the flip-flop control block is connected to the midpoint between the resistance-loaded inductors. The comparator outputs are coupled with the flip-flop input and with the reference voltage source.



Time-pulse analog-to-digital converter

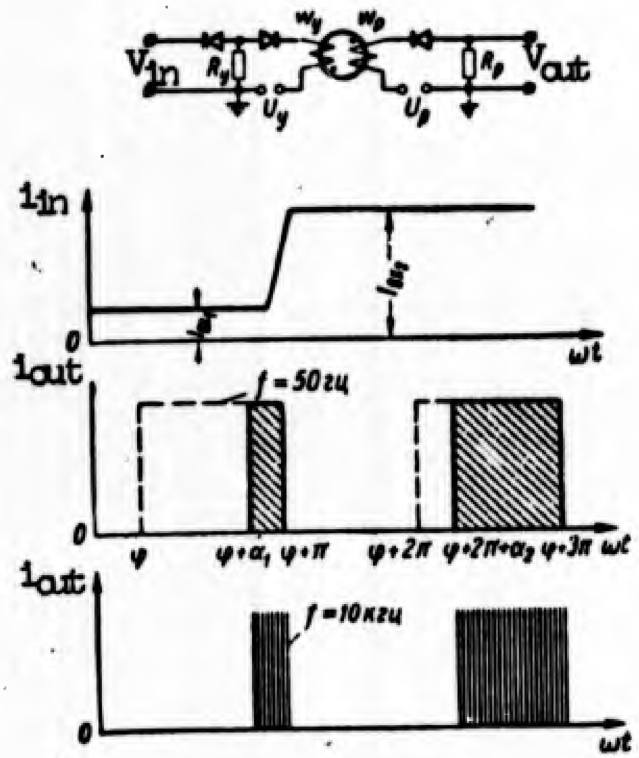
1 - Generator; 2 - monostable multivibrator; 3' and 3" - comparators; 4-6 - resistors; 7 - flip-flop; 8 - switching elements; 9 - standard frequency generator; 10 - counter; 11 and 12 - inductors.

Vinnichenko, N. K., and G. N. Shur. Multichannel airborne code converter. Tsentral'naya aerologicheskaya observatoriya. Trudy, no. 63, 1965. Voprosy dinamiki atmosfery (Problems of atmospheric dynamics), 96-103.

A multichannel airborne code converter has been designed for continuous synchronous pulse-frequency coding of time-varying meteorological parameters in a form suitable for magnetic recording. Circuit design and construction of the device are described in considerable detail. Laboratory tests have shown that the time constant does not exceed 0.005 sec, even though the circuits of some channels, particularly channels 1—5, have inertial elements. In the frequency range employed, even the first five channels are practically inertialess. The dependence of channel output frequency on input signal voltage is also practically linear. Thus, despite the essentially nonlinear operation of pulse-frequency modulation, the device is linear and inertialess, and random signals (time-varying parameters) passing through the code converter do not change their statistical characteristics. Total conversion error for each channel under static conditions does not exceed ±2% with a supply voltage fluctuation of ±6%.

Yeremeyev, I. S. Analog-to-digital units based on magnetic elements. Priborostroyeniye, no. 1, 1965, 16-17.

The development of new types of analog-to-digital units based on logical elements and pulse-width modulation is reported. Based on half-wave magnetic amplifiers, the units can perform amplification, addition, and multiplication operations, can store continuous input signals or convert them into duration-modulated pulses which are in turn converted into digits. As shown in the figure, 10 kc bursts are generated whose duration is a function of input signal amplitude. A description of circuit operation is included.



Pulse width modulator

Zelenkova, I. A., V. Ye. Zelenkov, and V. P. Zaytsev. Measurements of absorption in the ionosphere by the A5 method. Apparatus. First results. Geomagnetizm i aeronomiya, v. 6, no. 1, 1966, 149-150.

This is a report on the use of the A5 method (as proposed at the Ionosphere Conference at Nice, December 11-12, 1961) in measuring absorption of radio waves in the ionosphere. This technique involves vertical sounding with continuously varying frequency. Measurements were made at standard ionosphere-scanning stations with the vertical Sp-3 sonde. This instrument permits measurements in the frequency range from 0.5 to 20.0 megahertz with a pulse frequency of 30 hertz, pulse duration of 100 microseconds, and a pulse power of 20 kv. Amplitude-height-frequency characteristics were obtained. The amount of information supplied by this method proved to be much greater than that of previous methods (particularly A1). A defect of the method is the great time-consuming task of handling the experimental records. It is suggested that in the future the amplitudes of reflections at different signal frequencies be averaged by accumulation on the photographic prints; i.e., allow all 60 exposures of the selected images to be made on a single frame.

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This compilation of abstracts is based on Soviet, Satellite, and CHICOM open sources published 1965-1966 including a few articles published earlier which relate to the following three topics: precision frequency measurements, precision angular displacement measurements, and precision analog-digital data conversion. The 81 abstracts are arranged alphabetically by author within the following categories: 1. Tracking facilities and institutions (3 entries); 2. Tracking equipment and techniques (14 entries); 3. Precision baseline establishment (3 entries); 4. Slant range and range rate measurement (1 entry); 5. Angle and angular rate measurement (4 entries); 6. Absolute time measurement (2 entries); 7. Frequency measurement and standards (7 entries); 8. Relative time or delay time measurement (6 entries); 9. Velocity of light determination (2 entries); 10. Radio astronomy (15 entries); 11. Technological advances (24 entries). A bibliography comprising 81 entries is presented at the end of the report.