

JPRS-UEQ-92-009
5 AUGUST 1992



**FOREIGN
BROADCAST
INFORMATION
SERVICE**

JPRS Report

Science & Technology

***Central Eurasia:
Engineering & Equipment***

19981221 079

DTIC QUALITY INSPECTED 3

DISTRIBUTION STATEMENT E
Approved for public release
Distribution Unlimited

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL INFORMATION SERVICE
SPRINGFIELD, VA 22161

Science & Technology

Central Eurasia: Engineering & Equipment

JPRS-UEQ-92-009

CONTENTS

5 August 1992

Aviation and Space Technology

- Flight to Alpha Centauri [V. Lagovskiy; *RABOCHAYA TRIBUNA*, 16 Jun 92] 1
- One Method of Laminarizing the Boundary Layer on a Vibrating Wing
[S.V. Manuylovich; *DOKLADY AKADEMII NAUK SSSR*, Vol 322, No 1, 92] 3

Optics, High Energy Devices

- NPO 'Uran' Offers Underwater Towed Sensor for Sale [TEKHNIKA I VOORUZHENIYE, No 3-4 92] . 4

Nuclear Energy

- Military Seen Dodging Scrutiny of Novaya Zemlya Radiation Hazards
[A. Yemelyanenko; *ROSSIYSKAYA GAZETA*, 23 Jun 92] 5
- New Transformer Designs [M.L. Feldman; *ELEKTRICHESKIYE STANTSII*, Mar 92] 7
- Thermohydraulic Model of the Primary Loop for a Full-Scale Simulator With a VVER-1000 Reactor
[A.Ye. Koroshilin, A.P. Zhukavin, et al.; *ELEKTRICHESKIYE STANTSII*, Mar 92] 8
- Analysis of the Assimilation of 500-kW Equipment at the Sayano-Shushenskaya GES
[V.V. Bolnov, V.A. Kyari, et al.; *ELEKTRICHESKIYE STANTSII*, Feb 92] 8
- Analysis of Energy Expenditures To Create and Operate Nuclear Power Plants With Series-Produced
Types of VVER and RBMK Reactors
[Ye.I. Dyakonov, Ye.I. Ignatenko; *ELEKTRICHESKIYE STANTSII*, Feb 92] 9
- The Distribution of Dissolved Drinking Water Impurities in the Water Space of the PGV-1000 Steam
Generator [Yu.V. Kozlov, L.K. Rummyantsev, et al.; *ELEKTRICHESKIYE STANTSII*, Feb 92] 9

Non-Nuclear Energy

- Prospects for Development of Solid Fuel-Fired TES
[Yu.K. Semenov, A.F. Dyakov, et al.; *TEPLOENERGETIKA*, Jan 92] 10
- Using Flash Primary Furnaces To Burn Low-Grade Solid Fuels—A Method of Improving the Ecological
Characteristics of Electric Power Plants
[E.P. Volkov, A.F. Gavrilov, et al.; *TEPLOENERGETIKA*, Jan 92] 10
- Energy-Storing Heat Pump Unit [A.L. Petrosyan; *TEPLOENERGETIKA*, Jan 92] 11
- Semiconductor Devices for High-Power Electronics
[V.V. Grekhov; *IZVESTIYA ROSSIYSKOY AKADEMII NAUK ENERGETIKA*, No 1, Jan-Feb 92] 12
- Solar Batteries With Bilateral Sensitivity
[N.M. Bordina, V.R. Zayavlin; *GELIOTEKHNIKA*, No 1, Jan-Feb 92] 12
- A Solar Unit for Experimental Research on Optical Materials' Heat Resistance
[Yu.Z. Mavashev, G.M. Arushanov, et al.; *GELIOTEKHNIKA*, No 2, Mar-Apr 92] 13
- Optimizing the Operating Mode of a Power System Under Conditions of Ecological Constraints
[A.P. Golovanov, Zh.M. Medetov; *IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY:
ENERGETIKA*, Apr 92] 13
- Specific Power Generation of Modular Solar Power Plants: Output Losses
[D.I. Teplyakov; *GELIOTEKHNIKA*, No 2, Mar-Apr 92] 14
- Solar Cells With Shallow and Recessed InGaP *p-n* Junctions
[M.A. Abdukadyrov, A.A. Alayev, et al.; *GELIOTEKHNIKA*, No 2, Mar-Apr 92] 14
- Forecasting the Demand Adaptability of the Operation of a BKZ-420-14OPT-2 Boiler While It is
Burning Irsha-Borodino Coals [Yu.A. Zhuravlev, A.G. Blokh, et al.; *TEPLOENERGETIKA*, Jan 92] .. 15
- The Formation of Nitrogen Oxide When Anthracite Culm Is Burned in a Pilot Unit
[A.A. Kniga, V.T. Sidorkin, et al.; *TEPLOENERGETIKA*, Jan 92] 15

Dynamics of the Change in the Heat Engineering Characteristics of Ekibastuz Coal and Their Effect on the Operation of Steam Boilers in 500 MW Power Plant Units [V.I. Mansurov, S.M. Tsyganov, et al.; <i>TEPLOENERGETIKA</i> , Jan 92]	16
Evaluation of Conical Concentrators [A.V. Vartanyan; <i>GELIOTEKHNIKA</i> , No 2, Mar-Apr 92]	17
Results of Full-Scale Tests and Technical Characteristics of the SOU-100 Solar Desalination Unit [B.M. Achilov, K. Batirov; <i>GELIOTEKHNIKA</i> , No 2, Mar-Apr 92]	17
Investigation of the Heat Losses of the Vacuum Tube Selective Heat Absorber of a Solar Concentrator [G.V. Tsiklauri, T.O. Nozadze, et al.; <i>GELIOTEKHNIKA</i> , No 2, Mar-Apr 92]	18
Conditions of the Formation of the Gas and Gas Condensate Deposits of Central and Eastern Turkmenistan [K.M. Tegelekov, N.B. Bekmuradov; <i>IZVESTIYA AKADEMII NAUK TURKMENISTANA</i> , No 2, Mar-Apr 92]	18
Structural and Design Features of Nontraditional Energy Sources [R.I. Zapatrin, M.D. Al-Abdullakh; <i>IZVESTIYA VYSSHNIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA</i> , Apr 92]	18
An Economic Assessment of Forecast and Long-Range Gas Resources in Turkmenistan [Ch.M. Paytykov; <i>IZVESTIYA AKADEMII NAUK TURKMENISTANA</i> , No 2, Mar-Apr 92]	19
Computer Analysis of the Condition of the Optical System of the SES-5 [T.K. Koyshiyev; <i>GELIOTEKHNIKA</i> , No 1, Jan-Feb 92]	19

Mechanics of Gases, Liquids, Solids

Calculating Rotation Derivatives in the Case of "Local" Interaction of a Flow and Body Surface [A.I. Bunimovich, A.V. Dubinskiy; <i>PRIKLADNAYA MATEMATIKA I MEKHANIKA</i> , Vol 56 No 1, Jan-Feb 92]	20
The Buckling of Trilayer Round Plates Lying on a Linearly Deformed Base [T.Sh. Shirinkulov, U. Alikulov; <i>IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: TEKHNIЧЕСKIYE NAUKI</i> , No 6, Nov-Dec 91]	20
One Case of Wave Propagation in Layered Porous Media [S. Abdullayev, T.U. Artikov, et al.; <i>IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: TEKHNIЧЕСKIYE NAUKI</i> , No 6, Nov-Dec 91]	20
The Stress-Strained State of Retaining Walls Subjected to the Effect of Dynamic Loads [A.Sh. Karimov, G.Kh. Khozhmetov; <i>IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: TEKHNIЧЕСKIYE NAUKI</i> , No 6, Nov-Dec 91]	21
Optimal Control of the Rotation of a Solid Body With a Flexible Pivot [Ye.P. Kubyshkin; <i>PRIKLADNAYA MATEMATIKA I MEKHANIKA</i> , Vol 56 No 2, Mar-Apr 92]	21
Dynamics of a High-Speed Compressor [A.R. Isayuk-Sayevskaya, A.S. Kelzon; <i>PRIKLADNAYA MATEMATIKA I MEKHANIKA</i> , Vol 56 No 2, Mar-Apr 92]	21
Shock-Free Motions in Systems With Unilateral Constraints [A.P. Ivanov; <i>PRIKLADNAYA MATEMATIKA I MEKHANIKA</i> , Vol 56 No 1, Jan-Feb 92]	22
The Use of "Forbidden" Amplitudes When Calculating a Vessel's Wave Drag [E.L. Amromin, A.N. Lordkipanidze, et al.; <i>PRIKLADNAYA MATEMATIKA I MEKHANIKA</i> , Vol 56 No 1, Jan-Feb 92]	22
The Stability of One Particular Motion of a Solid Body With a Viscoelastic Membrane in a Circular Orbit [O.V. Kholostova; <i>PRIKLADNAYA MATEMATIKA I MEKHANIKA</i> , Vol 56 No 1, Jan-Feb 92]	22
Particular Directions in the Configurational Space of Linear Oscillation Systems [V.F. Zhuravlev; <i>PRIKLADNAYA MATEMATIKA I MEKHANIKA</i> , Vol 56 No 1, Jan-Feb 92]	22
The Dynamic Intensity of a Conductive Half-Space With a Curvilinear Crack in a Strong Magnetic Field (The State of Antiplane Deformation) [L.A. Filshinskiy, L.I. Fomenko; <i>PRIKLADNAYA MATEMATIKA I MEKHANIKA</i> , Vol 56 No 1, Jan-Feb 92]	23
Issues of Plastic Straining of Anisotropic Textured Metallic Materials [P.F. Prasolov; <i>PROBLEMY MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN</i> , No 1, Jan-Feb 92]	23
Reasonable Balancing Accuracy Limits [A.S. Kelzon, A.S. Meller; <i>PROBLEMY MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN</i> , No 1, Jan-Feb 92]	23

Industrial Technology, Planning, Productivity

Unitary Models of Manipulating Robot Mechanics [V.A. Konoplev, A.T. Zaremba; <i>PROBLEMY MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN</i> , No 1, Jan-Feb 92]	24
Effect of Control Cycle on Stability and Dynamic Accuracy of Industrial Robot [L.M. Bolotin, L.I. Tyves; <i>PROBLEMY MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN</i> , No 2, Mar-Apr 92]	24
Dynamics of Controlled Cycling Machine [V. Omran, A.V. Sloushch; <i>PROBLEMY MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN</i> , No 1, Jan-Feb 92]	24

Flight to Alpha Centauri

927F0229A Moscow *RABOCHAYA TRIBUNA*
in Russian 16 Jun 92 pp 1, 3

[Article by Vladimir Lagovskiy under the "Sensation" rubric: "Flight to Alpha Centauri"; boldface as per source text]

[Text] Specialists at the Experimental Machine Building Scientific Research Association have created a high-temperature superconductor that loses its electrical resistance at 80 degrees Celsius. It breaks the old confirmed world's record by nearly 100 degrees Celsius. Moreover, there is proof that this is not the limit: Superconductors may be created at 850 degree Celsius. And it may be used as the basis for constructing a fundamentally new type of spacecraft capable of reaching light speed.

On a Flying Saucer

From the outset, we acknowledge this as fact. The rumors that the military-industrial complex, which is precisely the owner of the Experimental Machine Building Scientific Research Association, is in all seriousness interested in "flying saucers" and considers them to be real. I have the document in front of me. It is called "Protocol for a Future Method of Aircraft Travel." On top is the customary "Approved by" signature stamp followed by the signature of the deputy commander of the military unit and his official stamp. Next comes the date and site of the test and the test object. And then there is the objective, at which point it is written that the experiments were conducted to assess the effect of the movement of a bulk high-temperature superconductor subjected to the effect of a flux of fast-moving electrons in accordance with the aircraft research program developed at the Experimental Machine Building Scientific Research Association and the N-th military unit.

It is no accident that I am presenting these data in such detail. Our stereotypes are strong. Indeed, many will say that "saucers" means "newcomers." And newcomers are gibberish. No, this matter is uncommonly serious. This is no discussion of fantastic hypotheses but of the current rift between technology and fundamental knowledge. The "Protocol" is not the only such affirmation. There are also patents, inventor's certificates, and applications for discoveries and inventions.

"What we are proposing," says Vasily Shabetnik, senior scientific associate of the Experimental Machine Building Scientific Research Association and candidate of technical sciences, "is a fundamentally new method of space travel. And we can demonstrate it."

Here is the so-called Mohammed's grave—a saucerlike body made of a cooled superconductor sailing freely in a magnetic field. Nearly all developers of high-temperature superconducting compounds have "toyed around with" this focal point. And it has excited its enthusiasts' imagination. It seems that this is just how one can fly over the

earth in some sort of miracle craft. It is possible. There are no theoretical obstacles. But here is the problem: On closer examination, this generally sensible idea turned out to be fraught with irresolvable technical problems.

To rise above our planet in the geomagnetic field, for example, a "saucer" would have to create its own incredibly strong magnetic field. And this is far from easy, even with the superconductors themselves. But suppose a way could be found? How would it move in space, which is chock-full of magnetic fields?

"The ship would need to be equipped with additional sustainer engines," the enthusiasts shouted back. That was, of course, the way out. Only would the game be worth the candle?

In a word, for reasons that are entirely understandable, many specialists consider such methods of travel more hypothetical than realistic. And so a solution was found. It was a simple one, as it should have been.

An experimental unit. A flux of fast-moving electronics would fly from an accelerator and be carried along with a model made of a superconductor. And "Mohammed's grave" instantaneously jumped to the side in the flash of an eye.

"Now imagine a real spacecraft," says Shabetnik. "Its body is will be covered with a high-temperature superconductor. Fast-moving electron emitters will be mounted in a circle. The charged particles will bathe the ship. As they move, they will create a current and an electromagnetic field. And a field and current will simultaneously arise in the superconducting layer. What will happen? The fields and currents will begin to interact with ampere force. Simply speaking, their carriers will repel one another. And this is incomparably more efficient than the interaction of the simple electromagnetic field of a craft and the earth's geomagnetic field. The ship will soar and appear to sail in the very electron medium that it formed around itself."

The sphere is the ideal shape for interstellar travel. "Saucers" are best for travel in the atmosphere. It is therefore obviously necessary to create a craft with a changing geometry. Its start from the surface will require only an extremely modest electrical force. About 100 amperes will suffice for a 5-ton spaceship. It will be easy to maneuver by increasing or decreasing the currents along its sides.

From a Superconductor

Scientists are essentially proposing an electromagnetic method of travel. But it has been fundamentally modernized. The idea itself is not subject to doubt. But will it be possible from an engineering standpoint? Superconductors are needed. The record, i.e., minus 80 degrees Celsius, would be fine for space. There the temperatures are much lower. But this threshold is not enough for the atmosphere.

"But have you forgotten," wonders Vasily Dmitriyevich, "that we have proposed superconductors that maintain zero resistance at 850 degrees Celsius?"

"I have not forgotten. But all that is still just plans."

"Yes, they are just plans, but they are entirely realistic."

Shabetnik and his colleagues are certain that they have discovered new fundamental laws governing the structure of matter. This knowledge makes it possible to explain the properties of matter in a way never attempted before—on the basis of probability and statistics. A more natural approach has been proposed.

Researchers have demonstrated, for example, that the physical parameters of all elements depend on the number and state of their elementary particles. It has even been possible to establish the shape and structure of these building blocks. And it has turned out that everything in the material world around us is subject to exact calculation. Everything from boiling point and entropy to superconductivity is a phenomenon that may be discovered but could not be explained from the standpoint of previous principles. And where there is exact calculation, substances with prespecified properties may be designed. That is how scientists initially theoretically predicted the existence of a superconductor at minus 80 degrees Celsius. And then they produced it. And the result confirmed the theory exactly. And now a plan for 850 degrees has appeared. And there is no basis for suggesting that it will not be successful.

"I will not stop until all secrets have been revealed," says Shabetnik, "but I give a hint that ordinary iron may become the basis of the new superconductor. The intricacy will be the energy order of arrangement of the rest of the elements."

"Okay. But what fuel do you intend to use in space?" I suddenly remembered.

And Almost With a Perpetual Motor

"Will you place a nuclear reactor or a thermonuclear reactor on the ship? Or perhaps you will return to the energy of a vacuum?"

"Neither of the three," answers Vasily Dmitriyevich. "Do you recall yet another sensation that burst forth about the same time as high-temperature superconductivity? I mean, when the discover of what is called the 'cold thermal nucleus' was announced in the United States. This effect was later reproduced in many laboratories. It was reproduced but again left unexplained. And why? Because they tried to find signs of thermonuclear reactions where none exist."

"I remember those experiments well. I even observed one at Moscow State University: a tank with heavy water, two live electrodes, and no idea where the additional heat was coming from. But if its source was not a 'cold thermal nucleus,' what then was it?"

"We call the phenomenon 'energy conversion.' And that very tank is a primitive model of a converter. The water in it boils. To put it in scientific terms, a phase transition takes place. The particles in the water move in an ordered fashion on account of the electric field. According to our theory, in such cases phase transitions yield an increased amount of thermal energy. The gain is a factor of 2.12 to 4.2 higher than the work expended."

"Wait, wait," I said while trying to digest what I was hearing. "Does this mean that a perpetual motor has been produced?"

"No. The internal energy of the matter has been extracted."

"And can it be used in some way?"

"If you please. You could even build power plants instead of conventional ones. But I repeat, it will all be unbelievably primitive—water, boiling....And of course, such a converter would not be fit for space flights."

"We have found an electric analogue of processes involving energy conversion," continues Shabetnik. "And energy can be extracted not just from water but, let's say, from metal as well. It is conceivable that you could connect our converter to an electric generator. And the output would be fourfold the energy that it could provide while operating conventionally. A fourth could be diverted to feed the generator, and you would have the rest as a gift from your microworld."

"But in reality everything is of course more complicated. In essence, an energy converter consists of several devices working in conjunction with one another. The main components are a closed superconductor and control system. They are for ground needs. The electron accelerator that is connected to the circuit transforms the converter into a spacecraft engine. With its help, a spacecraft can fly to Alpha Centauri and back to earth in 12 years."

"Has it been possible to recreate these processes, if only in experiments?"

"Yes. Otherwise I would never have told you anything. According to our calculations, the energy hidden in a kilogram of iron is completely sufficient for interstellar travel."

As far as the future is concerned, let us say straight out that it is fantastic. Even without flights to other worlds. Indeed energy converters will be used to meet needs on earth. The time has already come to dream not only of miraculous generators capable of replacing nightmarish nuclear and thermal power plants or of new means of travel. Our entire lives will be turned around.

One Method of Laminarizing the Boundary Layer on a Vibrating Wing

927F0224A Moscow DOKLADY AKADEMII NAUK
SSSR in Russian Vol 322, No 1, 1992 (manuscript
received 13 Nov 91) pp 52-56

[Article by S.V. Manuylovich, Central Aerohydrodynamic Institute imeni N.Ye. Zhukovskiy, Zhukovskiy, Moscow Oblast; UDC 532.526]

[Abstract] The author of this study examined a method of laminarizing the boundary layer on a vibrating wing. Specifically, he considered the problem of a smooth-surfaced straight wing with an infinite span that is circulated by a flow of viscous incompressible liquid. The flow in the boundary layer in the vicinity of the point O (the beginning of the coordinate system used) is assumed to be unstable and laminar. The first term in the expression used for the current function (wave displacement) $\psi(t, x, y)$ describes the Stokes wave generated by the horizontal oscillations of the wall. The second term describes those disturbances that correspond to the "frozen-in" boundary layer on the vertically oscillating wall. The third component corresponds to Tollmin-Schlichting waves excited by the wing's vibrations in the vicinity of the leading edge and propagated downward along the flow. A method of laminarizing the boundary layer is presented. It is analogous to a published method of laminarizing a boundary layer subject to a multiharmonic acoustic effect. The essence of the said method lies in the mutual suppression of the natural instability

wave generated in the vicinity of the leading edge of the wing and the artificial wave excited by the very same acoustic field on a specially organized two-dimensional irregularity of the circulated surface. The entire packet of Tollmin-Schlichting waves is suppressed by selection of the shape of the irregularity. The Fourier amplitudes ($\varphi_{2,3x}$) of the solution being sought are shown to satisfy nonuniform boundary value problems for an Orr-Sommerfeld equation. The characteristic features of the amplitudes are analyzed for the cases of transcritical and subcritical frequencies. It is demonstrated that not all frequencies of Tollmin-Schlichting waves need to be laminarized to laminarize the flow in the boundary layer; only those corresponding to the most "dangerous frequencies," i.e., transcritical frequencies, need to be laminarized. The case of multiharmonic vibration with a frequency of ω_0 is considered with just such suppression. The solution derived is said to describe a new mechanism of the generation of Tollmin-Schlichter waves on a vibrating surface. Unlike the linear type of wave excitation by a localized vibrator that has been considered elsewhere, the excitation examined herein is caused by the nonlinear interaction of a disturbance that is nonstationary albeit homogeneous in its lengthwise direction and that is caused by the vibration of a smooth wall with a stationary inhomogeneity in the boundary layer over the irregularity. The solution obtained demonstrates that in the unstable region, the amplitude and phase of the generated wave both increase with Reynolds number and frequency. Figures 3; references 7 (Russian).

NPO 'Uran' Offers Underwater Towed Sensor for Sale

92UM1206Z Moscow *TEKHNIKA I VOORUZHENIYE*
in Russian No 3-4, 92 p 45

[Article: "NPO 'Uran' Advertisement: "NPO 'Uran'"]

[Text] NPO [Scientific Production Association] "Uran", jointly with the Physical-Technical Institute imeni A. F. Ioffe and "Fizintekh" MGP [translation unknown], are offering a towed unmanned underwater device for research of the water environment (NPA-EKO), that has been created within the framework of conversion based on our own original research.

NPA-EKO is designed to collect information that is needed to look for deposits of oil, gases, and other useful minerals, including metals, on the bottom of seas and oceans. It may be used for hydroacoustical and television photography of the sea bottom, to search for and study underwater objects, to detect anomalies of the Earth's magnetic field, and to measure background radiation.

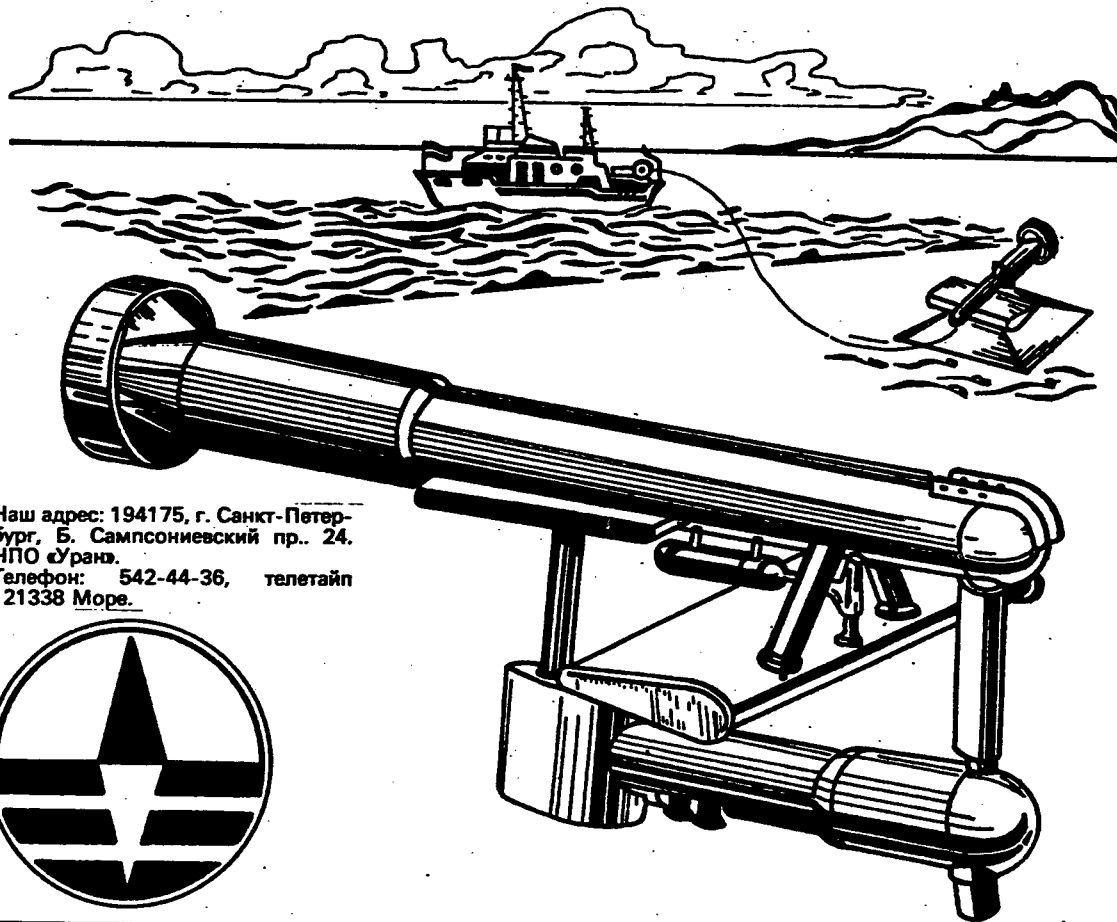
It is distinguished from existing underwater devices by its capability to conduct uninterrupted searches for assigned ingredients of the water environment while being towed. It has a physical-chemical change module that provides quantitative and qualitative analysis of components. The research program can be changed in the automatic mode which has not been achieved in any of the existing unmanned underwater devices. A similar module was used as part of an astrophysical device on space stations.

The commercial proposal of NPO "Uran", The Physical-Technical Institute imeni A. F. Ioffe and "Fizintekh" MGP consists of the development, based on the customer's requirements, and the delivery of a manufactured model of the device, fulfillment of ordered research, organization of joint production and sale of NPA-EKO on the world market.

Our address: NPO "Uran", 24 B. Sampsoniyevskiy Prospect, St. Petersburg, 194175.

Telephone: 542-44-36, teletype 1213388 More [Sea].

COPYRIGHT; "Tekhnika i vooruzheniye", 1992



Наш адрес: 194175, г. Санкт-Петербург, Б. Сампсониевский пр., 24.
НПО «Уран».
Телефон: 542-44-36, телетайп
121338 Море.



Military Seen Dodging Scrutiny of Novaya Zemlya Radiation Hazards

92WN0622A Moscow ROSSIYSKAYA GAZETA
in Russian 23 Jun 92 p 5

[Article by Aleksandr Yemelyanenkov, chairman of the board of the "To Novaya ZEMLYA!" Ecological Safety Movement: "It Points North, Like a Compass Needle"]

[Text] Anyone who saw, felt, and understood what happened in the atmosphere over the archipelago and deep within the earth, under its eternal frost, who guessed what forces raged there, after all that was experienced, was frightened out of his wits.

From time immemorial, courageous sailors and travelers have turned their eyes toward Novaya Zemlya. At the turn of the 20th Century, the archipelago became a platform in the mastery of the Arctic, or rather, in its conquering, in man's vainglorious attempts to establish his rule over the world of white silence. These attempts ended tragically more often than not, but homo sapiens, especially homo sovieticus, could no longer be stopped by anything.

'Project 700'

The fate of many Russian islands befell Novaya Zemlya: Youthful lieutenants discovered them, and a century later generals from big politics closed them. As of 1954, the rapid construction of "Project 700," as the Northern range for testing nuclear arms was called in secret documents and documents with the "Special File" seal, began on the Arctic archipelago.

All economic activity—reindeer herding, fur trapping, and fishing—on the islands was stopped, the local soviet was abolished, and more than a hundred Novaya Zemlya families were resettled on the mainland, where for an agonizingly long time they had to adapt to a way of life, unfamiliar to the islanders.

The military began to make Novaya Zemlya habitable. Strictly speaking, the test range encompassed 90,000 square kilometers, 55,000 of which were on dry land. For comparison, the area of the entire archipelago is 82,000 square kilometers. According to the testimony of retired Lt. General G. Kudryavtsev, who in his day commanded the Northern Test Range, the first underwater nuclear explosion in the Soviet Union was conducted in Chernaya Bay at a depth of 50 meters on 25 September 1955. Two years later, on the east bank of this bay (the so-called zone "A"), the surface test of a nuclear warhead was conducted. In the same year, Chernaya Bay and the entire southwestern shore of the archipelago shuddered with the explosion of a nuclear torpedo from the submarine of Captain 1st Class G. Lazarev.

Today, at the test range Chernaya Bay is called a "sanitary zone." According to existing official reports, the radiation background there is up to 1000 microRoentgen/hour [mR/hr]. The few eyewitnesses say that for a long time the superstructures of half-sunken

target ships, thrown into the shallows by the nuclear explosions, stuck up along the shore.

There is also an extensive sanitary zone at the cape of Sukhoy Nos, at the southwestern tip of the north island. There is reason to believe that serious contamination also exists in the Mityushin Bay-Krestova Bay region, where tests of powerful thermonuclear warheads were conducted in the atmosphere over a specially prepared battlefield, including the explosion of a 58 megaton hydrogen bomb on 30 October 1961—a sad record and, alas, not the only Novaya Zemlya record of this type.

The most intensive periods of tests at Novaya Zemlya were in 1958 (26 atmospheric and underwater explosions), 1961 and 1962 (24 and 36 tests, respectively, all atmospheric). Their total TNT equivalent exceeds 90 megatons. No other nuclear test range on Earth has known such a colossal burden. For comparison, the total power of the 259 explosions, conducted in the atmosphere from 1949 to 1974 by the U.S., Great Britain, and France taken together was 92 megatons. From 1964 to 1980, China conducted 22 atmospheric tests with an overall power of 12.7 megatons TNT equivalent.

According to data of USSR Goskomgidromet observation stations, after the 1961-1962 tests at the Novaya Zemlya test range, the levels of radioactive fallout in northern regions of the USSR increased by an order of 2-3 compared to 1960. For example, if we take the maximum density of radioactive fallout (by total beta activity) registered by the Goskomgidromet services at Amderma in 1962, it turns out that it exceeded present-day background values by a factor of 11,000 (!).

As is now becoming clear, nature in the Arctic belt turned out to be very sensitive to this fallout. By the late 1950s, the levels of radioactivity in the "lichen—reindeer—man" food chain in the region north of the 60th parallel already exceeded the background indicators by a factor of more than 10.

Meanwhile, to this day departmental commentaries on these comparisons are being made in soothing tones, even though it is admitted that the 1961-1962 series of powerful nuclear explosions caused the entry of the basic part of the radioactive products into the stratosphere and thence, after redistribution, to land. Surface contamination with cesium-137 and strontium-90, official science asserts, is related to global fallout from the atmospheric explosions of all countries whose test ranges are in the Northern hemisphere.

The same departmental reports characterize the radiation situation directly at Novaya Zemlya as entirely favorable: The average level of surface contamination of the island territory with cesium-137 is 0.09 curie per square kilometer, and the average power level of a dose of gamma radiation is 10 +/- 2 mR/hr (at a height of 1 meter); in regions where rocks with an elevated content of radioactive elements come up to the surface, the average dose is 16-25 mR/hr; there are local zones in Novaya Zemlya with high levels of contamination,

which are strictly localized and far from places of human habitation, where the dose of gamma radiation at the present time does not exceed 1 mR/hr...

The command of the test range officially acknowledges the existence in its territory of only three sanitary zones, formed as a result of conducting the first underwater, ground, and powerful atmospheric nuclear explosions, as well as due to one accidental emission during an underground nuclear test. The obvious incompleteness of these data is indicated by many trustworthy sources. For example, there is the report of the St. Petersburg Scientific Research Institute for Radiation Hygiene, submitted for examination to the Supreme Soviet of the Russian Federation. In particular, it states: "Several dozen (!-A.Ye.) local sectors with an elevated radiation background (up to 2 mR/hr) of a diameter of from several hundred meters to 5 kilometers were discovered during aerial gamma photography of the Southern island by USSR Mingeo [Ministry of Geology] specialists..."

The USSR Mingeo specialists succeeded in documenting that which ecologists had guessed for a long time. However, previously they had no opportunities to verify their assumptions and guesses under field conditions: From the moment the nuclear test range at Novaya Zemlya was created, the territory of the archipelago was virtually inaccessible for monitoring by the state nature-preservation services. Even now, regardless of the 2 November 1991 order by the President of the Russian Federation, "On Urgent Measures to Ensure Radiation Safety in the Territory of the RSFSR," the Main Headquarters of the Navy, under whose auspices the test range continues to remain, is obstructing the organization of comprehensive radiological and ecological studies of Novaya Zemlya and adjoining bodies of water in the Kara and Barents seas. Meanwhile, the conduct of this work must not be delayed any longer.

Traces in the Water!

The information, popularized in the open press, about the secret sinking of radioactive wastes in open regions of the Barents Sea and in shallow bays on the Kara side of the Novaya Zemlya archipelago elicits particular alarm from specialists and society (including in the Scandinavian countries). These operations were carried out from 1961 to 1990 by technical vessels of the Murmansk Steamship Line and the Navy with obvious violations of the requirements of MAGATE and the London Convention on preventing the contamination of seas and oceans.

According to existing information, more than 11,000 containers with radioactive wastes, as well as 15 damaged reactors from nuclear submarines and the "Lenin" icebreaker—5 of the reactors with the nuclear fuel still loaded—were sunk near Novaya Zemlya.

In rapidly developing atomic power and feverishly cultivating nuclear arsenals, we gave little thought to the consequences and were not concerned about tomorrow. The means were found only to design and build a new

nuclear ship, a new reactor... The accident rate grew, and with it, like a snowball, the problems of utilization and storage of radioactive wastes also grew. They saw a way out in hiding the traces in the water.

Here are just a few fragments of this gloomy chronicle, which has been restored from archive documents.

From 1967 to 1990 the auxiliary ships of the "Atomflot" sank 1,450 containers with solid radioactive wastes in the area of the Novaya Zemlya deep-water valleys. The total radioactivity, according to data of the Navy Main Administration for Use and Repair, was about 3,000 curies. Besides this, the reports do not indicate: In 1972, the barge MBSN-356250 was sunk with a nuclear reactor, removed from a damaged submarine (total radioactivity—170,000 curies); in August 1976, the PSSN-328 lighter for the transport of liquid radioactive wastes was sunk. In addition, 4,750 containers and the lighter "N. Bauman" (in September 1964), and the central compartment of the icebreaker "Lenin" with three damaged reactors and a crane assembly (October 1967) were sunk in Tsivolok Bay.

Abrosimov Bay was turned into a radioactive cemetery even earlier. In 1965-1966, the compartments of four damaged nuclear submarines were sunk here. Next door, in Stepoviy Bay, 1,850 containers and the damaged nuclear submarine K-27 were sunk at a depth of 35-50 meters.

This dark list could go on even longer. It is also known that liquid radioactive wastes were poured by Navy and "Atomflot" vessels into five regions of the Barents Sea from 1961 to 1990.

The paradoxical nature of the situation lies in the fact that the command of the test range and the 8th Main Administration of the Navy, which oversees its work, categorically refuse to comment on these facts and to bear responsibility for what happened for many years within the borders of the test range and near it. They explain this by the fact that operations with radioactive wastes were performed by a different subdivision of the Navy, the Main Administration for Use and Repair.

Meanwhile, in the territory of Arkhangelsk and Murmansk oblasts the number of nuclear power installations has exceeded 270 units. In this regard, the problem of dealing with radioactive wastes, formed in the process of use and repair and as a consequence of removing the first-and second-generation nuclear submarines from fighting status, acquires extraordinary urgency. Today already, about 20 submarines with nuclear reactors that are worn out or no longer fit for use have accumulated in the Northern Fleet.

Specialists believe that the creation of a regional radioactive waste burial site here, meeting the requirements of MAGATE, would help cardinaly to solve the problem of radioactive wastes in Russia's European North. The Murmansk Oblast administration, the command of the Northern Fleet, and the Scientific Research Institute for

Industrial Technology (Moscow) have submitted a proposal to locate such a burial site on the southern island of Novaya Zemlya, in the borders of the Central Test Range of the Russian Federation. However, there is also an alternate proposal: A plan to locate the regional radioactive waste burial site on the Kola Peninsula, in the rock strata of the Dalniye Zelentsy region, has been drafted by the St. Petersburg Scientific Research and Design Institute for Power Engineering Technology.

In order to objectively assess the merits and shortcomings of both plans, it is proposed to organize the state expert analysis of them, including the economic, ecological, social, and technological aspects, as soon as possible.

The question of transferring the Central Test Range to the auspices of the Russian Federation Ministry of Nuclear Power is becoming ever more topical. Then the Ministry of Defense would retain only the functions of guarding its borders and ensuring a regime of safety. This would help remove many extreme limitations.

To Novaya Zemlya!

A conference on the unification of anti-nuclear, ecological, and eco-cultural organizations of the northwestern oblasts of Russian into a popular movement for ecological safety, "To Novaya ZEMLYA!," was held in the fall of 1991 in Arkhangelsk. Its programmatic goal is to achieve the cessation of nuclear tests at Novaya Zemlya and throughout the world. Among its practical tasks are: the restoration of the true picture of everything that happened at Novaya Zemlya from the moment the nuclear test range was created there; the organization of a comprehensive radiological and ecological study of the archipelago and the sites where radioactive wastes were sunk; the revelation of the distant consequences of nuclear arms tests on the population's health for the purpose of medical and social rehabilitation; and conversion of the archipelago, the involvement of its natural and raw material resources in economic circulation.

We consider the thoughtfulness of evaluations and authenticity of the information being disseminated an indispensable condition of our work. In many cases, our volunteer consultants and experts have at their disposal more complete and more accurate information on the ecological problems of the region, than the state ecological monitoring services. This also relates to data on the sinking of solid and pouring of liquid radioactive wastes in the area of Novaya Zemlya, as well as in open regions of the Barents and Kara seas. At the present time, we are conducting an additional search for eyewitnesses and participants in such operations, and we are systematically organizing their recollections.

We are also open to cooperation in other areas of our activity. The dynamic appeal—To Novaya ZEMLYA [a New LAND]!—should not be interpreted only in the literal, geographic sense. We are not urging our supporters to storm the archipelago and its secret projects. To a New LAND means to a renewed, safe planet to live on, to a new world order based on good-neighbor and

cooperation principles, ruling out violence and military threat as a political argument.

New Transformer Designs

927F0216B Moscow ELEKTRICHESKIYE STANTSII
in Russian No 3, Mar 92 pp 6-12

[Article by M.L. Feldman, candidate of technical sciences, Energosetproyekt, Northwestern Department; UDC 621.314.2]

[Abstract] In the past few years manufacturing plants and institutes in the former Soviet Union have begun production of a number of new transformers. These transformers may be classified into the following three groups: transformers with forced cooling, transformers with a reduced rated winding power, and autotransformers with an increase in reactance. Analysis of the operation of these new transformers reveals that equipping transformers with an additional cooling stage does not change their rated parameters with respect to All-Union State Standard GOST 12965-85; rather, it only makes their load capacity significant on one more count. The use of such transformers is economically justified when they are used at their maximum load for fewer than 3,000 hours annually. For this reason, they should not be used at the new PS [not further identified; possibly mobile stations] that are part of electrical networks and power systems. It would be a good idea to supply additional coolers as independent products that may be installed on operating transformers when justified (i.e., when a PS reaches its design load). The transformers with reduced winding powers that were developed at the Transformer SVPO are not three-winding transformers in the sense specified in All-Union State Standard GOST 16110-82. They expand the TRDN series (their design, parameters, and application areas are identical to those of transformers in the TRDN series). When compared with three-winding transformers, the new transformers with reduced winding powers have 10% higher overall losses (including 18% higher short-circuit losses). For this reason, production of series produced transformers in accordance with GOST 12965-85 should absolutely be maintained. The series of transformers with reduced winding power and forced cooling (tentatively termed TDTNF) combine the flaws inherent to both designs and should, in general, not be used at PS in power systems. Further analysis reveals that transformer plants' attempts to solve design problems (including increasing windings' dynamic stability) by increasing reactance are unacceptable. The reactances of both transformers and autotransformers should generally be kept as low as possible. Plants manufacturing transformers should cease the practice of forcing customers to use transformers not suited to their needs and should work together with the design organizations of those sectors using the transformers to determine the specific conditions under which the transformers will operate. References 4 (Russian).

Thermohydraulic Model of the Primary Loop for a Full-Scale Simulator With a VVER-1000 Reactor

927F0216A Moscow ELEKTRICHESKIYE STANTSII
in Russian No 3, Mar 92 pp 6-12

[Article by A.Ye. Koroshilin, doctor of technical sciences, A.P. Zhukavin, candidate of technical sciences, and V.N. Pryakhin, engineer, All-Union Scientific Research Institute of Nuclear Power Plants; UDC [621.311.25:621.039].001.57]

[Abstract] In accordance with a contract reached with the firm Singer Link Miles (currently S3-Technologies), operation of a full scale simulator to train unit control room operators at power plant units with a VVER-1000 reactor will begin in 1992. The mathematical model of the power plant unit implemented on the full-scale simulator is rather complex in structure and describes nuclear physics, thermohydraulic, electrical, radiation, and meteorological conditions, and the branched connections between them. A Retact computer system is used to calculate the thermohydraulic parameters of the primary loop and steam generator during steady-state and transient operating modes. Specifically, the model is capable of describing the following phenomena: inhomogeneity and unevenness of the flow during modes with forced and natural circulation; nucleate boiling and condensation of phases on walls and in streams; leakage of boiling coolant through breaks in the circulation loop and safety devices; heat and mass transfer through interface surfaces; transfer of boric acid and radioactive fission products; heat transfer from the fuel core to the coolant; a steam-and-zirconium reaction involving the evolution and propagation of hydrogen, and a departure from nucleate boiling in the heated channels. A neutron model is not included as a component of the Retact program; however, neutron interactions may be taken into consideration through interface variables. Most of the text of this article is devoted to describing the models in whose terms the aforesaid basic thermohydraulic phenomena may be described when working with the new simulator. Figures 10; references 2: 1 Russian, 1 Western.

Analysis of the Assimilation of 500-kW Equipment at the Sayano-Shushenskaya GES

927F0214C Moscow ELEKTRICHESKIYE STANTSII
in Russian No 2, Feb 92 pp 55-59

[Article by V.V. Bolnov, candidate of technical sciences, and V.A. Kyari, engineer, Krasnoyarsk GES, Sayano-Shushenskaya GES; UDC 621.311.21.002.5]

[Abstract] Switchgears and lines in the 500-kW class become widely popular in the creation of power systems.

The 500-kW outdoor switchgear at the Sayano-Shushenskaya Hydroelectric Generating Station [GES] is used to receive electric power from five 1,280-MW units and send it out along four VL 500 system lines. To reduce the switchgear's dimension, the Lengidroyekt developed a configuration calling for the use of bus portals with a vertical suspension system for the collecting buses. Its width was reduced by configuring the limit switches in two rows turned at an angle of 45° and by using overhead unit connectors. The outdoor switchgear's overhead intervals were reduced by using highly nonlinear lightning and switching surge limiters, as well as by using 500-kW switchboards with reduced overall dimensions. The ORU-500 outdoor switchgear includes a number of devices that were initially developed in the former Soviet Union. The OPN-500 and OPNI-500 nonlinear surge limiters are, for example, used to protect the ORU-500 from atmospheric and switching surges. Thanks to the use of these nonlinear surge limiters, the distances used between those current-carrying sections of the ORU-500 with different phases and the distances between the current-carrying sections are the same as those of 330-kW outdoor switchgears. The grounded structures have been similarly shortened by 20 to 28%. This system configuration has been in use since 1987, and no flashovers have occurred (except for three cases involving a failure to adhere to the said distances). The type RGZ-2-500/3200-U1 disconnector is being used to switch the no-load current of the units' transformers under specified meteorological conditions as a way of increasing the operating flexibility and reliability of the system. The said disconnector is a two-column device with moving-type main legs that turn in a horizontal plane to one side from the pole axis. The distance along the column axes measures 4,000 mm, and that between the screens measures 3,100 mm. The supporting and moving columns are each made of four series-connected insulators. Of the 2,784 insulators used in the ORU-500 outdoor switchgear, only three of the 444 IOSP-100/400 insulators used have been found to contain cracks in their porcelain. The VVBK-500 air switches used with the ORU-500 have a node failure rate at the 0.4 level. Further improving their reliability will require improving the epoxy lead node. Problems involving the failure of the outdoor switchgear's air heater have been encountered. These problems have been linked to the compressors' configuration (inadequate ventilation) and maintenance. Maintenance by highly qualified personnel has been shown to be crucial to ensuring that the operating reliability of the 500-kW equipment set is at the level required in power systems. When new generating stations and switchgears are designed, it is extremely important that they include a level of hardware and circuit redundancy that is adequate from the standpoint of actual equipment reliability parameters and that a sufficient repair base be available to keep the equipment in good working order. Figures 3, tables 2; references 4 (Russian).

Analysis of Energy Expenditures To Create and Operate Nuclear Power Plants With Series-Produced Types of VVER and RBMK Reactors

927F0214B Moscow ELEKTRICHESKIYE STANTSII in Russian No 2, Feb 92 pp 50-54

[Article by Ye.I. Dyakonov, engineer, and Ye.I. Ignatenko, doctor of technical sciences, USSR Ministry of the Nuclear Power Industry; UDC [621.311.25:621.039]:657.471.1.001.24]

[Abstract] The authors of the study reported herein conducted their own analysis of a comparative analysis of nuclear power plants [AES], nuclear heat and power stations [ATETs], and district heating nuclear power plants [AST] with different types of nuclear reactors (VVER and RBMK). Specifically, they compared the total energy expenditures required to create and operate the different types of power plants with the two types of reactors. Included among the factors considered in the analysis were the construction materials used in building the plants, the energy expended to create the construction materials themselves, and the yearly energy expenditures associated with using the materials (including the cost of all chemical reagents required). Direct energy expenditures required to operate a plant throughout the course of its useful life and the energy intensity of manufacturing plant equipment were also considered. ATETs with VVER-1000 reactors, which produce both electric power and heat, were found to have the lowest specific consumption of materials per megawatt-year [MWy] (both to build and operate) and the highest energy investment efficiency. Recycling plutonium resulted in a reduction in specific consumption of materials per MWy in the case of AES with VVER-1000 reactors and ATETs with VVER-1000 reactors but an increase in specific consumption of materials per MWy in the case of AES with RBMK-1000 reactors and AST with VVERT-500 reactors. AES with VVER-1000 reactors and ATETs with VVER-1000 reactors at which plutonium was recycled were also found to have a higher energy investment efficiency, whereas the decision to recycle plutonium resulted in a lower energy investment efficiency at AES with RBMK-1000 and AST with VVERT-500 reactors. The analysis further revealed that reprocessing depleted nuclear fuel from AES with RBMK-1000 reactors or AST with VVERT-500 reactors was not feasible from an energy standpoint. Finally, increasing the service life of nuclear power plants was found to result in a reduction in the specific consumption of materials per megawatt of useful energy per year during the creation and operation of AES and ATETs

with VVER-1000 reactors and to increase energy investment efficiency in the case of both of the said types of plants. AST with VVERT-500 reactors had the lowest energy investment efficiency, and the said indicator decreased even further (by an additional 10%) when plutonium was recycled at the said plants. Tables 3; references 10: 8 Russian, 2 Western.

The Distribution of Dissolved Drinking Water Impurities in the Water Space of the PGV-1000 Steam Generator

927F0214A Moscow ELEKTRICHESKIYE STANTSII in Russian No 2, Feb 92 pp 33-38

[Article by Yu.V. Kozlov, L.K. Rumyantsev, Ye.P. Svis-tunov, V.P. Sevastyanov, G.A. Tarankov, and N.B. Eskin, candidates of technical sciences, and I.O. Budko, A.S. Grigoryev, N.P. Dudchenko, Ye.V. Dronova, V.M. Kryukov, and N.B. Trunov, engineers, All-Union Scientific Research Institute of Nuclear Machine Building, Gidropress Special Design Office, Tsentratomtekhen-ergo, All-Union Heat Engineering Institute imeni F.E. Dzerzhinskiy, and Khmelnik Nuclear Power Plant; UDC [621.311.25:621.039]:621.182.1.001.15]

[Abstract] The results of the first stage of thermochemical tests of the PGV-1000M made it possible to assess the nature of the distribution of dissolved impurities throughout the steam generator's length and to develop additional mathematical estimates. The objective of the subsequent stage in research on the said steam generator was to refine the boundaries of the zones of elevated salt contents in the middle section of the steam generator, establish the nature of its change in the end zones of the water space and over the submerged screen plate, and estimate the change in salt concentration throughout the steam generator's width in individual check zones. The tests performed revealed that the standard system of distributing water throughout the length of a PGV-1000 steam generator is the reason why the maximum salt concentration in the steam generator's water space is around the inlet header. It would be advisable to change the system by moving the zone of maximum salt concentration to the cold end of the PGV-1000 and to update its purge system accordingly. The tests further revealed that the standard purge system of the PGV-1000 is not optimum. Periodic purging from the pockets is most effective in cases of an increase in the amount of salt present in the steam generator. Purging from the steam generator shell is advisable to remove deposits from the nozzle zone (d, 80). Finally, the tests established that the efficiency of the PGV-1000 steam generator's standard purge system could be improved by separating the individual line from the hot nozzle (d, 80) and implementing continuous purging at the design flow rate from just that nozzle. Figures 6; references 5 (Russian).

Prospects for Development of Solid Fuel-Fired TES

927F0198A Moscow *TEPLOENERGETIKA in Russian*
No 1, Jan 92 pp 2-7

[Article by Yu.K. Semenov, A.F. Dyakov, V.I. Dobrokhotov, and A.A. Madoyan, USSR Minenergo, RSFSR Mintopenergo, and USSR State Committee for Science and Technology; UDC 621.311.22]

[Abstract] Coal will become increasingly important as a fuel for firing TES as the amount of mazout available for firing TES continues to decrease. The real possibilities of an increase in coal recovery remain extremely limited, however. Coal remains a reliable source for increasing the country's fuel and energy resources for many years to come. At the same time, the prospects of increasing the amount of coal burned at TES are also dimmed by labor problems and difficult working conditions in the coal mining industry, the ecological damage that results when coal is burned, and the country's lag in the development of ecologically pure coal recovery and combustion processes. Despite these problems, it is estimated that there will be a continuous increase in the amount of coal used to fire TES in the next 10 years. Most of the said coal will be coal from secondary deposits or coal of reduced quality (anthracite culm). The state scientific-technical program Ecologically Pure Power Generation calls for developing ecologically pure TES fired by coal from the Kansk-Achinsk, Ekibastuz, Kuznetsk, and Donets deposits. Efforts are underway to develop progressive coal recovery, coal enrichment, coal transport, waste recovery, and land recultivation technologies. The said technologies will be expected to use at least 80% of the ash produced by burning coal, result in 100% clean sewage, and reduce the emission of toxic gases into the atmosphere many times over. To date, nine alternative scenarios have been developed for using the coal of the four aforesaid deposits. Two versions of GRES with a capacity of 4 million kW and with 500,000-kW units equipped with steam boilers and flash furnace cells and boilers with a tangential furnace have been planned for use with Ekibastuz coal. Two versions of a GRES with a capacity of 5.0 to 6.4 million kW and with units with individual unit capacities of 625 to 800 MW have been planned to use Kansk-Achinsk coal. Two versions of a TETs with a capacity of 1.1 to 1.25 million kW and with six steam turbine units with a capacity of 180,000 kW each have been planned to burn Kuznetsk coal. Two versions of a GRES with a capacity of 2.4 million kW with individual units with a capacity of 320-MW each that are equipped with boilers for high-temperature burning of coal (including liquid slag removal and burning of the coal in a circulating bed) have been planned for use with the lower-quality coal of the Donets Basin. The Enterprise for Ecological Problems of Power Generation and the State Scientific Research Institute of

Nonferrous Metals have developed a process to burn different grades of coal in a liquid slag melt through which oxygen-enriched air is bubbled. The new technology is based on an emulsion process of liquid-phase metal reduction. The new process is ecologically pure and highly attractive from an economic standpoint. It will not require most of the trapping, filtration, and scrubbing equipment required by conventional processes and will result in salable by-products (including ammonia fertilizers, a slag suitable for further use in the metallurgy industry, liquid oxygen and nitrogen, and nitrogen gas). The scientific-technical councils of the USSR Ministry of Power and Electrification, the concern Tyazhenergomash, the USSR Ministry of the Coal Industry, and the USSR State Committee on Science and Technology's scientific council on the scientific-technical program Ecologically Pure Power Generation held a joint meeting in June 1991. Plans for the following projects were approved at the meeting: the Berezovka GRES-2 (to be fired by Kansk-Achinsk coal and to have eight 800-MW steam turbine units with reduced-size steam boilers); the Ekibastuz GRES-3 (to be fired by Ekibastuz coal); a TETs with steam-and-gas units with a capacity of 300 MW each; and the Rostov GRES (to have a capacity of 2.4 million kW and to be fired on Donets anthracite culm). The joint council also recommended that the Ecologically Pure Power Generation program be extended to include pilot commercial units based on gasification of coal dust from Kansk-Achinsk coal, the use of flash furnace cells to burn Ekibastuz coal, and the use of the existing boiler at the Kharkov GRES-2 to burn Donets anthracite culm. Figures 3, tables 2.

Using Flash Primary Furnaces To Burn Low-Grade Solid Fuels—A Method of Improving the Ecological Characteristics of Electric Power Plants

927F0198C Moscow *TEPLOENERGETIKA in Russian*
No 1, Jan 92 pp 11-15

[Article by E.P. Volkov and A.F. Gavrilov, doctors of technical sciences, A.V. Perepelkin, candidate of technical sciences, and V.N. Gusev, engineer; UDC 621.311.22.577.4]

[Abstract] Researchers in various Western countries (the United States, Finland, Germany) have conducted extensive research on fluidized bed-based methods of burning sulfur- and nitrogen oxide-containing fuel. One such technology proposed by the West German firm Deutsche Babcock results in stack gases containing no more than 200 mg/m³ sulfur oxides, no more than 100 mg/m³ nitrogen oxides, and about 30 mg/m³ aerosols. A new technology that uses flash primary furnaces to burn solid fuel in a circulating fluidized bed has been developed at the Power Engineering Institute imeni Krzhizhanovskiy. The new process makes it possible to conduct the first stage of burning fuel in a suspended state at

speeds much faster than those achieved in Western boilers with a circulating fluidized bed. This in turn has made it possible to conduct the fuel-burning process in more compact equipment at nearly atmospheric pressure. The new boiler with a flash primary furnace is designed so that the temperature in the reactor may be maintained at 500 to 800°C. At the said temperatures, volatiles and moisture form a steam-and-gas mixture with a combustion heat of 8 to 24 MJ/m³. This steam-and-gas mixture is then sent onward to the boiler's burners to be burned. The air required for combustion of the steam-and-gas mixture is supplied from an air heater that is included as a component of the boiler. The carbon in the fuel that is not converted into a gaseous phase combines with the mineral portion of the fuel and coolant to form a coke-and-ash residue that is in turn fed into the flash furnace cell. In the flash furnace cell, the carbon is burned completely in several passes, with the carbon in smaller pieces of residue burning first and the larger fractions becoming smaller and smaller until the carbon in them has been burned as well. Air is fed into the flash furnace at a pressure equal to 3,000 to 4,000 mm in a water column. The combustion products formed then pass to a cyclone, where the ash is separated out. From there, the combustion products pass to the boiler's furnace chamber, where their heat is recovered. The temperature of the flux at the outlet from the flash furnace cell is selected so as to keep the cyclone and the path after it from becoming covered with slag. The new technology offers several important advantages over conventional technologies. It permits the efficient burning of low-grade fuel at virtually all combustion heats from 4 to 12 MJ without any need to lighten the furnace with mazout. The dust content of the combustion products in the boiler is reduced by a factor of 4 to 6. The emission of nitrogen oxides is reduced by a factor of nearly 3.5, and the mineral portion of the fuel contains far lower amounts of alkaline metals (especially calcium) than result from the conventional technology. The capital investments required to outfit a boiler with the new flash furnace cells is estimated at 25 to 30 rubles per kilowatt of installed capacity (electrical) (in 1990 prices), and the operating costs of the new units are virtually the same as those of conventional units. The new flash furnace cells may also be used as a basis for a power plant with a gas turbine loop including a self-contained combustion chamber, gas turbine with electric heater, air or nitrogen heater, compressor, and cooler. Using flash furnace cells in such units would make it possible to heat the steam-and-gas mixture in a gas turbine's combustion chamber to air temperatures between 1,050 and 1,070°C. A compressor could then feed this air to the turbine at a pressure of 1.3 to 1.6 MPa. Another possible alternative would be a loop in which the steam-and-gas mixture is first cooled to temperatures at which effective scrubbing of aerosols is possible. The new flash furnace cells make it possible to reduce NO_x and SO₂ contents in stack gases at TES burning low-grade coal to 80-100 mg/m³. Figures 4; references 7 (Russian).

Energy-Storing Heat Pump Unit

927F0198F Moscow TEPLOENERGETIKA in Russian
No 1, Jan 92 pp 52-56

[Article by A.L. Petrosyan, candidate of technical sciences, Armenia Power Generation Scientific Research Institute; UDC 621.577]

[Abstract] The shutdown of the nuclear reactors at the Armenia AES has created a shortage of electric power in the Armenia and Transcaucasus power grids. TES have once again become the main electric power sources of the said regions, and as such their capacity must be increased. The proposed curtailment of major construction of large power generation facilities and delays in the manufacture of power generation equipment have made any large increases in TES capacity in the near future unlikely, however. One way of increasing the amount of heat and power available to the affected regions is to conserve energy by developing a more economical method of supplying heat to the Razdan Heat and Vegetable Combine and to produce additional electric power to cover peak demand periods. This could be done by accumulating the electric power produced at the Razdan GRES during its nightly low-load periods. Analysis of the heating supply situation existing at the Razdan Vegetable Greenhouse Combine indicates that the greenhouse has fairly short peak-demand periods and rather lengthy low-demand periods. Both the Razdan Vegetable Greenhouse Combine and other greenhouses, residential sectors of cities, and power grids that are also characterized by short peak-demand periods and lengthy low-demand periods, would be well served by an energy accumulation system based on a large heat pump and cold- and hot-water storage units. Such a scheme could have significant economic and ecological benefits in the Armenia and Transcaucasus regions. The annual fuel consumption in a system consisting of a heat pump and cold- and hot-water storage units would amount to 61,400 tons versus 96,000 tons for a heat supply system based on a water storage power plant, 22,600 tons for the region's currently existing heat supply system, and 118,600 tons for a system consisting of a water storage power plant and the currently existing heat supply system. Thus, using a system consisting of a heat pump and hot- and cold-water storage units instead of the latter type of system would result in a 93% fuel savings. The ecological savings of using a combination heat pump and water storage unit system would be considerable as well. When a water storage power plant is used, up to 30% of the water in the ponds is lost to infiltration and evaporation (i.e., 178,000 m³ of water yearly at a cost of 8 kopecks per cubic meter for commercial-grade water, which translates to 14,200 rubles yearly). Given the continental climate of the affected region, its intensive solar radiation, and its lower water supply, such losses of water would also be quite detrimental to the republic's water balance. The use of a system consisting of a water storage power plant and the region's currently existing heat supply system would also result in a significant increase in toxic nitrogen oxide emissions (up to 163.5 t/y), which in turn would result in ecologic damage amounting to 12,200 rubles yearly. Figures 2, table 1; references 4 (Russian).

Semiconductor Devices for High-Power Electronics

927F0189A Moscow IZVESTIYA ROSSIYSKOY
AKADEMII NAUK ENERGETIKA in Russian No 1,
Jan-Feb 92 (manuscript received 21 Jan 91) pp 60-73

[Article by V.V. Grekhov, Saint Petersburg; UDC
621.382.2/3]

[Abstract] Modern high-power semiconductor electronics has at its disposal a large array of semiconductor instruments capable of effectively converting electric power at virtually unlimited levels over a wide range of frequencies. Microelectronics-based methods and devices are becoming ever-increasingly important in the development of the high-power semiconductor instrument making sector. The overall consequence of this fact has been a noticeable trend toward combining instruments and converter nodes into high-power integrated circuits. The revolution caused by this same trend in low-power electronics is likely to extend into the realm of high-power electronics as well. The potential role of high-power electronics in the area of large-scale electric power generation and energy conservation is not yet fully appreciated in Russia. Most publications on the subject have focused primarily on the problems connected with increasing available power by various methods and have largely overlooked the fact that comparatively small investments in the development of high-power semiconductor electronics can result in savings of an enormous amount of power. The high-power semiconductor instruments market in the former USSR is very different from its Western counterpart. In the former USSR, production of bipolar transistors is clearly inadequate, and high-power field-effect transistors are absent entirely. These factors are having a very adverse effect on the quality of low- and medium-power converters and are resulting in unjustifiable power losses. Decisive steps to remedy this situation must be taken immediately. Bipolar field-effect and field-effect transistors must be duly recognized as the most promising component base for high-power integrated circuits, and measures must be taken immediately to make them available in adequate amounts. Several developments in the area of pulse technology appear especially promising. High-frequency generators with a frequency of 66 kHz and a capacity of 5 MW or more that are based on reversible diodes are, for example, currently being developed for use in plasma chemistry. Megawatt generators in the nano- and subnanosecond ranges are greatly expanding the prospects of video pulse radar. Underground radars are already being manufactured for use in geology, and high-power radar instruments are being created that will be able to detect objects with a small radar cross section. Other developments that are currently in the development stage include prototype high-power pulsed systems to power various types of lasers and other devices. By connecting peaker-diodes in a series and increasing surge pulse curvature, it has been possible to increase commutable voltage to 15 kV and capacity to about 4-5 MW. Figures 10; references 20: 11 Russian, 9 Western.

Solar Batteries With Bilateral Sensitivity

927F0218B Tashkent GELIOTEKHNIKA in Russian
No 1, Jan-Feb 92 (manuscript received 7 Aug 91)
pp 39-47

[Article by N.M. Bordina, V.R. Zayavlin, M.B. Kagan,
and V.A. Letin, All-Union Current Sources Scientific
Research Institute; UDC 621.383:535.215]

[Abstract] Bilateral solar batteries convert the solar radiation absorbed reaching one or both of their surfaces with high efficiency. One way of creating a solar battery with bilateral sensitivity is to use conventional solar elements with unilateral sensitivity on both sides of the battery. This technique doubles the cost and weight of the said battery, however. A better way of creating a solar battery with bilateral sensitivity is to use solar elements that themselves have bilateral sensitivity. Batteries of the said type have been produced based on silicon and gallium arsenide and have been studied extensively in flight tests on spacecraft. Silicon bilateral solar elements are essentially a silicon wafer with an n⁺-p-p⁺-structure that have comb contacts and an antireflective coating on their front and rear surfaces. Such solar elements can operate when illuminated from one or both sides. Commercial silicon bilateral solar elements 300 μm thick with a resistivity of 10 ohm x cm have been created that have the following characteristics as measured on a unit simulating the sun in outer space at 25°C: short-circuit current, 38.0 mA/cm² on the front and 30.4 mA/cm² on the back; U_{xx}, 601.0 mV on the front and 595.0 on the back; U_{opt}, 510 mV on the front and 505.0 on the back; volt-ampere characteristic fill factor, 0.80 on both the front and back; and efficiency, 13.1% on the front and 10.5% on the back. Solar elements with bilateral sensitivity that are based on a p-GaAlAs—p-GaAs—n-GaAs structure yield higher efficiencies than are possible with silicon solar elements. In such solar elements, bilateral sensitivity is achieved by creating p-n junctions under the two illuminated surfaces. Capillary liquid epitaxy is used to create the p-n-p structures. In view of the currently achievable base layer thickness (about 250 μm) of such solar elements and other associated factors, gallium arsenide-based solar elements may be looked upon as two photocells with a common base. Unlike conventional and bilateral silicon solar elements, such a solar element represents a three-electrode instrument. Solar elements with bilateral sensitivity may be used to create solar batteries with bilateral sensitivity that may in turn be used under conditions wherein each of their surfaces is illuminated alternately or both are illuminated simultaneously. Bilateral solar batteries are capable of converting solar radiation absorbed on their back sides into electrical radiation. The extra power of bilateral solar batteries versus unilateral solar batteries depends on the efficiency of conversion of the radiation absorbed on the back side of the battery. Solar elements have been produced whose efficiency on their back sides equals 0.85 of that on their front sides. Using such solar elements in a bilateral solar battery results in an average increase in power level of about 30% when the normal to

the solar battery lies in the plane passing through the radius vector of the spacecraft and the normal to the plane of its orbit. Prototype solar batteries with bilateral sensitivity have been tested on low-orbiting spacecraft. Tests conducted on the Salyut-5 orbital station, for example, revealed that bilateral solar batteries produce a current that is an average of 17 to 18% higher than that produced by unilateral solar batteries. Bilateral solar batteries have also been tested on the Glonass high-orbiting navigation satellite (orbit altitude, 20,000 km). The batteries tested resulted in a 15 to 45% increase in power depending on the relative positioning of the orbital plane and the sun. The silicon bilateral solar battery tested was demonstrated to operate reliably for a period of about 5 years. Figures 5, table 1; references 9: 8 Russian, 1 Western.

A Solar Unit for Experimental Research on Optical Materials' Heat Resistance

927F0220A *Tashkent GELIOTEKHNIKA in Russian No 2, Mar-Apr 92 (manuscript received 6 Aug 91) pp 9-14*

[Article by Yu.Z. Mavashev, G.M. Arushanov, and P.A. Zakharov, Institute of Physics and Technology and Fizika-Solntse Scientific Production Association, Republic of Uzbekistan Academy of Sciences; UDC 621.472:621.363]

[Abstract] A new solar unit has been developed for use in studying the heat resistance of a number of optical materials. Solar energy is used to focus a concentrated radiant flux onto optical materials. The moment at which the heat from the said flux destroys the test specimens is then fixed. The new solar unit is based on a solar furnace with an FK-68 faceted concentrator and consists of the faceted concentrator, a heliostat, a coordinate device, a system of high-speed gates, and a water-cooled diaphragm-holder. The measuring portion of the new unit includes recording equipment and a circuit for synchronous recording of the measured parameters of the heat resistant of the optical materials being tested. The solar furnace with its faceted concentrator has 68 spherical facets measuring 250 x 250 mm with a focal distance of 2.7 m. The system of high-speed gates is designed to protect the test specimen against premature heating and to ensure that the effect of the concentrated radiant flux on the test specimen's surface is instantaneous. The new unit is designed to measure the heat resistance of test specimens measuring 30 or 40 mm in diameter and 3 to 4 mm in thickness. A procedure for calculating the resistance of test materials has been used to test the heat resistance of optical leuco sapphire, silicon, cadmium telluride, lithium fluoride, and glass in the K-208 series. Silicon has been found to be the most heat resistant of the materials tested; specimens thereof withstood flux densities up to 55 W/cm² without fracturing. Figures 4; references 2 (Russian).

Optimizing the Operating Mode of a Power System Under Conditions of Ecological Constraints

927F0222A *Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 4, Apr 92 (manuscript received 20 Nov 91; after revision 26 Dec 91) pp 23-28*

[Article by A.P. Golovanov, candidate of technical sciences and docent, and Zh.M. Medetov, engineer, Alma-Ata Power Engineering Institute; UDC 621.311]

[Abstract] The authors of this article have proposed a mathematical model for use in optimizing the operating mode of power systems operating under ecological constraints. They begin from the postulate that an integrated approach to balancing ecological and economic considerations when optimizing a power supply system requires that the following contradictory functions all be taken into account: total cost of the electric power sold (this includes the profit from sale of the electric power within the power supply system itself [with a tariff labeled C_1] and the profit from sales of the electric power when the power is exported to (imported from) neighboring power supply systems [with a tariff labeled C_2]); the total losses caused by toxic emissions from the given thermal electric power plant [TES]; total economic costs incurred by the industrial enterprise in connecting with a regulating load; the unrealized profits related to the cost of the total power losses in power supply systems; and the costs of fuel for the TES. An objective function is presented for use in solving the multiple-objective problem of optimizing a TES (on a daily basis) while minimizing ecological and economic costs in monetary terms (rubles) throughout an entire region. The said objective function includes seven indicators. The first of these indicators, i.e., the economic indicator of the TES (in rubles), is estimated on the basis of the profit received by the power supply system as a result of selling the electric power it generates with the two aforesaid tariffs and with consideration for the specific cost of the fuel required by the TES. The second indicator, i.e., the economic indicator of the power supply system (in rubles), is estimated based on the cost of the power lost (unrealized profit) in the power supply system's internal electrical network in relation to the power supply system's electrical consumption load. The third indicator, i.e., the ecological indicator of the TES (in rubles), is estimated as a function of the mass of SO₂, NO_x, ash, and CO emitted; the areas over which they are propagated; meteorological conditions; and other data related to the electrical load of the TES. The fourth indicator, i.e., the economic indicator of the industrial enterprise (in rubles), is estimated as a function of the regulated power during the period in which the constraints are in effect. The fifth indicator, i.e., the ecological indicator of the industrial enterprise (in rubles), is estimated as a function of the mass of system's emissions, the ingredients included in the emissions, the area over which they spread, meteorological data, and the electrical load of the

industrial enterprise. The use of the proposed mathematical model is illustrated by way of the example of the Pavlodar power supply system. The calculations performed for the Pavlodar system made it possible to reduce the total yearly losses incurred by the system (with consideration for the ecological factor) by 1.6 million rubles with some worsening of the economic indicators of TES (by 0.36 million rubles) and industrial enterprises (by 0.8 million rubles). Figure 1; references 12: 2 Russian, 10 Western.

Specific Power Generation of Modular Solar Power Plants: Output Losses

927F0220B Tashkent GELIOTEKHNIKA in Russian
No 2, Mar-Apr 92 pp

[Article by D.I. Teplyakov, State Scientific Research Institute of Power Engineering imeni G.M. Krzhizhanskiy; UDC 621.472]

[Abstract] In a continuation of his previous publications on the same topic, the author of this article examines the energy losses resulting from simplification of the kinematic system of the parabolocylindrical modules that make up modular solar power plants. Specifically, he examines the consequences of using single-axis tracking of the sun instead of tracking along two axes. He introduces a series of mathematical expressions that make it possible to compare the efficiency of various methods of mounting parabolocylindrical modules on clear (absolutely cloudless) days for the four characteristic seasons of the year and for the specific geographic latitude at which the said modules are mounted. A formula is also given for calculating the relative (for example, average-daily) indicators of the useful input of solar radiation into the receivers of a parabolocylindrical module within a set period of time. The expressions presented are used to compare differences in the efficiency of using perpendicular [P] and horizontal (either north-south [NS] or east-west [EW]) mountings at the No. 5 solar power plant [SES-5] by season in an equivalent year (i.e., a year consisting entirely of clear days), by an entire year, and in a three-season (spring, summer, autumn) period. According to the calculations performed for the SES-5, an NS mounting is best for the summer months, an EW mounting is most effective for the winter months, and the P mounting is best for year-round service. The EW mounting is also best for a three-season period. The author concludes by cautioning that his calculations are only preliminary in nature and that calculations based on individual months rather than seasons are needed. Figure 1, table 1; references 4 (Russian).

Solar Cells With Shallow and Recessed InGaP p - n Junctions

927F0220C Tashkent GELIOTEKHNIKA in Russian
No 2, Mar-Apr 92 (manuscript received 1 Jul 91)
pp 30-32

[Article by M.A. Abdukadyrov, A.A. Alayev, Kh.Kh. Bustanov, A.S. Ganiyev, S.A. Diordiyev, Yu.K. Kru-togolov, Yu.I. Kunakin, and M. Mirzabayev, Fizika-Solntse Scientific Production Association, Institute of

Physics and Technology and Republic of Uzbekistan Academy of Sciences; UDC 621.383.5]

[Abstract] The development of a process to produce multilayer heterostructures has made it possible to use a band diagram of heterojunctions in combination with the distinctive features of the band structure of material to improve the parameters of a number of semiconductor instruments. The advantage of using wideband solid solutions of InGaP with a direct-band-gap structure in photocells is that they permit the creation of high-efficiency photocells to convert the violet and ultraviolet portions of the solar spectrum, which is especially important in the development of photocells with a cascade structure. The authors of the study reported herein examined photocells based on InGaP p - n junctions that were produced by an epitaxial-diffusion process from the gas phase by forming a submicron (0.1 to 1 μm) p layer during the process of fine diffusion of zinc in a quasi-closed area on n - $\text{In}_{1-x}\text{Ga}_x\text{P}$ epitaxial layers ($0.6 \leq x \leq 0.7$) that had been grown in advance. The n -type conduction layers were grown in a chloride-hydride system doped with tellurium doping. An isotopic transition layer of variable composition with an InP gradient of about 2 mol%/ μm was introduced between the n - $\text{In}_{1-x}\text{Ga}_x\text{P}$ epitaxial layer and the n -GaP (100) substrate. The concentration of charge carriers in the p and n layers and in the substrate was in the range $N \approx 1$ to $5 \times 10^{17} \text{ cm}^{-3}$. Strip ohmic contacts based on Ag-Ni-Sn were applied to the p -InGaP and GaP layers. Antireflective coatings were applied to the photoreceiver surfaces of the InGaP by anodic oxidation. Experiments varying the thickness of the surface p -InGaP layer indicated that varying the said layer's thickness in the interval from 0.2 to 1 μm has only a weak effect on photosensitivity at the maximum. As the thickness of the p layer is decreased to 0.2 μm , however, photosensitivity increases in the violet and ultraviolet regions of the spectrum. The photocells with shallow InGaP p - n junctions that were illuminated with extraatmospheric solar radiation from the p -InGaP side had a short-circuit current of between 12 and 15 mA/cm^2 with an open-circuit voltage of 1.2 to 1.4 V. Upon photostimulation, the deep InGaP p - n junctions studied were located under the illuminated wideband GaP substrate. When the p - n junctions were arranged in this manner, narrowband spectra were detected. The shape of the long-wave absorption edge was identical to the spectra of the shallow p - n junctions. The attenuation of sensitivity at the maximum and its sharp drop in the violet portion of the spectrum that were observed were linked to volumetric recombination of the current carriers in the relatively thick (300 to 400 μm) GaP. The deep p - n junctions were distinguished by the fact that they afforded the possibility of controlling the half-width of spectrum by varying the composition of the solid solution and the thickness of indirect-band-gap GaP with a sloping absorption edge. Next, InGaP and GaAs photocells were cascaded by mechanically joining p -InGaP- n -InGaP- n -GaP structures with a shallow p - n junction and n -AlGaAs- n -GaAs- p -AlGaAs structures with a wideband GaP substrate. The short-circuit current in

the said cascade was between 13 and 15 mA/cm². The close values of the wide- and narrowband elements' currents found permits series commutation without any significant electrical losses and thus makes it possible to achieve a higher output voltage than is possible with existing two-element cascade photocells. Moreover, because of the rather high transparency of InGaP and GaAs elements and the cascade as a whole to infrared radiation, it may be possible to create three-element cascade photocells in the future by using narrower-band structures in the system In-Ga-As-P or silicon. Figures 2; references 5 (Russian).

Forecasting the Demand Adaptability of the Operation of a BKZ-420-140PT-2 Boiler While It is Burning Irsha-Borodino Coals

927F0198B Moscow TEPLOENERGETIKA in Russian No 1, Jan 92 pp 7-10

[Article by Yu.A. Zhuravlev and A.G. Blokh, doctors of technical sciences, E.I. Gorb, candidate of technical sciences, and Yu.V. Kovalev and V.Ye. Mezhevich, engineers, KITsM, Central Boiler and Turbine Scientific Research and Design Institute imeni I.I. Polzunov [TsKTI] Scientific Production Association, and Ust-Ilimskaya TETs; UDC 621.181]

[Abstract] Furnaces equipped with liquid slag removal are widely used to burn coals from the Kansk-Achinsk Basin. Because the overall poor quality of Kansk-Achinsk coal poses special problems when it is burned, furnaces intended to burn it must be designed with full consideration for the special problems posed by reduced-quality coal. In view of this fact, the authors of the study reported herein estimated the operating reliability of the furnace chamber of the BKZ-420-140PT-2 boiler at the Ust-Ilimskaya TETs when Irsha-Borodino coals with different ash contents were burned. In the basic version of burning tested, an air-fuel ratio of 1.2 at the furnace outlet was used. The recirculation of 10% of the off-gases and the consumption of 10% of the gases from the upper part of the furnace to dry the fuel when a drying agent was added to the upper part of the furnace cell was assumed. The fuel had a starting (before drying) moisture content of 33%, an ash content of 6%, and a combustion heat of 15.64 MJ/kg. In the theoretical calculations performed, the ash content of the fuel as a percentage of dry mass [A^d] was varied from 9 to 25%, the combustion heat was varied from 15.6 to 13.6 MJ/kg, and the moisture content was varied from 33 to 29%. The calculations were based on a mathematical model that made it possible to determine the temperature of the bulk and surface zones, the distribution of the density of the different heat fluxes along the surface of the screens, and other heat transfer characteristics as well. A nomogram was constructed for determining the maximum permissible heat intensity of the volume of the furnace that would ensure continuous output of liquid slag when Irsha-Borodino coals of different ash content are burned under changing air conditions within the furnace. A normal slag removal temperature [t_{ns}] of 1,500°C was

achieved. For the dependence of t_{ns} on A^d assumed, the maximum permissible ash content with respect to the condition of output of liquid slag for the rated heat intensity of the volume of the furnace equaled 16%. When the said dependence was cut in half, the maximum permissible value amounted to 14.5%. Slight changes in the chemical composition of the external ash of Irsha-Borodino by mixing in rock was found to result in a sharp change in the physicochemical properties of the mineral portion of the ash and, consequently, in its melting characteristics as well. The operating reliability of steam boilers burning high-slag Kansk-Achinsk coals hinges on more than just continuous output of liquid slag, however. It also hinges on maintaining a low level of slagging of the furnace screens. Calculations performed by the authors indicated that an acceptable level of slagging of the furnace screens may be achieved by burning coal with a maximum ash content of 16%. Because the quality of Kansk-Achinsk coals makes adhering to this requirement impossible, mazout must be added to the coal burned. Mazout added at a rate of 11.4 t/h was shown to be sufficient to permit the successful burning of Irsha-Borodino coal with an ash content of $A^d = 21\%$ when the heat intensity in the volume of the furnace is at its rated value or $A^d = 20\%$ when the heat intensity is cut in half. The authors conclude by stating that combined burning of solid and liquid fuel increases the likelihood of slagging of the heating surfaces of the cooling chamber due to an increase in temperature level and that the formation of a reducing medium close to the screens significantly increases the danger of high-temperature gas corrosion of the boiler pipes. Figures 5, table 1; references 7 (Russian).

The Formation of Nitrogen Oxide When Anthracite Culm Is Burned in a Pilot Unit

927F0198E Moscow TEPLOENERGETIKA in Russian No 1, Jan 92 pp

[Article by A.A. Kniga, candidate of technical sciences, and V.T. Sidorkin and N.I. Rakitina, engineers; UDC 621:662.612]

[Abstract] In view of the importance of finding a way to stabilize the ignition of anthracite culm and burn it completely, the authors of the study reported herein examined the formation of nitrogen oxide when anthracite culm was burned in a pilot unit developed at the Power Engineering Institute imeni Krzhizhanovskiy and in operation at the Kokhtla-Yarve TETs. The pilot unit used was a straight-through reactor with a strip packing that operates as follows. The dust-and-air mixture and heated secondary air are completely mixed in the straight section of the reactor, after which they pass through an annular slit and into the furnace space. The ignition of the annular stream is stabilized by the geometry of the precombustion chamber, which creates the required aerodynamics and dictates the recirculation of the fuel gases to the root of the flame jet. Intensive secondary

combustion of the fuel gas residues occurs in the second part of the precombustion chamber, i.e., in the packing section on the strips of a slag-trapping beam. From the precombustion chamber, the stack gases pass into gas ducts and then onward to a smokestack. The system to prepare the secondary blast has a number of distinctions. The blast is heated by burning a certain amount of mazout in the stream, and the oxygen content is controlled by feeding in additional pure oxygen in gas form. In this manner, the blast-heating temperature may be raised from the external air temperature to 970-1,070 K and enriched with oxygen in an amount of 21% or more. If the amount of additional oxygen fed is less than the amount used to burn the mazout, the oxygen in the blast may amount to 21

or less. Four types of combustion modes were studied: modes close to those used in contemporary boilers, modes involving a transition to the magnetohydrodynamic mode, magnetohydrodynamic modes, and combined burning of anthracite culm and Estonian shale. During the studies, the concentration of nitrogen oxides was measured simultaneously by a 344KhL-01 chemiluminescent gas analyzer, by a technique involving nitrate-selective electrodes, and by two versions of a method involving Griss' reagent. Ion chromatography and a Testo-33 multicomponent gas analyzer (West Germany) were also used in individual tests. The average results obtained by the different methods were in satisfactory agreement with each other, and the spread of the results of the individual measurements did not exceed +/-30%. The measurements taken established that the amount of nitrogen oxides formed when anthracite culm is burned in a straight-through precombustion chamber with strip packing is relatively low. When the air is heated to 750-860 K, the NO_x concentration ranges from 0.9 to 1.4 g/m^3 , which is characteristic of contemporary coal dust boilers. When anthracite culm is burned together with Estonian shale, an NO_x concentration of 1.2 g/m^3 in the off-gases may be achieved provided that the air is heated to 860 K. When the concentration of oxygen in the blast is reduced, an NO_x concentration as low as 0.28-0.40 g/m^3 may be achieved. Figures 2, table 1; references 3 (Russian).

Dynamics of the Change in the Heat Engineering Characteristics of Ekibastuz Coal and Their Effect on the Operation of Steam Boilers in 500 MW Power Plant Units

927F0198D Moscow *TEPLOENERGETIKA in Russian*
No 1, Jan 92 pp 27-33

[Article by V.I. Mansurov, candidate of technical sciences, and S.M. Tsyganov and V.P. Makhortov, engineers, Ural Heat Engineering Institute; UDC 621.181.662.62.004.3]

[Abstract] The development of technologies permitting the burning of high-ash Ekibastuz coal is one of the great achievements of Soviet power engineering. Ekibastuz coal is now being burned in electric power plants in

Kazakhstan, the Ural region, and Western Siberia. Consumption of Ekibastuz coal has reached 84 million tons yearly. Since 1979 the quality of commercial Ekibastuz coal that may be burned at TES and GRES has been regulated by All-Union State Standard GOST 8779-79. According to the said standard, coal classified as being of quality group I must have an average ash content (calculated for dry mass, i.e., A^d) of 39.5% and an average combustion heat of 17.375 MJ/kg (4,150.0 kcal/kg). Quality group I coals may have a maximum ash content of 43% and a minimum combustion heat of 16.12 MJ/kg. Coals classified as being in quality group II coals must have an average ash content of 48% (a maximum ash content of 53%). The revision of this standard to permit a new conditional ash content of 60% (instead of 45%) has made it possible for the Ekibastuzgol Production Association to switch to a excavation bulk technique at all of its coal seams. Shipments of this reduced-quality coal have increased yearly, reaching 12.6 million tons (including 5 to 7 million tons with an ash content exceeding 53%) in 1988. It is projected that use of the said coal will increase to 28.4 million tons by 1995. Meanwhile, the percentage of quality group I coal used has remained virtually unchanged despite the increase in volume of group I coal recovered as a result of the recovery of up to 34 million tons from the Vostochnaya (eastern) seam, which has an estimated ash content of 41.4%. The increase in the use of reduced-quality coal has raised concerns regarding the stability of the heat engineering characteristics of the coal available to fire steam boilers at TES. Of special concern is the fact that 90% of all coal shipped to TES via railroad is unloaded directly from the mine shaft bin rather than from warehouses. In view of these concerns, the authors of the study reported herein studied coal arriving at the Troitsk TES via railroad during each of the 12 months of 1988. According to data provided by the supplier, the ash content of the incoming coal ranged from 26 to 55%, and the combustion heat ranged from 13.6 to 18.8 MJ/kg. According to data provided by the electric power plant, individual carloads of coal with an ash content as high as 65 to 70% were received. Supplier estimates put the moisture content of the coal received at the TES at 3.6 to 5.1%; data provided by the electric power plant put the moisture content of the said coal at 4.6 to 7.1%. The main factor determining the spread of heat generated when coal is burned is its ash content. Ash content is in turn dictated by the percentage and quality of the quality group II coal included in a given coal shipment. An analysis of documents regarding 82 routes over which 385,312 tons of coal was transported over the course of a month revealed that the ash content varied from 26 to 55% from one railroad car to another or by 39% over an entire route. To place their estimates in some sort of order, the researchers divided the incoming coal into three groups based on ash content. The coal in the group 1 routes (accounting for 51.2% of all commercial coal shipped during the study period) had an ash content ranging from 33 to 47% (inclusively), the coal in the group 2 routes (accounting for 20.7% of the commercial coal shipped) had an ash content of 47 to 55%. The coal

in the remaining group (constituting 28.1% of the coal shipped) had an ash content ranging from 26 to 55%. When the latter coal was unloaded without the benefit of a warehouse in which different batches of coal could be blended, it was virtually impossible to load mills, burners, and furnace sections uniformly and virtually impossible to sustain the operation of an automatic control system. These great disparities in the ash content of individual coal shipments, coupled with increasing problems in the areas of fuel preparation and burning, have resulted in a big drop in the operating reliability of boilers' heating surfaces and have also adversely affected the operation of automatic boiler control systems. It has been estimated that the productivity of the 500-MW boiler units at the Troitsk TES is reduced about 30% of the time due to shortcomings of the coal being burned. The technical and economic indicators of the said units have been declining steadily since 1982 because of a regular increase in the relative amount of quality group II coal shipped to the plant. The main technical and economic indicators of the Reftinskaya GRES are more stable and better than at the Troitsk plant. This difference is due largely to two factors: 1) the Reftinskaya plant has more modern equipment than the Troitsk plant does, and 2) its the mean-weighted ash content of the fuel it uses is about 1% below that burned at the Troitsk plant. Ash trapping and slag removal equipment and processes are turning out to be increasingly important. The existing GOST 8779-79 and authorized deviations from it are directed primarily at increasing gross output of coal are not giving the Ekibastuzugol Production Association any incentive to improve the quality of the commercial coal it ships to power plants. Figures 2, tables 3; references 12 (Russian).

Evaluation of Conical Concentrators

927F0220D Tashkent GELIOTEKHNIKA in Russian
No 2, Mar-Apr 92 (manuscript received 28 Jun 91)
pp 39-43

[Article by A.V. Vartanyan; UDC 628.981:621.48:628.9.021]

[Abstract] The manufacturability of conical concentrators and significant concentrations of solar energy that they provide make them highly interesting from the standpoint of use in heliostats and have made them the subject of numerous scientific research studies. The author of this article examines conical concentrators whose receivers are configured with the small section of the cone perpendicular to the incident solar radiation flux so that the concentrated rays undergo one-time and repeated re-reflection. His purpose in so doing is to establish the limits of the feasibility of using the said concentrators depending on the concentrations required. His chosen evaluation criterion is the efficiency of the mirror surface (M), which has been used successfully in studies of linear composite concentrators with plane reflectors. The coefficient M represents the average specific surface of a concentrator creating a unit average concentration on a unit surface of the receiver. Three

types of concentrators are compared mathematically: a single-section cone concentrator (A), a single-section cone concentrator with repeated reflection (B), and a multiple-section concentrator with one-time reflection (C). The comparison revealed that type A concentrators (single-section cone concentrators) have the highest efficiency in the range of concentrations up to 5.35 when the reflectivity of the mirror surface (R_m) equals 0.9. Single-section concentrators with double re-reflection are most efficient in the range of concentrations from 6 to 12, and single-section concentrators with triple re-reflection are most efficient in the range of concentrations from 12 to 21. Concentrators designed with a greater number of instances of re-reflection were not considered in view of their overall low efficiency. Figures 2, table 1; references 9 (Russian).

Results of Full-Scale Tests and Technical Characteristics of the SOU-100 Solar Desalination Unit

927F0220F Tashkent GELIOTEKHNIKA in Russian
No 2, Mar-Apr 92 (manuscript received 5 Jun 91)
pp 61-63

[Article by B.M. Achilov and K. Batirov, Bukhara State Pedagogical University imeni F. Khodzhayev; UDC 662.997:621.187.142(02)]

[Abstract] The SOU-100 desalination unit, which has a capacity of 5 m³/d, is intended for use at karakul sheep breeding sovkhoses. In 1989 the SOU-100 was constructed at the Karakul-500 substation (about 70 km from Bukhara) to produce distilled water. The SOU-100, which is a sloped and staged type of desalination unit, has a useful area of 105 m². The desalination system used in the unit consists of individual blocks in the form of reinforced concrete boats 4 m long, 1.2 m wide, and 0.3 m high in the form of a glass surface in a metal frame. The illuminated surface of each individual desalination block operating in a self-contained mode is 4.8 m². The SOU-100 desalination unit was subjected to full-scale tests in 1989-1990 to determine its efficiency. During the test period, the total intensity of solar radiation, direct solar radiation, wind speed, working surface temperature, and condensation on the unit's side walls and bottom were measured. The unit was filled with water daily and cleaned to remove accumulated salt deposits twice a year. The tests demonstrated that the unit's productivity varies throughout the course of a year depending on external (meteorological) conditions. The SOU-100 was at its peak productivity during the first 10 days of August. The year-long test confirmed that the SOU-100 desalination unit is reliable to operate and produces distilled water that meets the requirements set in the respective All-Union State Standard. Preliminary estimates place the cost-effectiveness of using the SOU-100 condition at 5,000 rubles per year. Figures 3; references 4 (Russian).

Investigation of the Heat Losses of the Vacuum Tube Selective Heat Absorber of a Solar Concentrator

927F0220E Tashkent GELIOTEKHNIKA in Russian No 2, Mar-Apr 92 (manuscript received 1 Jul 91) pp 43-47

[Article by G.V. Tsiklauri, T.O. Nozadze, A.I. Rzayev, L.L. Filatov, Ye.B. Kabanova, and A.I. Tsvetkov, State Scientific Research Institute of Power Generation imeni G.M. Krzhizhanovskiy; UDC 662.977:537.22]

[Abstract] Scientists from the State Scientific Research Institute of Power Generation imeni G.M. Krzhizhanovskiy and Machine Mechanics Institute of the Georgian Academy of Sciences collaborated in the creation and study of different versions of vacuum tube heat absorbers with selective absorbent coatings. Models of the said designs were subjected to full-scale tests at the Machine Mechanics Institute's proving grounds and to laboratory tests on an experimental unit developed at the State Scientific Research Institute of Power Generation imeni G.M. Krzhizhanovskiy. The solar radiation heat absorber studied was designed in the form of a tube made of 12Cr18Ni10Ti steel, measuring 45 x 1 mm, and consisting of two separate sections each 2,500 mm long. Its outer surface was coated with a selective coating made of black chrome. The sections of the unit were connected by bellows to compensate for temperature expansion. Detachable and nondetachable sealing flanges were mounted on the ends of the tube. In order to create vacuum thermal insulation, the sections of the heat absorber's tubes were placed in a cylindrical glass shell made of two tubes measuring 67 x 5 mm. Each of the sections, which were made of borosilicate glass, was 2,436 mm long. The tube's seals had a working temperature between 250 and 300°C. An electrochemical technique was used to create the selective absorbent coating. The coating had an absorptance of 0.96 and an emissivity of 0.12 to 0.15. The heat absorber was subjected to a battery of tests to determine its heat losses. Three series of tests were conducted; the pressure in the annular gap between the glass shell and heat absorber's wall amounted to 3×10^{-3} and 10^{-4} mm Hg in the first two series of tests versus 745 mm Hg in the third series. The heat absorber's wall temperature varied from 50 to 295°C. The tests established that the linear heat losses occurring in the case of an evacuated heat absorber do not depend on the intensity of the vacuum but are in good agreement with the dependence $q_1 = \alpha(T_{\text{heat absorber}})$ calculated in accordance with a method presented by the authors. The smallest change in temperature of the glass shell (23 to 87°C) occurred when the heat absorber's wall temperature was between 65 and 285°C and when vacuum thermal insulation was present. In the absence of vacuum thermal insulation, the contribution of natural convection to the transfer of heat from the heat absorber's wall to the glass shell was observed at a heat absorber's temperatures as low as 80°C and increased as the latter increased. The experiments performed thus confirmed the need to create vacuum insulation for the

high-temperature solar radiation heat absorbers of solar concentrators. Figures 3; references 2 (Russian).

Conditions of the Formation of the Gas and Gas Condensate Deposits of Central and Eastern Turkmenistan

927F0226A Ashkhabad IZVESTIYA AKADEMII NAUK TURKMENISTANA in Russian No 2, Mar-Apr 92 (manuscript received 2 Apr 91) pp 73-78

[Article by K.M. Tegelekov and N.B. Bekmuradov, Turkmen Polytechnic Institute; UDC 553.98.551.762.3/762.3/(575.4)]

[Abstract] A great many scientists have studied the conditions of the formation and laws governing the location of gas and gas condensate deposits in Central and Eastern Turkmenistan. Various authors have pointed out the significance of tectonic, lithologic, hydrogeologic, and geochemical factors to the formation of gas and gas condensate deposits. A review of the research that has been conducted indicates that the formation of the said deposits is attributable to the dispersion of the organic matter of gas and oil mother deposits. The hydrocarbon deposits in the said territory formed as a result of horizontal and vertical migrations. The petroleogenetic properties of the Permian-Triassic formations and the terrigenous deposits of the Callovian-Oxford stage provide the basis for optimism as to the oil content of the beds in the Jurassic and Lower Cretaceous deposits in the more submerged parts of the trough near Kopet-Dag [Predkopetdagskiy] and the Murghab and Amu Darya trenches. References 8 (Russian).

Structural and Design Features of Nontraditional Energy Sources

927F0222B Minsk IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: ENERGETIKA in Russian No 4, Apr 92 (manuscript received 6 Dec 91) pp 47-49

[Article by R.I. Zapatrin, candidate of technical sciences and docent, and M.D. Al-Abdullakh, engineer, Byelarus State Polytechnic Academy; UDC 621.383:535.215]

[Abstract] Individual electric power sources are a promising type of converter of alternative energy into electric power. They are self-installable mobile combination supporting structures and generators containing converter modules that may, given the required know-how, be used to convert solar, water, chemical, and other forms of energy into electric power. A network of such units is in use in Syria and in the CIS. An individual electric power source consists of a lightweight rack and heavy base. The rack consists of a series of modules that each has an energy conversion element as its main component. A module may contain one of a number of types of alternative energy converters (solar, wind, rain, etc.). The supporting structure is made of some hard material (iron or concrete) and may be filled (weighted) with any number of materials, including concrete, sand,

and stone. The top module may be outfitted with protection against lightning. One important advantage of individual electric power sources is that they are efficient even for small users requiring only about 3 to 5 kW of electric power who are at least 5 km from an electric power system. Figure 1; references 5: 4 Russian, 1 Western.

An Economic Assessment of Forecast and Long-Range Gas Resources in Turkmenistan

927F0226B Ashkhabad IZVESTIYA AKADEMII NAUK TURKMENISTANA in Russian No 2, Mar-Apr 92 (manuscript received 25 Mar 91) pp 107-109

[Article by Ch.M. Paytykov, Turkmen Scientific Research Institute of Geological Exploration; UDC 550.853.003.13(575.4)]

[Abstract] Previous economic analyses of the forecast and long-range oil and gas resources in Turkmenistan have failed to give adequate consideration to the differences in the quality of oil and gas located in regions with very different geological, geographic, and economic conditions. In an effort to remedy this problem, the author of this study divided the oil and gas resources of Turkmenistan into five different categories based on oil-and-gas-bearing province, oblast, and integrated and local facilities. The analysis revealed that throughout the Amu Darya oil-and-gas province, the average cost of discovering and processing 1,000 m³ of gas is forecast at about 1.5 rubles. The actual production costs for 1,000 m³ of gas throughout the province from 1956 to 1990 amounted to 0.77 rubles; 66.3% of the said resources were found and prepared at a cost of less than 0.5 r/1,000 m³. The lowest costs for increasing gas reserves were forecast for the Murgab and Chardzhou oil-and-gas-bearing regions, where new deposits may indeed be discovered. The cost of finding and processing 1,000 m³ of gas in the Upper Jurassic deposits in the said regions is estimated at 0.9 rubles. The cost of finding and processing 1,000 m³ of gas in what has been termed the relatively "simple" Lower Cretaceous complex, on the other hand, increases to 1.8 rubles (primarily because it has not been as extensively explored and because it is thought to have mainly small deposits). Of the oil and gas resources in the Southern Caspian province, 69% can probably be discovered and processed for less than 0.5 rubles/1,000 m³, and another 23% will likely cost 0.6 to 2 rubles for the same amount (for a province average of 1.7 rubles/1,000 m³). It is estimated that the costs of processing 1,000 m³ of gas resources of those forecast as being of commercial grade will double in the future. Nevertheless, these costs will remain relatively low (1.5 ruble). Moreover, 60% of the said resources will be able to be delivered at a cost of less than 0.5 rubles for 1,000 m³. This low cost is primarily attributable to the anticipated high efficiency of geological exploration operations. The analysis performed further established that intense geological exploration operations within a 60-km zone around the Amu Darya's cross-country pipelines in order to augment gas resources is economically feasible.

The lowest projected production costs are for gas recovery in the Chardzhou Oblast (0.73 rubles). Tables 3.

Computer Analysis of the Condition of the Optical System of the SES-5

927F0218A Tashkent GELIOTEKHNKA in Russian No 1, Jan-Feb 92 (manuscript received 4 Jan 91) pp 32-38

[Article by T.K. Koyshiyev, Krymenergo Economic Planning Department, Simferopol; UDC 621.472.004]

[Abstract] A multifactoral mathematical model and accompanying computer program have been developed for use in investigating the main characteristics of the optical system of the No. 5 solar power plant [SES-5]. The model and program are based on the information about a heliostat field's condition that is gathered by the automated heliostat field control system [ASU PG]. The ASU PG-5 automated heliostat field control system that is used to control the heliostat field of the SES-5 solar power plant uses signals from sensors mounted in front of the heliostats to control the heliostats. The said information is thus simultaneously used to control the heliostats and to analyze the operation of the optical system in a tracking mode. Four main factors are used to characterize the operating mode of the SES-5 solar power plant's optical system in the mathematical model and computer program developed. The first, i.e., the cosine factor, characterizes the utilization factor of tracking heliostats' mirror surfaces. The second factor considered is the velocity field, which refers to the velocity loads that the tracking heliostats incur during the control process. These loads change throughout the course of a day depending on the sun's position relative to the tower and heliostat. Both the azimuthal and zenith velocities are considered in the case of tracking heliostats. The slit effect is the third factor considered. This effect results from the fact that the mirror surface of a plane heliostat is assembled from individual rectangular facets with a slit between them. When the heliostat is oriented, the central reflected beam passing through the center of a sensor "draws" a curve on the mirror facet. At the moment when the curve crosses from one facet to the next, the reflected beam does not fall on the sensitive element, which means that the operation of the optical sensor is blocked. This mathematical model developed permits real-time determination of sections of a heliostat field where this slit effect is in operation. The new computer analysis program makes it possible to print out a chart of facet numbers showing the individuals facets subjected to the slit effect at any given moment. The final factor considered in the mathematical model and computer program is that of the shadowing of the heliostat field by the solar steam generator tower. By repeating these subprograms of the analysis program in cycles for different moments in time, it is possible to determine the bounds of the appearance of each of the said factors for each peripheral control point of the SES-5. This information in turn makes it possible to detect when a more complicated control regimen is required for given sections of the heliostat field at given moments in time. Figures 4; references 2 (Russian).

Calculating Rotation Derivatives in the Case of "Local" Interaction of a Flow and Body Surface

927F0217D Moscow *PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 56 No 1, Jan-Feb 92* (manuscript received 2 Jul 91) pp 52-57

[Article by A.I. Bunimovich and A.V. Dubinskiy, Moscow; UDC 533.6.011.8]

[Abstract] Others have examined the problem of creating analytical methods for calculating rotation derivatives of bodies moving in a nonadvancing free-molecular flow. Yet others have examined the respective methods for rarefied gas in the intermediate flow range. In a previous publication, the authors of the study reported herein proposed an approach geared toward a rather general class of "local" models describing the interaction of a flow and body in the presence of a rotation. They then proceeded to derive formulas for calculating first-order rotation derivatives. In this article they develop this approach in relation to second-order rotation derivatives. Specifically, they examine the problem of calculating the rotation derivatives of the force and moment characteristics of bodies of revolution that are moving at an attack angle with a low angular velocity. Formulas for calculating second-order rotation derivatives are derived and investigated for the general class of models of "local" interaction of the body surface and the gas flow around it. The results obtained by the proposed method and formulas are compared with the results of a 1988 examination of free-molecular circulation. The enumerations of zero derivatives are said to coincide with one another. This fact is said to be one of the main impetuses for turning to consideration of a general class of models of local interaction. Figure 1; references 7 (Russian).

The Buckling of Trilayer Round Plates Lying on a Linearly Deformed Base

927F0223C Tashkent *IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: TEKHNIЧЕСKIYE NAUKI in Russian No 6, Nov-Dec 91* (manuscript received 18 Apr 91) pp 38-43

[Article by T.Sh. Shirinkulov and U. Alikulov, Samarkanda State Institute of Architecture and Construction imeni Mirzo Ulugbek; UDC 624.044:539.384]

[Abstract] Multilayer plates and shells made of polymer and other materials that interact with a deformable foundation are widely used in many areas of construction and engineering. In a continuation of the extensive research that has been done on the topic, the authors of the study reported herein have solved a contact problem of the theory of elasticity for trilayer round plates interacting with an elastic half-space. The said problem is based on classic orthogonal polynomials. It is assumed that the trilayer plates possess different elastic characteristics and that the filler is a linear Winkler body. The process of solving the problem is reduced to that of investigating systems of two different equations and one integral equation linking the vertical displacements of

the boundary points of the elastic half-space and the normal reactive pressure of the base as per Boussinesq. Ultimately, an infinite system of algebraic equations is used to solve the problem of the buckling of trilayer round plates interacting with an elastic half-space. References 6 (Russian).

One Case of Wave Propagation in Layered Porous Media

927F0223B Tashkent *IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: TEKHNIЧЕСKIYE NAUKI in Russian No 6, Nov-Dec 91* (manuscript received 23 Mar 89) pp 34-37

[Article by S. Abdullayev, T.U. Artikov, and A. Soatov, Seismology Institute, Uzbekistan Academy of Sciences; UDC 539.30]

[Abstract] The authors of this study have examined one case of wave propagation in porous media. Specifically, they considered the case of a fluid-saturated unconstrained porous medium consisting of plane-parallel layers of identical thickness and possessing identical properties. The authors confined themselves to an examination of the plane deformed state of the said medium and assumed that the cracks in the medium were not open because the weight of the higher-lying layers would keep them from opening up. The said porous medium is treated as a complex microstructure that necessitates the use of a dual scale. Microelements are examined within the confines of a layer, and macroelements are examined within the confines of several layers. It is further assumed that the presence of a slip at the interface of the layers will not disrupt the symmetry of the tangential stresses on a microelement but may disrupt the said symmetry in the case of a macroelement and thus result in buckling of the layers. The tangential stress will also become asymmetrical when slippage occurs. The buckling of the layers is associated with turning of the different sections, which in turn makes it necessary to include local rotation or a change in local porosity as a kinematic element of the continuum model. The process of constructing a continuum model is reduced to one of averaging ("smearing") the properties of the layered medium throughout the entire space. After constructing the model, the authors worked within its framework to solve problems associated with plane waves propagated in an unconstrained medium and the problem of the reflection of waves onto plane and curvilinear boundaries. They also considered the dependence of the phase velocity of plane sinusoidal waves on their frequency and direction of propagation. In addition to being applicable to the four types of waves considered, the expressions derived are said to also be applicable in cases where waves are propagated parallel to the layers of porous media. Figure 1; references 3: 1 Russian, 2 Western.

The Stress-Strained State of Retaining Walls Subjected to the Effect of Dynamic Loads

927F0223A Tashkent IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: TEKHNICHESKIYE NAUKI in Russian No 6, Nov-Dec 91 (manuscript received 21 Feb 91) pp 31-34

[Article by A.Sh. Karimov and G.Kh. Khozhmetov; UDC 624.137.5:539.4]

[Abstract] One of the main ways of increasing the stability of a soil mass and preventing landslides is to use retaining walls. From an engineering standpoint, two primary factors must be considered when designing a retaining wall: the soil pressure on the retaining wall and the strength parameters of the enclosing structure. The various problems entailed in determining the soil pressure on bearing walls and other similar enclosing structures have received a great deal of attention. Far less attention has been devoted to dynamic analysis of the stress-strained state of bearing wall-type structures. In view of this fact, the authors of this study have examined the dynamic stressed state of a massive bearing wall of variable thickness that has been erected on a rigid base and that is serving to retain a soil mass that is under a seismic load. For purposes of their analysis, the authors have used table-specified values of the acceleration of disturbing seismic loads corrected and an actual earthquake accelerogram that has been subjected to zero-line correction. A triangular law specified analytically under the assumption of plane slip surfaces has been used to give consideration to the soil pressure on the retaining wall along its height. The problem of determining the seismic stresses to which the retaining wall is subjected has been reduced to a mixed boundary value problem of the plane dynamic theory of elasticity in a trapezoidal region describing the geometry of a retaining wall of unit width. Finite-difference schemes with second-order precision (the net-point method) have been used to solve the said problem. A Lamé dynamic equation has been used to describe the retaining wall's motion during seismic tremors. A universal computer program has been developed to obtain numerical solutions of the problem. The program features automatic increment selection and meets the requirement of computational stability with a specified precision. A sample numerical analysis is presented. The proposed engineering method and accompanying computer program make it possible to obtain a complete picture of the stressed state of an elastic bearing wall-type structure for all its horizontal and vertical sections. The method may be used with enclosure and retaining structures of constant or variable thickness that are subject to various types of dynamic loads transferred through the foundations on which they have been built. Figures 2; references 4 (Russian).

Optimal Control of the Rotation of a Solid Body With a Flexible Pivot

927F0219A Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 56 No 2, Mar-Apr 92 (manuscript received 28 Feb 91) pp 240-249

[Article by Ye.P. Kubyshkin; UDC 531.38:62-50]

[Abstract] The author has examined two problems of the optimal control of plane rotation of a solid body and an elastic pivot attached to it. The first problem considered is that of bringing the system from its initial phase state to its ultimate phase state while maintaining the minimum quadratic control functional. The second problem considered is that of the system's speed. The author proposes a new method of plotting optimal control that is based on the results of two published studies that he co-authored as well as on functional analysis methods that make it possible to plot control in the form of a series in terms of some system of functions. A system with a viscoelastic pivot is also examined within the framework of a rheological model of Voigt material. The mathematical model is shown to be a system of differential equations with the same boundary conditions that exist for the initially examined case of a solid body and flexible (elastic) pivot. Analogous results are obtained for both systems. The proposed method is shown to be applicable to the problem of bringing a system from its initial phase state to its ultimate phase state while minimizing all convex control functionals. Figures 4; references 7 (Russian).

Dynamics of a High-Speed Compressor

927F0219B Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 56 No 2, Mar-Apr 92 (manuscript received 12 Jan 91) pp 331-334

[Article by A.R. Isayuk-Sayevskaya and A.S. Kelzon, Saint Petersburg; UDC 531.36]

[Abstract] The life of rolling bearings used in the supports of high-speed compressors is significantly reduced because the pressure between the bearing's balls and its outer ring increases in proportion to the square of the angular rotation speed. According to the theory presented in theoretical mechanics courses, reducing the pressure on a high-speed compressor's supports requires that the static and torque imbalance of the rotating compressor body be reduced to zero. In an effort to address this problem, the authors of this article have examined the dynamics of a high-speed compressor. Each of the said compressor's supports consists of two single-row rolling bearings pressed into a common bushing. Springs with a calculated stiffness are assumed to be mounted between the bushing and body. Proceeding from these assumptions, the authors derive dependences linking the bushings' mass characteristics, the elastic supports' stiffness coefficients, and the compressor rotation frequency at which the dynamic pressures on the supports of an unbalanced rotating compressor vanish. Formulas are derived for determining the first two critical speeds of a compressor on elastic supports. By virtue of the mathematical analysis presented herein, the authors demonstrate that supports consisting of two single-row rolling bearings pressed into a common bushing that is elastically connected to the compressor body provide all of the advantages of a shaft in elastic bearings without any skewing of the retainer. Figures 2; references 5 (Russian).

Shock-Free Motions in Systems With Unilateral Constraints

927F0217A Moscow *PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 56 No 1, Jan-Feb 92* (manuscript received 2 Oct 90) pp 3-15

[Article by A.P. Ivanov, Moscow; UDC 531.36]

[Abstract] The problem of shock-motions is of practical interest from the standpoint of the possibility of making "flights" between segments wherein some constraint is "intense" without being plagued by such undesirable effects inherent to shocks as overloads, vibrations, and energy losses. The general properties of such motions have not yet been studied comprehensively, and the partial results that have been obtained are in need of refinement. For this reason, the author examines shock-free periodic motions in systems with a unilateral constraint. The constraint on the said motions is assumed to undergo alternating periods of intensity and attenuation. It is further assumed that the periods of intense constraint are not accompanied by shocks. The conditions of the existence of shock-free motions are derived, and their connection with the characteristic features of differentiable mappings is clarified. The attracting properties of shock-free motions are established: When certain conditions are met, they are analogous to semistable limiting cycles. The results obtained are illustrated by way of the cases of a body on an elastic foot and the constraint of bodies in a satellite orbit. Figures 5; references 9: 8 Russian, 1 Western.

The Use of "Forbidden" Amplitudes When Calculating a Vessel's Wave Drag

927F0217F Moscow *PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 56 No 1, Jan-Feb 92* (manuscript received 15 Mar 91) pp 163-167

[Article by E.L. Amromin, A.N. Lordkipanidze, and Yu.S. Timoshin, Saint Petersburg; UDC 532.5:534.1]

[Abstract] A vessel's wave drag depends on the amplitudes of the ship waves that it generates. The linear theory of ship waves assumes these amplitudes to be directly proportional to the intensities of those wave-forming features that are interchangeable with bodies moving close to a free surface. This in turn has made it possible to derive relatively simple formulas for calculating a ship's wave drag (wave resistance $[R_w]$). As the said intensities increase, however, the discrepancies between experimentally obtained and calculated dependences become striking and thus unacceptable. Attempts to solve a three-dimensional nonlinear problem of wave resistance by expanding the flow's characteristics into a perturbation power series or by using the characteristic features distributed along its boundaries have not yielded satisfactory results for different vessel shapes and Froude numbers despite the extensive computer resources used for the said calculations. The authors of this article have succeeded in solving the problem by

introducing the cutoff, i.e., "forbidden," values of amplitudes into the Havelock formula linking wave drag (resistance) with wave amplitude that is widely used in the linear theory of ship waves. They demonstrate that introducing these "forbidden" amplitudes makes it possible to obtain calculated results that are in satisfactory agreement with experimentally obtained data for diverse vessel shapes. Specifically, they show that introducing these "forbidden" amplitude values is the simplest way of correcting the existing ship resistance formula to allow for the nonlinearity of the interference of ship waves. Figures 3; references 10: 7 Russian, 3 Western.

The Stability of One Particular Motion of a Solid Body With a Viscoelastic Membrane in a Circular Orbit

927F0217C Moscow *PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 56 No 1, Jan-Feb 92* (manuscript received 19 Mar 91) pp 29-33

[Article by O.V. Kholostova, Moscow; UDC 531.35]

[Abstract] The author has examined a system consisting of a bearing body and a viscoelastic circular membrane attached to the body along its contour. The system is assumed to be dynamically symmetrical when in a non-deformed state. The symmetry axis is assumed to be orthogonal to the plane of the membrane. Motion is assumed to occur in a central Newtonian gravity field in a circular orbit. The mathematical investigation presented is developed within the framework of the linear theory of elasticity. The quasi-static motion of the system is examined under the assumption that the membrane is rather rigid and that any dissipative forces present are small in comparison with the elastic forces present. That particular motion of the system is found where the plane of the membrane is parallel to the orbital plane and where the system is rotating uniformly around its symmetry axis with an arbitrary (with respect to magnitude) angular velocity. The stability of the said motion is examined. The computer analysis performed established that when compared with the results obtained in the corresponding problem involving a symmetrical solid satellite, the presence of a viscoelastic membrane in the system results in a narrowing of the regions of stability and in the occurrence of asymptotic stability with respect to a portion of the variables. Figure 1; references 7 (Russian).

Particular Directions in the Configurational Space of Linear Oscillation Systems

927F0217B Moscow *PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 56 No 1, Jan-Feb 92* (manuscript received 7 Feb 91) pp 16-23

[Article by V.F. Zhuravlev, Moscow; UDC 531.36:534.1]

[Abstract] The concept of the main directions of free oscillations is familiar in the theory of vibrations of

linear systems with constant coefficients. In an effort to supplement this concept, the author introduces the concepts of the directions associated with the said main directions and the main directions of forced vibrations. He then presents a series of theorems and proofs establishing the properties of the vibrations along these directions. Both subresonance and transresonance cases are considered. The effects of the presence of dissipative forces in the system are also considered. Next, the effects of gyroscopic forces are examined. The case of gyroscopic forces is shown to differ from the case of dissipating forces by virtue of the fact that the implicit function $\mu(\omega^2)$ does not diminish monotonically in the case of gyroscopic forces. The effect of strictly nonconservative forces is also examined. The properties of the amplitude-frequency characteristic of the main direction of the forced vibrations in such a case are shown to be exactly the same as those in the case of purely conservative forces. Figures 4; reference 1 (Russian).

The Dynamic Intensity of a Conductive Half-Space With a Curvilinear Crack in a Strong Magnetic Field (The State of Antiplane Deformation)

927F0217E Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 56 No 1, Jan-Feb 92 (manuscript received 25 May 90) pp 143-149

[Article by L.A. Filshinskiy and L.I. Fomenko, Sumy; UDC 539.375]

[Abstract] When a dia(para)magnetic located in a static magnetic field is subjected to mechanical excitation, induced (eddy) currents arise in the body. This in turn leads to the appearance of Lorentz body forces. Taking these forces into consideration results in a complementary tensor, i.e., a Maxwell intensity tensor, that in turn makes significant corrections in the body's stressed state. In view of these facts, the authors of this study consider a boundary value problem of magnetoelasticity for a half-space attenuated by a curvilinear crack (cavity). The problem is reduced to a singular integral equation. Calculation results are presented that characterize the dependence of the stress intensity coefficient on the configuration of the crack, the intensity of the applied magnetic field, and the excitation frequency. The problem considered is analogous to the problem of a single rectilinear crack in an unrestricted dia(para)magnetic medium, which was analyzed in a 1976 publication. Figures 4; references 5: 4 Russian, 1 Western.

Issues of Plastic Straining of Anisotropic Textured Metallic Materials

927F0232B Moscow PROBLEMY MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN in Russian No 1, Jan-Feb 92 pp 45-53

[Article by P.F. Prasolov, Moscow; UDC 539.3]

[Abstract] The difficulty of describing analytically the plastic deformation of metallic materials with a natural crystallographic anisotropy as well as the anisotropy acquired by blanks and products under plastic working and the importance of textured alloys of hexagonal lattice metals are outlined and ways of further developing the theory of plasticity and improving the methods of analyzing plastic deformation of anisotropic metallic materials with a crystallographic texture used in mechanical engineering are examined. The anisotropy hypothesis is considered, a tensor-polynomial conditions of the material's plastic state is formulated, physical and phenomenological models are developed, and the use of the deformation space is investigated. The specific problem of analyzing the yield contours for the zircalloy-2 material for the yield strength and its corresponding deformations in the rolling direction, across the rolling direction, and normally to the rolling plane are considered for illustration. It is speculated that the use of the deformation space will make it possible to expand the possibilities of elastoplastic straining description of products from anisotropic materials. Figures 4; tables 1; references 29: 20 Russian, 9 Western.

Reasonable Balancing Accuracy Limits

927F0232A Moscow PROBLEMY MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN in Russian No 1, Jan-Feb 92 pp 19-25

[Article by A.S. Kelzon, A.S. Meller, St. Petersburg; UDC 620.1]

[Abstract] The accuracy of today's engineering methods of balancing a solid which is spinning in two immovable supports in the case where the rotation axis coincides with the central axis of inertia has reached a limit due to a rapid increase in rotation speeds while the number of patents for new balancing designs, especially for increasing the balancing accuracy, has plummeted. As a result, a mathematical model of a solid spinning in two immovable supports is considered and it is demonstrated that a model of perfectly rigid bearings used as an assumption in conventional balancing methods is flawed. Instead, a rolling-contact ball bearing is considered in order to show that in the case of a zero eccentricity and a total momentum equilibration, the rolling-contact bearing reactions increase in proportion to the sixth power of the rotation speed. The analytical findings are confirmed by the results of experiments which reveal that gas turbines spinning at a maximum rotation speed of 10,000 to 45,000 RPM are designed with flexible supports, making it possible to utilize the effect of self-centering at above the second critical velocity and the equality-to-zero condition of dynamic reactions of the unbalanced rotor at a given rotation speed. This is used in the SIP-800K machine where an unbalanced 200 kg grinding wheel spins stably at all speeds up to 11,400 RPM; it is noted that only very light rotors weighing less than 1 kg can be spun at speeds of up to 120,000 RPM in rolling-contact ball bearings rigidly braced in the housing. Figures 6; references 7.

Unitary Models of Manipulating Robot Mechanics

927F0233A Moscow PROBLEMY
MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN
in Russian No 1, Jan-Feb 92 pp 85-93

[Article by V.A. Konoplev, A.T. Zaremba, St. Petersburg; UDC 621.52]

[Abstract] The increasing complication of the tasks being performed by mechanical engineering entities calls for reevaluating the role of theoretical research at the conceptual design stage and necessitates the development of mathematical models of the machine performance processes and in particular, the models of these machines' mechanics. The algorithms for developing the models of manipulating robot mechanics are considered on the basis of unitary formalism of the mechanics of systems of bodies with a tree structure. The resulting models of the control dynamics and kinematics of manipulating robots are designed from similar models, i.e., aggregates, of links with the help of a unitary structural matrix. The presence of dynamically unbalanced and offset (non-axisymmetric) rotating flywheels and an inertial external force are taken into account. The robot design algorithms are characterized in that they do not call for labor and time outlays for preliminary design of symbolic expressions for the kinetic and potential energy of the robot as well as the Appel and Gauss functions. The algorithms are very efficient with respect to computer RAM requirements. An application software package is developed on the basis of the proposed algorithms; for illustration, the problem of dynamic analysis of a standard operation of cutting and stacking a tree by a felling machine equipped with an articulated angular four-element manipulator and a gripping device is considered. Figures 3; references 15: 14 Russian, 1 Western.

Effect of Control Cycle on Stability and Dynamic Accuracy of Industrial Robot

927F0234A Moscow PROBLEMY
MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN
in Russian No 2, Mar-Apr 92 pp 105-110

[Article by L.M. Bolotin, L.I. Tyves, Moscow; UDC 621.01:621-52]

[Abstract] The principles of modern industrial robot (PR) control with the help of digital computer-based discrete servo systems with a delay between the recording of the measured phase coordinate feedbacks by transducers and the application of control action by the drives are considered and the issue of selecting the

control cycle during which the control signals are generated for realizing the specified programmed trajectories of the manipulator arm, i.e., the controlled entity, is addressed. The problem of computer simulation of the control cycle selection problem is discussed and its analytical solution by the method of curve-fitting is investigated, making it possible on the one hand, to derive finite formulas for determining the allowable control cycle durations and on the other, to identify the general patterns of the effect of principal controller parameters and mechanical part of the industrial robot on its stability and dynamic accuracy. A method of synthesizing the sampled data control law of the servo drive without regard to its constraints is proposed; the method ensures the stability and requisite properties of the transient process for the specified control cycle and delay in the system. It is noted that the clock frequency $1/T$ must be no less than the doubled transmission frequency of the equivalent analog system. Figures 1; references 8: 6 Russian, 2 Western.

Dynamics of Controlled Cycling Machine

927F0233B Moscow PROBLEMY
MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN
in Russian No 1, Jan-Feb 92 pp 99-104

[Article by V. Omran, A.V. Sloushch, St. Petersburg; UDC 531.3:681.513.2]

[Abstract] The individual advantages and shortcomings of the two basic principles of realizing the necessary law of motion of the machine unit actuator—the stored program control principle and the programmable mechanism principle—are discussed and the expediency of combining these principles is considered using the example of a crank (and slide) mechanism each point on whose crank moves by a given trajectory whereby the trajectories of different points differ from each other. The function of the crank point positions is derived. The issues of programmed crank motion selection, control principles of the programming mechanism, and programming mechanism dynamics are addressed and the conditions necessary for increasing the system's dynamic stability are formulated. The operation dynamics of this single-mover machine functioning as a test bench for checking the accuracy of robotics systems are investigated and the specified law of motion along the standard trajectory realized by a feedback control system is formulated. The accuracy of the machine is assessed and it is shown that the use of the cycling machine's coordinate and velocity feedback increases the dynamic accuracy of the system. Figures 4; references 4.