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By M. S. Sominskiy

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## SCIENCE CHRONICLE:

## THE LENINGRAD PHYSICO-TECHNICAL INSTITUTE OF THE ACADEMY OF SCIENCES USSR

M. S. Sominskiy

The Leningrad Physico-Technical Institute was established 18 October 1918. The irreplaceable director for over 20 years and at the present time [1940] is academician A. F. Ioffe.

The program of the Institute has been continuously widened since the start of its activity and has been comprising ever new fields of science and [redacted] ~~nique~~, which necessitated increase of scientific personnel and conversions of whole departments into independent research centers. The Leningrad Physico-Technical Institute became the source of many specialized physical and physico-technical institutes and created a many schools of physicists.

Until mid 1936 LFTI was in the Narkommash [The People's Commissariat for Machine Building]. In June 1939 Sovnarkom decided to transfer the institute from Narkommash to the Academy of Sciences USSR.

At the present time LFTI has three basic groups: 1) electrophysics, 2) nuclear physics, and 3) molecular physics. Seventeen laboratories belong to these three groups.

The following article will mention only the most conspicuous results obtained during the year 1939.

### 1. THE ELECTROPHYSICS GROUP

**Group Head:** academician A. F. Ioffe

The main problem of determining the electrical properties of solids is at present centered in semiconductors, which are finding wider and wider application in modern electrical engineering. Many laboratories of LFTI are devoting their efforts to this problem.





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## 1. SEMICONDUCTOR LABORATORY

Laboratory Head: academician A. I. Ioffe

This laboratory conducted and completed researches on the behavior of semiconductors in strong electric fields; for it is under such conditions that the semiconductors find their application. It was established that electric conductivity does increase in a strong field and depends on neither the number of initial electrons nor increase in their mobility. Tests proved that the increase of electric conductivity in strong fields is due to an increase of charge carriers. Basic laws governing currents in strong fields were established and a critical analysis of current representations and theories was published during 1939 in the ZhTF (Zhurnal Tekhnicheskoy Fiziki).

Investigations of 220 combinations of two semiconductors connected in series led us to the fact that the deviation from Ohm's law must be related to the rectifying effect of semiconductors. All semiconductors studied could be placed in a certain series such that any member of the series performs rectification of one sign with every succeeding member and rectification of the opposite sign with every preceding member. The laboratory subjected to experimental tests B. I. Davydov's rectification theory, which considers the equilibrium of a semiconductor with a metal possessing different contact potential; the relation, expected by B. I. Davidov, with the contact potential was not observed.

## 2. CUPROUS-OXIDE RECTIFIERS LABORATORY

Laboratory Head: Candidate of physico-mathematical sciences,
P. V. Sharavskiy

The production of big rectangular plates of sizes 40 x 130 mm and 80 x 20 mm was first completely organized by the laboratory and then transferred to industry, while the expenditure of copper was at most lowered to one-watt power. The following problems were solved:

1. The effect of surface treatment of copper upon the properties of cuprous-oxide rectifiers.



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2. The computation of the data for big cuprous-oxide plates operating under artificial air-cooling.
3. The test operation of rectifiers within a wide temperature range.
4. The design and construction of a light-duty rectifier of 12 volts - 6 amperes and 24 volts - 1 ampere.
5. The design and construction of a 40 volt - 5 ampere rectifier.

The experimental data obtained by the laboratory furnished the basis for the technical design of a rectifier of 1500 amperes - 6 and 12 volts, executed by the designing organization "Metallokhimzashchite", and destined to equip galvanizing works.

The Khar'kov electromechanical and turbogenerator plants started the production of some rectifier types that are based on methods developed by the laboratory.

Besides direct experimental work, the laboratory has been active also in organization and consultation on problems of rectification. Only last year 54 consultations were granted to plants and institutes.

### 3. NEW-TYPE RECTIFIERS LABORATORY

Laboratory Head: candidate of physico-mathematical sciences
B. V. Kurchatov

Work on new types of hard rectifiers was conducted along two lines: 1. completion and study of copper-sulfate and magnesium; 2. search for new semiconducting materials for use as rectifiers.

It is known that the contact of copper and magnesium sulfate allows one to rectify currents as strong as 7 amperes in an area of only a square millimeters. In 1938 the laboratory accepted this problem and solved it by constructing a copper-sulfate and magnesium rectifier with a wide operating area as large as 4 $cm^2$, which allow one to rectify currents as great as 50 - 100 amperes by a single element.





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In 1939 the laboratory successfully eliminated a basic defect of the rectifier - namely, its rapid aging - and achieved great stability of operation. Finally the first technical model of a rectifier of 5 volts - 60 amperes was built. The new rectifier is distinguished by extremely small dimensions and possesses great mechanical strength.

In its present stage the rectifier may be used in electrolysis and arc lighting in motion-picture equipment.

4. SELENIUM-RECTIFIERS LABORATORY

Laboratory Head: A. M. Levinson

A technological process for the purification of selenium used in rectifiers has been developed. It was established that rectifiers made from pure selenium without admixtures have electric parameters not worse than those of German samples. It was proved that domestic selenium is appropriate for selenium rectifiers if purified according to the method developed by the laboratory. A selenium rectifier of 110 volts - 0.3 ampere was produced.

5. PHOTOCELLS LABORATORY

Laboratory Head: candidate of physico-mathematical sciences Yu. P. Maslakovets

The main problem of the Laboratory consisted in improving further thallous-sulfate photocells, made by the institute still in 1938 and used in practical application. The laboratory performed much work along these two lines of theory and practice.

At present the most important consumer of photocells in USSR is the motion-picture industry, until recently using only gas-filled ones with external photoeffect. In this respect much work was done together with the factory "Kinap" [Kinema apparatus] the possible application of photocells with blocking layer of thallous sulfate for use in sound-reproducing equipment. It should be noted that great specialists in this matter considered as impossible the application of thallous-sulfate photocells as in motion pictures.



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In cooperation with the plant "Kinap", the Laboratory designed a special amplifier for operation with the new photoelement. Such equipment was installed experimentally in one of the motion-picture theaters in Leningrad. The results of a ten-months test were: 1) full possibility of application, in sound movies, of thallous-sulfate photocells with blocking layer; 2) the thallous-silfate photocell has many advantages in comparison with the usual photocells with external photoeffect - namely, its application conspicuously reduces external noises and eleminates the need for additional amplification. These properties of the new photocells improved the quality of the sound and facilitated operation so much that the movie theater in which the experimentation was performed changed in July 1939 entirely to thallous-sulfate photocells.

At the present time three amplifier units with thallous-sulfate photocells produced by the plant "Kinap" are installed for commercial use in three movies theaters of Leningrad. Negotiations are under way for the plant to produce a thousand such units. The new photocell possesses great spectral sensitivity, with a maxium around 1000 millimicrons and also great integral sensitivity as high as 8000 μA/lumen; thus it can be used not only in the motion-picture industry but also in many other fields; for example, the new photocell has already found application in the mining industry for the indication of gases.

It is necessary to note that the production of new photocells as well as of new rectifiers is based on extensive studies in the physics of semiconductors, which studies were possible only when the quantum mechanical theory became applicable to practical problems.

## 6. HIGH-VOLTAGE TECHNIQUES LABORATORY

Laboratory Head: doctor of physico-mathematical sciences B. M. Gokhberg

In 1939 the high-voltage laboratory conducted works along three lines: 1) researches on dielectric gases and their possible practical application; 2) tests on a 700-kV electrostatic generator; and 3) the use of thin



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poorly-conducting layers for potential distribution on the surface of insulators in order to eliminate surface discharge.

a. Researches on dielectric gases

In the researches on the physical properties of dielectric gases the LPTI considered the problem of comparing such constants as the ionization excitation potentials and temperature of electrons in gaseous plasma with the dielectric constant of gases that possess high and low insulating power. These researches have been fully completed.

Difficulties arose in application of dielectric gases, due to their unsuitable physical and chemical properties.

A gas without these deficiencies was found and given the name of "elegas". Having a dielectric constant 2.2 greater than air's, this gas is chemically inert and at ordinary temperatures does not liquify under high pressures. Tests performed with various pressures up to 10 atmospheres proved that the breakdown voltage is 700 kV/cm at 10 atmospheres.

In 1939 tests were performed, in cooperation with the plant "Sevkabel", on the use of "elegas" in gas-filled cables. Tests on a segment of cable gave positive results. Recently the SNK [Council of the People's Commissariat] decided that during 1940 equipment should be built for production of gas to be used in gas-filled cables under pressure.

b. Improvement and tests of a 700-kV electrostatic generator

In 1938 was constructed a multidisc elegas-filled electric generator with potentials up to 700 kV and with a cathode-ray tube.

Tests on the generator performed in 1939 at excess pressure of 2.5 atmospheres gave satisfactory results. At this pressure a potential of 300 kV was obtained, which approximately corresponded to the theoretically computed value in the specifications. Therefore we have every reason to assume that the generator will develop the planned potential of 700 kV in an atmosphere of compressed "elegas".



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## II. THE NUCLEAR PHYSICS GROUP

1. Beta-decay laboratory

Laboratory Head: corresponding member of the Academy of Sciences USSR, A. I. Alikhanov

Work in the laboratory was performed along the following lines: 1. Specification and final elaboration of results previously obtained in the laboratory; and 2. finding of new methods for solving problems of beta-decay and cosmic rays.

The first problem is connected with the following questions: 1. researches at the end of the spectrum by the double-spectrographic method; and 2. scattering of relativistic electrons.

The first works finally established that within the limits of the present theory of decay the neutrino's mass cannot be set equal to zero. In the second work, investigating the scattering of high-energy electrons for wide angles, it was found that the scattering of electrons obeys the laws of quantum mechanics, with only the usual Coulomb forces being taken into consideration; specific nuclear forces do not appear in this case. In particular, the second work included: 1) development of methods for observing the recoil of atoms during beta-decay and capture of orbital electrons; 2) development of methods for observing and investigating the ionizing component of cosmic rays; 3) development of methods for observing electron absorption in an elementary action, and many other works.

The first work attempted to clarify by direct tests the existence of the neutrino and measure its mass. A method was developed for studying the recoil of heavy atoms during beta-decay.

The purpose of the second work was to construct a system of Geiger-Mueller counters and tube amplifiers such that one could study, separately and independently of the ionizing particles, the composition and properties of cosmic rays. After many great difficulties had been overcome and after many tests of counters and amplifiers, such a system was finally constructed.



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The third work evolved methods closely approaching the second one, and also met great difficulties which cannot as yet be considered as completely overcome.

2. Nuclear Physics Laboratory

Laboratory head: doctor of physico-mathematical sciences, I. V. Kurchatov

In 1938 LFTI discovered soft electron radiation associated with isomeric transmutation of bromine. This radiation was ascribed to internal conversion which occurs upon transition of the isomeric metastable nucleus into its ground state.

In 1939 the following two problems were proposed: a) to justify experimentally the hypothesis that the soft radiation of bromine originates in conversion; and b) to study the mechanism governing radioactive transmutations in the case of nuclear isomerism of bromine, making use of the new fact of conversion radiation.

In order to compare nuclear isomerism with experience, tests were made to determine the coefficient of internal conversion during isomeric transmutations of bromine and to study the relative probability of conversion on K and L levels of bromine. The basic results of the 1939 work, based on the presence of electron conversion radiation of bromine, may be considered to be the qualitative confirmation of the theory clarifying the phenomenon of nuclear isomerism in metastable nuclei. The problem concerning the detailed quantitative comparison of the theory of metastable states in atomic nuclei with experiments will be the object of studies in 1940.

Besides these items the laboratory started work on the construction of an electron accelerator (quadrutron) invented by Ya. L. Khurgin a worker at the LFTI; the first model is designed to accelerate 100-kV electrons to 3 MV. Many parts of the accelerator have already been constructed and tested.





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### 3. Fast Electrons Laboratory

Laboratory Head: doctor of physico-mathematical sciences, L. A. Artsimovich

Projects of the laboratory for 1939 include studies of the angular distribution of fast electrons scattered by the nuclei of various elements. In connection with these studies a magnetic spectrograph with double focussing of electrons in a longitudinal field was constructed in 1939 and its operation tested; measurements will be performed in 1940.

At present the whole nuclear physics group suffers from the lack of technical foundations, which makes further work impossible. Taking this matter into consideration, SNK (Council of the People's Commissariat) granted the Institute funds to construct a powerful cyclotron, the construction of which is supposed to start in 1940.

## III. MOLECULAR PHYSICS GROUP

### 1. Polymers Laboratory

(Laboratory of A. P. Aleksandrov and P. P. Kobeko)

Basic studies were devoted to problems of plastic deformation of rubber-like plastic materials over a wide range of temperatures (-180 to +200°C). By means of measurements of mechanical and electric relaxation characteristics of various polymers their physical nature was determined; thus, for example, it was established that relation between frequency and temperature of highly electrical bodies is determined by the ratio of the time of relaxation of the substance and the time of action of force undisturbed by structural changes. This last fact is very important in manufacture of plastic products intended for dynamic use. Interesting work was performed by N. Zhurkov, a scientific worker of the group, who succedded, after studying the destructive effect of oxidizing processes, in finding a method for rolling sodium divinyl rubbers without decreasing at the same time their mechanical strength, as would happen in the case of the methods employed in our factories.



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## 2. Mechanical Properties Laboratory

Laboratory Head: academician N. N. Davidenkov

The work of the laboratory consisted in extensive studies of the cold brittleness of steel. The main problems that were supposed to be solved in 1939 were the following:

1) determination of the best criterion for judging the tendency of steel toward brittleness; study of rational methods of brittleness tests.
2) determination of the effect of thermal and mechanical treatments on the brittleness of steel.
3) processing of the greatest number of commercial steels with respect to their tendency to brittleness and evaluation of their ratings.
4) processing of methods for computing impact brittleness by introduction of the new concept of "marginal viscosity", analogous to "safety factor" in ordinary calculations.

The solution of such problems is not mainly of theoretical interest but mostly of practical value. The laboratory is cooperating with a number of plants concerning consultations and work contracts.

After having outlined the main works of the Institute in 1939, we consider it useful to note the basic and most serious problems which the Institute still faces in 1940:

1) further perfection of photocells and rectifier types developed by the Institute and wide-spread introduction of these products into industry and engineering;
2) creation of strong-current thermoelectric apparatus and sensitive receivers of radiative energy;
3) development of theories of rectifiers, photoeffects and thermoeffects;
4) obtaining of polymerized materials with given properties - in particular, higher mechanical strength and thermal resistance;
5) further improvement of the quality of resins and rubbers, and also improvement of the techniques of rational production of automobile tires;



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6) new dielectric gases and gas-filled high-voltage cable;

7) design and construction of a powerful electrostatic generator with high efficiency;

8) establishment of the existence of the temporarily-hypothetical particle called the neutrino;

9) construction of a powerful cyclotron;

10) construction of a quadrutron;

11) thorough and manifold study of the fission of heavy nuclei under bombardment by neutrons. And, finally, we should note still another important problem - namely, the education of physical-science cadres that are able to establish physics as the foundation of our technical progress.

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