THE ORGANIZATION OF SCIENCE

Centenary of the "Journal of Experimental and Theoretical Physics" and the role of journals in the development of science [1)]

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It has been noted already by the historians of science that science began to develop on an international scale not until after the appearance and spread of the printing press in the 15-th and 16-th centuries. This is easily explained by the fact that the fundamental factor determining the collective work of scientists is the organization of information exchange. The more effectively this is carried out, the greater its scale and the more intensively science develops. The most effective method in scientific information up to date appears to be its dissemination through periodicals, since one can most widely and quickly communicate in this way the scientific achievements in which scientists are interested.

The first scientific journal in the world appeared in 1655, but their number began to grow uninterruptedly only after 1750 when a regular postal network was established in Europe. Figure 1, composed by the historian of science D.J. de Solla Price [1] shows a plot of the growth of the total number of scientific journals published in all countries. The number of scientific journals is given in a logarithmic scale; it is seen that during the last three hundred years their growth has been steadily exponential. Every 10–15 years the number of journals doubles and it it has now reached the imposing number of 200 000. The number of abstract journals now published is also shown in Fig. 1. These journals were aimed at facilitating familiarity with a great quantity of scientific information. They appeared back in 1830 and, as follows from Fig. 1, their number grows in parallel to the main curve and therefore follows the same exponential law as the growth in the number of the main journals. There are now about three hundred abstract journals.

Statistical data, which are at present widely available, show that the number of scientific workers and the funds allotted to scientific work also grow according to the same exponential law, doubling every 10–15 years. Thus it is obvious that a close connection exists between the growth of the number of scientific journals and the scale of development of scientific work. This points to the possibility that useful data can be had about the organization of scientific work from a study of the number and character of the scientific journals. For example, it follows from Fig. 1 that science has been developing uniformly over all three hundred years, and the jump which one could expect in accordance with now occurring scientific-technical revolution cannot be observed. The intensive contemporary development of science can be explained only by the well-known fact that every process that follows an exponential law always attains in final analysis an explosion character.

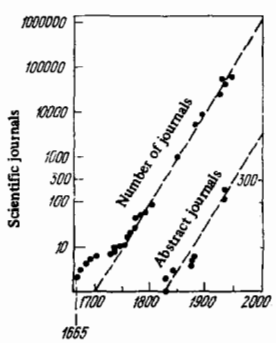
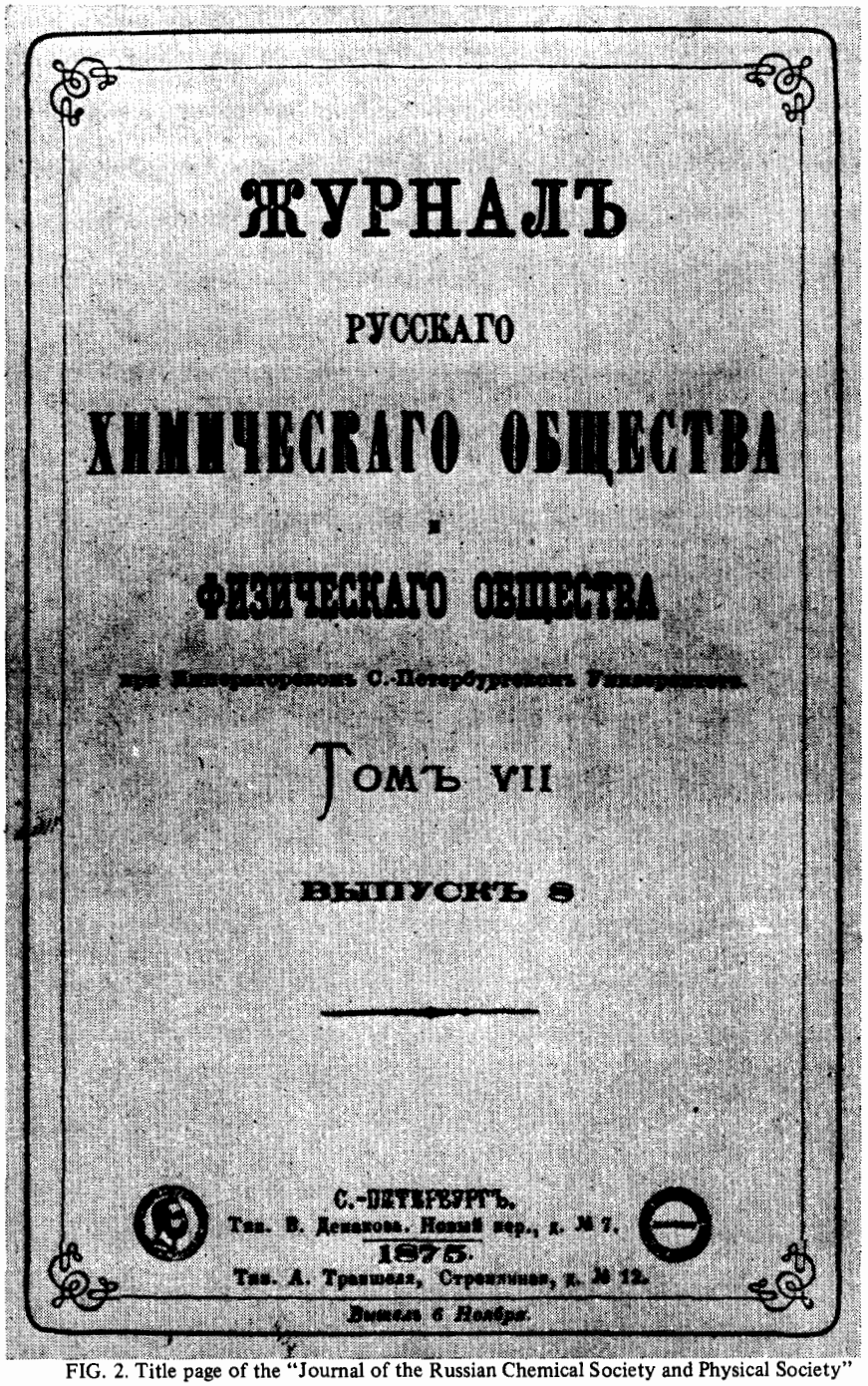


FIG. 1. Growth of number of scientific journals since 1665.

The first physics journal in our country was published by the Russian Physics Society a hundred years ago; its title page is shown in Fig. 2. After the October revolution it came under the cognizance of the USSR Academy of Sciences in 1930 and was called "Journal of Experimental and Theoretical Physics", as can be seen from the photograph of a recent cover page (Fig. 3). It is now considered to be our leading journal in physics. The fundamental stages of the development of our physics have been reflected in the journal for a hundred years. Therefore if one studies the material contained in the journal one can not only construct a picture of the development of the physical sciences, but one can also visualize their present status. A special article was printed in the jubilee edition of the journal by Yu.M. M. Tsipenyuk [2], in which a picture of the development of physics over the last hundred years is drawn, compiled from the material which had been printed in the journal. Here we can note only a few stages of the development of physics in our country over that period of time, focusing our main attention on how the journal reflects the contemporary status of the physical sciences in our country.

It is customary to think that the natural sciences began to develop in Russia at the beginning of the 18-th century when Peter I founded the Academy of Sciences, to which great scientists like Euler and Bernoulli were attracted from the beginning. It was there that Lomonosov, the first Russian scientist of genius, was educated. After Lomonosov, however, and in spite of this brilliant beginning of physics and chemistry, toward the end of the 18-th and the beginning of the 19-th century our physico-mathematical sciences developed much more slowly than in Western Europe. Effective progress in these sciences called for material and technical bases which did not exist in our still largely agricultural country. These sciences started to develop properly in the second half of the 19-th century, after the peasant reform in 1861. The country became richer at that time and began to develop its own industry. A scientific-technical community came into being and scientific and technical societies began to be created. One of these societies was the Physical Society and our journal was founded a hundred years ago as its printed organ. The journal of the Chemical Society was published first, and an independent physics section there appeared with it only in 1873. The founder of a Physical Society was S. F. Petrushevskiĭ, and the first editor of the journal was D. K. Bobylev. At first the journal printed both original and review articles. Since the basic scientific activity in those days went on abroad, it was only natural that our scientists, who wanted to be more actively involved in the development of the world's science, preferred to print their works in foreign journals, either


ЖУРНАЛЪ

РУССКАГО

ХИМИЧЕСКАГО ОБЩЕСТВА

И

ФИЗИЧЕСКАГО ОБЩЕСТВА

при Императорскомъ С.-Петербургскомъ Университетѣ.

ТОМЪ VII

ВЫПУСКЪ 8

С.-ПЕТЕРБУРГЪ.
Тип. В. Демакова. Новый пер., д. № 7.
1875.
Тип. А. Траншеля, Стремянная, д. № 12.
Вышелъ 6 Ноября.

FIG. 2. Title page of the "Journal of the Russian Chemical Society and Physical Society" for 1875.

German or French. It is interesting to observe that even at the beginning of this century, when we had already a number of brilliant scientists, such as N. A. Umov, A. G. Stoletov, P. N. Lebedev, A. A. Eĭkhenval'd, B. B. Golitsyn, and A. S. Popov, they printed their best works first abroad. As time went on and with increasing number of original articles, the survey articles were relegated to an appendix, and in 1907 the physics section of the journal was completely separated from the chemical section and became an independent publication.

It is enlightening to watch that happened to the journal after the October revolution. Despite the civil war and the harsh ordeals, scientific work in the country resumed immediately in all fields of learning, especially in the natural sciences. Our journal received steady material support from the state so that publication never stopped, and in the worst years of the Twenties, when it was impossible to print it in Petrograd because of the disorder, it was printed in Germany.

At that time only original scientific papers were printed in the journal. A journal "Uspekhi Fizicheskikh Nauk" for review articles was founded in 1918 and organized by É. V. Shpol'skiĭ who is still today its editor. This journal publishes steadily high-level information on the most important achievements in physics in all countries.

The Russian Physicochemical Society ceased to exist in 1930, and its journal came under the cognizance of the Academy of Sciences and its name changed to "Journal of Experimental and Theoretical Physics" (JETP). Its editor and editorial staff was nominated

FIG. 3. Front cover of Zhurnal Éksperimental'noĭ i Teoreticheskoĭ Fiziki, 1973.

by the Academy of Sciences on the basis of elections. After its transfer to the Academy, A. F. Ioffe and L. I. Mandel'shtam remained the chief editors, S. I. Vavilov was editor from 1939 to 1952, until 1956 it was N. N. Andreev, and since that year the editing of the journal has been entrusted to me.

After the establishment of the socialist system in our country, an intensive growth of the natural sciences took place and the previously lost time was made up. This is well illustrated by the materials introduced by D. de Solla Price in his cited paper, where data are given (p. 40) on the number of journal publications in chemistry in a number of countries between 1910 and 1960 (unfortunately, no such data are given for other sciences). Before the October revolution the greatest number of papers in chemistry were published in Germany (34%), followed by the USA (20%); Russia's contribution was only 2%. In 1960 the picture changed sharply: German journals–6%, American–28%, Soviet–18%.

In these years physics developed no less intensively, as reflected correspondingly in our journal. Although Zh. Eksp. Teor. Fiz. has increased in volume, it could no longer cover all the scientific papers in physics. Specialized journals in various areas of the physical sciences began to appear since 1925. The first was the

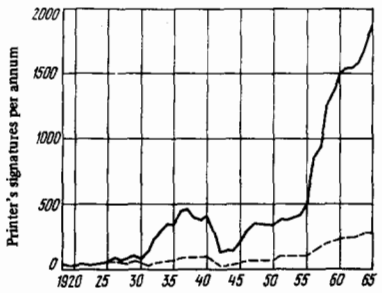


FIG. 4. Printer's signatures from 1910 to 1965 for the basic physical journals (solid line) and for JETP (dashed line).

"Journal of Technical Physics",[2] followed by journals on optics, mechanics, crystallography and a series of other specialties. At present there are no less than 25. There is practically no major branch of physics without its own special journal.

The dashed line of Fig. 4 illustrates the growth of JETP between 1917 and 1965. The solid line shows the total number of pages of all the journals in the different branches of physics (the 1942–1944 gap in the curve is a consequence of the war). It is evident that in 1925 JETP ceased to be the only physical journal, and at present it accounts for only 10–15% of the total volume of the journals.

This raises the natural question whether a general physics journal is needed at present, when there are so many specialized journals. Experience has shown that such a journal appears to be nonetheless needed for the development of science. This is confirmed not only by the fact that it continues to exist, but also because similar journals on general topics exist abroad, for example, "The Physical Review" of the American Physics Society, although a large selection of specialized journals is published also in the USA.

To justify the existence of JETP as a general journal of physics at the present stage of its development, let us consider its present role in international science. I shall use for this purpose some data from an original paper by S. Keenan and P. Atherton, "The Journal Literature of Physics," which is published in the USA.[3] The method used by the authors is the following: the most important American abstract journal covering all areas of physics is "Physics Abstracts." In 1961 it printed 20 287 abstracts of articles published in 45 journals of 39 countries. The paper cites numerical statistics on the distribution of these papers by countries, by journals, and by areas of physics. We include here only a few data from this extensive material, which takes up 156 pages. Table I gives the numbers of abstracts as percentages of the total number for the following countries: USA, USSR, England, Japan, France, Holland (the participation of other countries is considerably less). It follows from this table that the USSR and the USA produce together 47.5% of the total number of abstracts, i.e., practically half of all the publications in physics. In addition it must be taken into account that only 24 Soviet journals, less than the actual number, were abstracted.

Using the data of the same paper,[3] we can compare numerically the participation in "Physics Abstracts" of the USA and the USSR in different leading areas of physics. The results are listed in Table II. The first two columns show the percentages of the citations in "Physics Abstracts" for given areas of physics. The last column shows the ratio of abstracts from USSR journals to abstracts from USA journals. Of course all these data must be regarded critically since they are based on the material in an American abstract journal, where papers not in English were not readily included, in view of the language barrier. The quality of the scientific work is likewise not considered in such a formal method of comparison. But even under these circumstances it is evident that we in general now occupy the second place in physics, and lead in the study of the solid state. This method of comparison shows also that we are behind in certain areas, as for example in geophysics and biophysics. Therefore even such a formal study of scientific periodical literature gives us interesting and useful material for the organization of the science in its planning stage. The material cited in the paper by S. Keenan and P. Atherton affords also the opportunity to evaluate the significance of individual journals to the development of physics in its international aspect, since they cite the number of abstracts in "Physics Abstracts" from every journal. Thus, JETP is in first place among the Soviet journals (all its articles are abstracted), "Solid State Physics" is in second place, and the "Proceedings (Doklady) of the USSR Academy of Sciences" is in third place.

The international significance of JETP is furthermore confirmed by the fact that since 1955 it has been translated into English cover to cover, as are now a number of our other leading scientific journals. These translation journals had to be initially subsidized by the National Scientific Foundation, but have been self-supporting since 1964.

TABLE I. Number of journals and abstracts in the physical science in in the principal countries.

	USA	USSR	England	Japan	France	Germany	Holland
Number of journals	71	24	62	37	14	47	14
Number of abstracts	6316	3317	2729	1560	1268	1240	1043
Percentage of total number of abstracts	31.14	16.37	13.45	7.69	6.32	6.11	5.23

TABLE II. Comparative number of abstracts by fundamental areas of physics for the USA and the USSR

No.	Field of Physics	USA % of all abstracts	USSR % of all abstracts	USSR in relation to USA	
0	All areas in physics	31.14	16.37	0.53	average
1	Electronic properties of solids	25.0	29.7	1.19	
2	Solid state	25.2	26.1	1.04	
3	Optical properties of the solid state	32.1	23.4	0.73	
4	Electricity and magnetism	31.2	22.1	0.71	above average
5	Mechanics	27.6	16.6	0.60	
6	Nuclear physics	25.4	13.8	0.54	
7	Elementary particles	31.8	17.2	0.54	
8	Cosmic Rays	24.9	13.1	0.53	
9	Liquids and gases	29.4	13.4	0.46	
10	Acoustics	45.1	19.9	0.44	
11	Technology and materials	40.6	16.9	0.42	
12	Magnetic Properties of solids	33.5	13.1	0.39	
13	Heat and Thermal Phenomena	41.2	15.3	0.37	
14	Optics	35.4	11.9	0.34	
15	Mathematical Physics	27.2	8.8	0.32	below average
16	General Physics	52.6	10.6	0.20	
17	Astrophysics	35.8	7.3	0.20	
18	Atoms and Molecules	45.5	8.6	0.19	
19	Mathematics	35.1	6.7	0.19	
20	Physical chemistry	49.7	6.4	0.13	
21	Geophysics	36.5	4.9	0.13	
22	Biophysics	66.2	2.9	0.04	

The content of JETP has of course changed over the hundred years of its existence, in accord with the growth and development of physics, although it has preserved its general character. It is therefore natural to pose the following question: which tasks must this non-specialized journal perform, and what should be its content in order to be useful, if separate journals, where any of the articles now published in JETP can be printed, now exist for all areas of physics?

Obviously the natural answer to this question is that in physics as well as in other sciences there are scientific papers whose significance goes beyond the boundaries of the interests of specialists in its separate areas. These can be either the discovery of new phenomena, or original methods of research, or broad theoretical information that concerns many areas, etc. All of these papers must be printed in the general journals like JETP and "The Physical Review." Therefore the editing of a general journal has its own peculiarities that are reflected in the correct choice of such papers. Naturally the selection of scientific papers places a greater responsibility on the editors of JETP than in a specialized journal. This requires a larger staff of editors who are qualified in a number of areas in physics. And it is impossible not to involve specialists as referees in the evaluation of works. Besides, for an objective evaluation, a system has to be worked out in such a way that the referee can be assured that his opinion is held in full confidence. Experience has shown that in a number of cases the opinions of the referees do not decide the editor's final word. This happens, for example, when the author of the article is himself the most prominent scientist in the given area. But the opinion of the referee is nevertheless important, since it indicates how the article will be received by the scientific community.

It happens often that an article can be very valuable, but not written sufficiently clearly to be understood by a larger circle of physicists. It is generally accepted that any scientific article must satisfy the following demands: if the article is experimental, sufficient data must be communicated in it so that the qualified scientist could himself repeat the experiments; if the article is theoretical, the fundamental premises on which the theoretical structure is founded must be concisely formulated, and the mathematical calculations must be stated sufficiently fully so that the qualified theoretician could verify the results. For JETP, however, a journal read by a wide circle of scientists, it is necessary that the article satisfy one more condition: it must be understandable not only to the specialist in a given field, but also to the scientist who is working in different areas. Usually this is achieved by prefacing the article with an introduction that states in more comprehensible form the general significance of the questions dealt with in the paper and of the results. Such demands are frequently resented by authors, because even a prominent scientist is frequently unable to present his thoughts clearly and understandably.

The articles are selected by the editorial panel in accordance with the stated principles. Those articles which are not of general significance must be rejected, and their number reaches 40% of the submitted articles. The number of rejected articles is determined also by the need to limit the size of the journal (at present this is about 300 printers signatures (of 16 pages each) per year). This guarantees a short enough publication time. For JETP as well as for similar journals in other countries this time is about five to six months. This period is determined primarily by the time needed to referee and edit the articles. In those cases where the decision of the editorial panel differs from the opinion of the management of the scientific institution, the editorial board evaluates the articles with special care and makes the final decision. Under present-day circumstances an article rejected by JETP may still be published in one of the specialized journals. A physicist's desire to be published in JETP is motivated by the fact that the acceptance of a paper by this journal is regarded high appraisal by the scientific community.

Experience has shown that at the present rate of scientific work and inasmuch as much important physical research is carried out on an international scale, the six-month publication period is too long. Therefore, as has already been done in the USA, we launched in 1965 "Letters to the Editors of JETP," an offset-printed journal devoted to short articles, 3 to 4 pages. These are little booklets of four printers signatures; they appear twice a month; the publication time is 1–2 months.

Up to 400 articles are printed this way annually. A special editorial board was appointed for these "Letters," headed by Academician A. S. Borovik-Romanov. To shorten the publication period, refereeing is dispensed with. What has to be decided, beside the scientific value of the article, is the expediency of its rapid publication. The Letters journal is also very important because it establishes priority of discovery, and therefore enjoys great popularity. For this reason many articles are submitted to the "Letters," and at the moment 60% of them have to be rejected.

A subject analysis of the articles printed in JETP shows that the most deal with solid state physics (46%), followed by articles on plasma (21%), optics, mainly lasers (21%), and finally nuclear physics (9%). In physics, as in other sciences, there is always one field of research, which is most intensively pursued at any given time. Thirty years ago this was nuclear physics, right now it is solid-state physics, plasma and lasers. The distribution of articles in JETP corresponds to this tendency. Thus there is sufficient reason to think that JETP in its present form continues to be needed as a general journal of physics, even after a hundred years of its existence and promotes the development of our science. One cannot be certain that the situation will be the same in the future, since there are many indications of an impending crisis in the methods of a scientific information service.

The scales of scientific research have grown to such an extent that the dissemination of scientific information in the basic journals becomes difficult. According to the plot of Fig. 1, their number is growing uninterruptedly and will exceed a million by the year 2000. The number of abstract journals is also growing rapidly, and will reach 3000 by the year 2000 (see Fig. 1). Obviously, this method of information will likewise exhaust itself. The need to resort to new methods of information in this task makes itself felt more and more. These should be based on contemporary electronic techniques, as for example computers and teletype. Furthermore, it is obvious that with increasing international scientific cooperation, information should be available more and more centrally on a world scale. These questions have to be given full attention because,

undoubtedly, a well established information system is one of the fundamental factors that secure successful and effective development of science.

[1)]Report delivered at the session of the Presidium of the USSR Academy of Sciences, March 15, 1973.

[1]D. J. de Solla Price, Intern. Sci. and Technology, 37 (March 1963).
[2]Yu. M. Tsipenyuk, Zh. Eksp. Teor. Fiz. **64**, 3 (1973) [Sov. Phys.-JETP 37, 1 (1973)].
[3]S. Keenan and P. Atherton, The Journal Literature of Physics, N.Y., The American Institute of Physics, 1964.

Translated by J. G. Adashko