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## SCIENTIFIC AND TECHNICAL TRAINING IN THE SOVIET UNION

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## SUMMARY

In the U.S.S.R., great emphasis is placed on science and technology in planning the educational system. Part of the planning matches the education and training programs with the needs and requirements of the state. The U.S.S.R. educational system indicates an extent of academic training, coupled with on-the-job and military training, that can produce a highly skilled, dedicated, and matured person.

Soviet aviation training provides theoretical and experimental research into the problems of fundamental aeromechanics, aeroelasticity, stability and control, automatic control systems, transonic and supersonic interference effects, area rule concepts, flow field phenomena, and so on. The apparent use of these technologies are noticeable in the design of Soviet airplanes.

## INTRODUCTION

The Soviet Union recognizes that the foundation of their system depends upon complete dedication of the people to the state through thorough psychological training as well as through military training, and through specialized education in the broad fields of engineering, natural sciences, life sciences, social sciences, and education. The overall cultural development of the people has always been a stated concern of the Soviet government. V. I. Lenin, founder of the Soviet State and its first head, wrote that as a basic part of the plan for the building of socialism in the U.S.S.R., "there must be a veritable revolution--the entire people must go through a period of cultural development." Prior to the 1917 revolution, the literacy of the Russian people was estimated to be about 20 to 25 percent. By 1982 the literacy of the U.S.S.R. population was 98.5 percent for ages 9 to 49. By comparison, the literacy of the U.S. was 99 percent of the population for ages 14 or older.

The Soviet government took charge of public education in 1917 and undertook an immediate task to eliminate illiteracy. In December 1919, a decree on the Elimination of Illiteracy among the population of the Russian Federation was signed by Lenin. In 1923, the Away With Illiteracy Society was founded under the Central Executive Committee which was then the supreme legislative organ of the Soviet State. Education in the U.S.S.R. has continued as an integral part of the government structure with special emphasis on evolving communist views, and on science and technology, for the purpose of transforming the Soviet Union into an advanced industrial state.

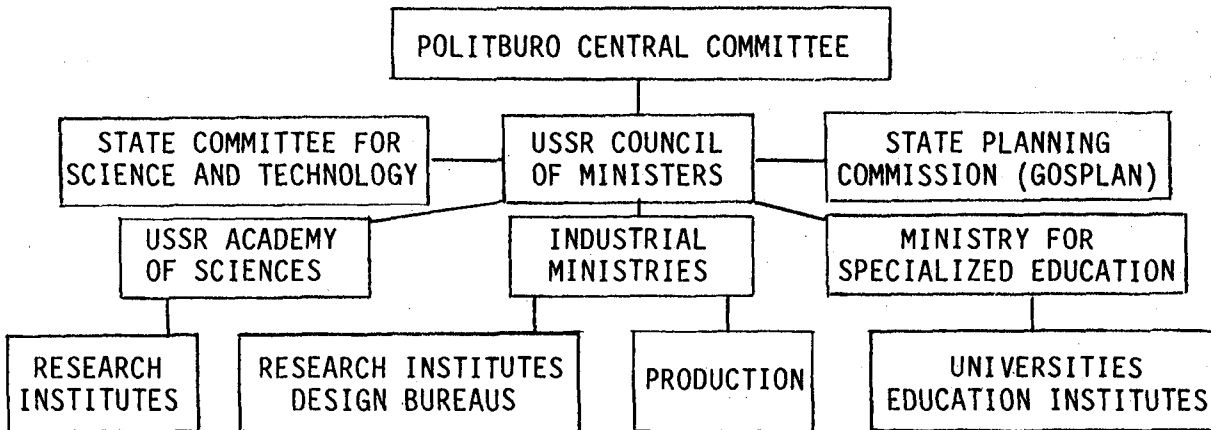
It is not presumed that this paper could cover all aspects of the Soviet educational system. However, it is the purpose to highlight some of the broad features of the system and to make some observations on the apparent effectiveness. A better understanding of Soviet training should be useful in making more objective assessments of Soviet activities from the standpoint of economic, military, or political influence.

## DISCUSSION

### Organization

Part of the organization of the U.S.S.R. includes a Ministry of Higher and Secondary Specialized Education reporting, with many other ministries, directly to the Council of Ministers under the Politburo Central Committee.

The following diagram depicts the U.S.S.R. Scientific and Technical Organization:



This organization shows the close relation between the government, the research institutes and design bureaus, industrial production, and the academic community. It is intended that this organization will assure that training, research, and production are directed toward the priority needs of the central government.

### Constitutional Background

Social development and culture.- In the constitution of the U.S.S.R., Article 25 reads as follows: In the U.S.S.R. there is a uniform system of public education, which is being constantly improved, that provides general education and vocational training for citizens, serves the communist education and intellectual and physical development of the youth, and trains them for work and social activity.

Article 26 reads: In accordance with society's needs the state provides for planned development of science and the training of scientific personnel and organises introduction of the results of research in the economy and other spheres of life.

The basic rights, freedoms, and duties of citizens of the U.S.S.R.- The right to education is established under Article 45 as follows: Citizens of the U.S.S.R. have the right to education.

This right is ensured by free provision of all forms of education, by the institution of universal, compulsory secondary education, and broad development of vocational, specialized secondary, and higher education, in which instruction is

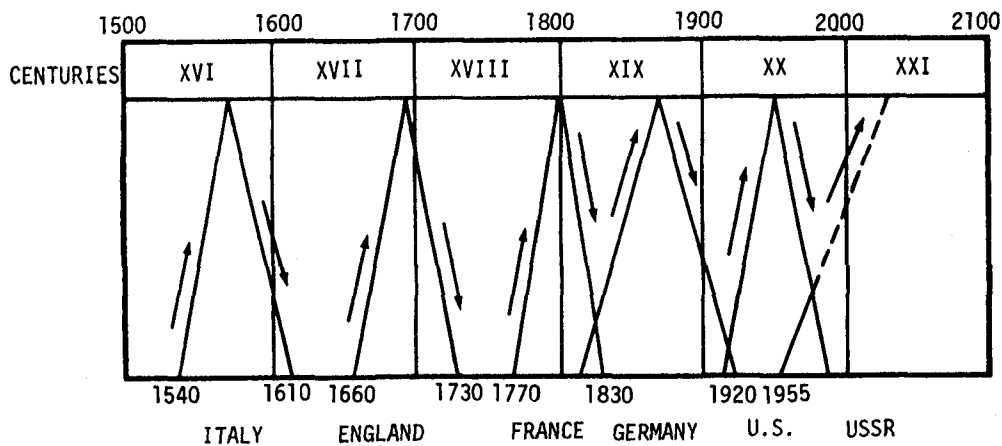
oriented toward practical activity and production; by the development of extra-mural, correspondence and evening courses; by the provision of state scholarships and grants and privileges for students; by the free issue of school textbooks; by the opportunity to attend a school where teaching is in the native language; and by the provision of facilities for self-education.

Guaranteed freedom of scientific, technical, and artistic work are proclaimed in Article 47 as follows: Citizens of the U.S.S.R., in accordance with the aims of building communism, are guaranteed freedom of scientific, technical, and artistic work. This freedom is ensured by broadening scientific research, encouraging invention and innovation, and developing literature and the arts. The state provides the necessary material conditions for this and support for voluntary societies and unions of workers in the arts, organises introduction of inventions and innovations in production and other spheres of activity.

The rights of authors, inventors and innovators are protected by the state.

### Importance of Education and Science

It is clear, insofar as the Soviet constitution is concerned, that the U.S.S.R. places great emphasis on the value of education. Further, special emphasis is placed on science and technology and the application thereof to the economy and to the aims of building communism. This emphasis is deeply rooted in the philosophy of the Soviet Union. For example, Karl Marx considered economy and technology to be directly proportional; Lenin related victory or defeat in war with the level of development of science and technology; Stalin said, "The main thing is to have the Bolshevik desire to master technology." Thus, to the U.S.S.R., the advancement of science to achieve and maintain technological superiority is a national objective. The Soviet view of the international prominence of nations as related to the level of scientific leadership is depicted in the following diagram. Since the 16th century, the Soviets recognize the rise and fall of Italy, England, France, and Germany. They indicate the rise of the U.S., beginning about 1920, peaking near mid-century, and disappearing at about the present time. They perceive their own rise to world scientific leadership beginning at about the mid 20th century period, surpassing the U.S. at about the present time, and projected to continue rising into the 21st century.



The Soviet perspective on world science leadership.

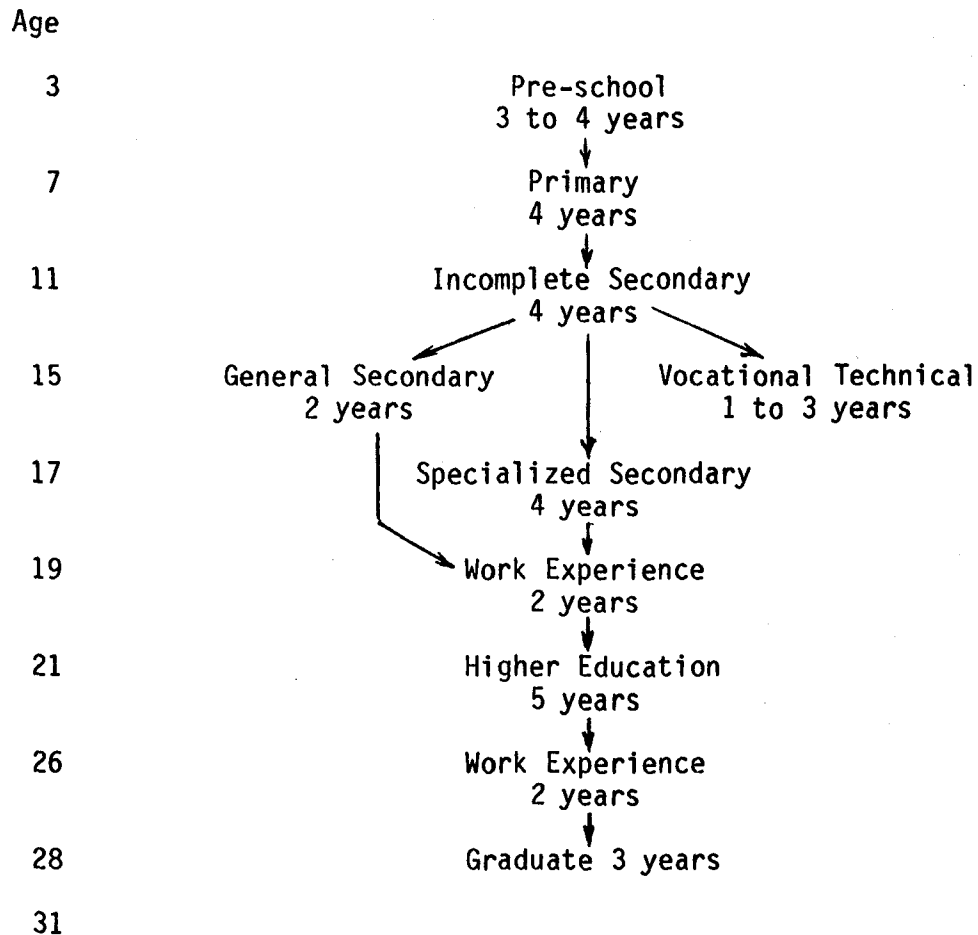
## Principles of Soviet Public Education

The basic principles of public education in the U.S.S.R., as established by legislation, are outlined as follows:

- o Equality in obtaining an education, regardless of race, nationality, sex, religious attitude, or social status.
- o Compulsory education (through 8 years in 1958; through 10 years introduced in 1975).
- o State and public character of all educational institutions.
- o Free choice of language--Russian or some other language spoken in the U.S.S.R. (Russian is essential, however, for those who aspire to advance in the party, government, military, etc.)
- o Free tuition at all levels of education.
- o A unified system of education and continuity of instruction at all institutions.
- o Unity of instruction and communist upbringing between school, family, and society in raising the younger generation.
- o Linking education of the younger generation to meet the requirements of life and of the building of a communist society.
- o A scientific approach to education with constant improvement based on the latest developments in science, technology, and culture.
- o Humanism and high moral principles in education and upbringing.
- o Co-education of boys and girls.
- o Secular character of education ruling out religious influences.

## Educational System Structure

Pre-school may begin at age 3, primary begins at age 7, beyond which there are no minimum entrance ages. A two-year work period is generally required between secondary and higher education and again between higher education and graduate school. Military service counts as work experience for admission to higher education, but work experience for graduate school must be in one's specialty. The general educational pattern is as follows:



Graduates of incomplete secondary education may either enter the work force (at age 16) or follow one of three alternate routes:

- o Complete secondary education (10th grade).
- o Enroll in specialized secondary education (12th grade) for technician level training.
- o Enroll in a vocational/technical school for 1 to 3 years after which they are generally employed at the enterprise where they received their industrial training.

Graduates of completed secondary and specialized secondary may continue to higher education (university or engineering institute) for 5 years and receive an undergraduate or "diplom" degree. Holders of the "diplom" degree may further their education in graduate programs and receive the first of the Soviet advanced degrees, the candidate of science or "kandidat nauk" (more or less equivalent to the U.,S. PhD). A second Soviet advanced degree, the doctor of science or "doktor nauk," is awarded to scientists and engineers for major contributions to the advancement of science. There is no U.S. academic degree which corresponds to the Soviet "doktor" degree.

Thus, a fully educated Soviet may be about 31 years old before entering his profession. Of this time, about 20 years is academic training interspersed with about 4 years of work experience and/or military training. Some differences in the U.S.S.R. and the U.S. academic systems in the college level programs should be noted:

- o Soviet undergraduate degrees require 5 years; U.S. degrees require 4 years.
- o The Soviet undergraduate degree requires practical work (on-the-job) experience.
- o The last year of the Soviet undergraduate study is spent on a project or thesis which must be successfully defended before graduation and thus is a degree more nearly comparable to the U.S. Master's degree.
- o There are two Soviet advanced graduate degrees, the "kandidate nauk" (approximate equivalent to U.S. PhD) and the "doktor nauk" which is a level above any U.S. degree and one that holds much prestige.

### Curriculum

Completed secondary school.- The standard curriculum for completed secondary school is:

Subject	Hours per week by grade									
	1	2	3	4	5	6	7	8	9	10
Native tongue	12	10	10	6	6	3	3	2		
Literature				2	2	2	2	3	4	3
Mathematics	6	6	6	6	6	6	6	6	5	5
History				2	2	2	2	3	4	3
Natural History		2	2	2						
Geography					2	3	2	2	2	
Biology					2	2	2	2	2	2
Physics						2	2	3	4	5
Foreign Language					4	3	3	2	2	2
Chemistry							2	2	3	3
Physical training	2	2	2	2	2	2	2	2	2	2
Manual training	2	2	2	2	2	2	2	2	2	2
Music	1	1	1	1	1	1	1			
Fine Arts	1	1	1	1	1	1				
Drafting						1	1	1		
Astronomy										1
Social Science										2
Optional							2	4	6	6
Total	24	24	24	24	30	30	32	34	36	36

School is generally 6 days a week, Monday through Saturday, averaging 4 to 6 hours a day. While many observations could be made about the curriculum, only a few points will be noted:



- o Emphasis on native language beginning in the first grade.
- o Emphasis on mathematics through tenth grade.
- o Continuous physical and manual training through tenth grade.
- o Foreign language beginning in fifth grade.

Vocational schools.- Vocational schools, of which there are about 6100 with training in over 1100 specialities, consist of urban schools that train workers for various industries, construction, transportation, trade and municipal services. Rural schools provide training in the operation of various types of farm machinery. These schools provide basic skills in school shops or farms with further training in actual working conditions in plants or at collective and state farms. A typical 3-year vocational school cycle may be as follows:

<u>Subject</u>	<u>Total Hours</u>
Production training	2,224
Special technology	334
Industrial electronics	126
Mechanical drawing	112
Materials	73
Physical training	212

Specialized secondary schools.- Those young people who have completed 8 or 10 years of schooling may be admitted for specialized training in more than 500 specialties. Specialized secondary schools are in two main categories:

- o Technical schools for training specialists for industry, construction, transportation, agriculture, etc., including mechanics, technologists, metallurgists, electricians, radio specialists, mining specialists, livestock experts, agronomist, surveyors, bookkeepers, etc.
- o Pedagogical schools for training teachers of music, art, and so on for kindergarten, primary, and secondary schools as well as medical schools for training assistant doctors, nurses, pharmacists, dental technicians, etc.

These schools provide theoretical as well as practical knowledge in the various specialties. The senior year (generally fourth year) is largely devoted to practical work, after which the student must present the results of a project and take state examinations.

Higher education.- Higher education is obtained at hundreds of universities, polytechnical, and specialized institutes in the broad fields of science, technology, and culture covering more than 430 specialties. The early years (two or three) are devoted to general science and engineering with essentially a common curriculum for all-related specialties. Specialization begins in the third or fourth year.

Serious attention is given to socio-political and aesthetic subjects-- political economy, philosophy, and foreign languages--as well as to physical training and sports. Practical work is done in well-equipped laboratories and the course is concluded by the presentation of a project or thesis resulting from independent research. State examinations may also be required. The Soviets pay special attention to the training of engineers while also providing training in the field of medicine, pedagogy, economics, law, humanities, agriculture, and so on.

In essence, it would appear that the Soviet undergraduate degree is closely tailored to an existing occupation. While this tends to produce a more prepared worker, it would somewhat restrict the flexibility of an individual to adapt to unrelated job assignments. In contrast, a U.S. undergraduate is generally more broadly educated and adaptable, but may require longer on-the-job training to be competent in performing required tasks. The pro's and con's of the educational systems are obviously subject to a variety of opinions. Any assessment would involve more than the academic structure alone and, at best, would have to take into account the differences in national priorities, objectives, philosophy, politics, economics, and culture.

### Military Training

Indoctrination.- The Soviets have a universal military service law that requires all able-bodied males to serve from 1 to 3 years in the armed forces. Military indoctrination in the form of various clubs and organizations are provided beginning with the first grade. These groups include:

- o Young soldiers and young aviators, military-sponsored clubs, established in the primary schools beginning with the first grade, instruction often provided by military personnel.
- o Little Octobrists, an organization sponsored by the Communist Party of the Soviet Union (CPSU) to which virtually all school children ages 7 to 9 belong, with the principle goal of insuring early indoctrination in Soviet doctrine.
- o Young Pioneers, sponsored by the CPSU to which nearly all school children ages 10 to 15 belong. Among other activities such as camping, hiking, crafts, etc., these children participate in small-scale annual military war games called "Summer Lightning" in which as many as sixteen million children may take part in learning the elements of military discipline, regulations, guard duty, maneuvers, and civil defense.
- o Komsomol, the apex of the CPSU indoctrination program for youth from ages 14 to 28. Membership is essentially mandatory for one who wants a college level education and aspires to progress in the party or military. The Komsomol is a training ground for potential party members and is a mechanism intended to maintain control and complete indoctrination of each generation of Soviet youth. The Komsomol also sponsors an annual military competition for the 16-18 year old group (called "Eaglet") that requires serious study of military life and regulations.

- o DOSAAF, sponsored by the military, is the Volunteer Society for Assistance to the Army, Air Force, and Navy for youth ages 16 and above. DOSAAF provides training in skills required for the armed forces such as flying, marksmanship, communications,.

As part of the military training, a vigorous program of atheistic indoctrination is also conducted. Marxist-Leninist ideology holds that atheism is obligatory for Communists, and all Soviet citizens are urged to struggle against religious prejudices. An article in the bimonthly journal, Communist of the Armed Forces, Number 3, February 1982, pages 53-58, points out the important work of the Komsomol and of the U.S.S.R. Armed Forces as effective schools of atheism. In stressing the importance of scientific-atheistic propaganda, the article states "Not one commander or political worker, and not one soldier has the right to forget that religion is a variety of an ideology alien to us and that, as before, it retards the growth of awareness and culture, and the social activeness of people who profess it. Moreover, we cannot lose sight of the negative effect of religious prejudices on soldiers' development of moral-political and psychological qualities needed for combat."

### Military Schools

The Soviets also operate over 140 military and higher military schools which provide military and technical training for the majority of the officers for the Soviet Armed Forces. These schools are similar to the three U.S. service academics. The qualifications, requirements, and curriculum for one of these schools, The Officer Candidate School, Yeysk Higher Military Aviation Order of Lenin Pilots School, will be used to illustrate.

General qualifications.- Males from 17 to 21 years of age who have completed secondary education with good recommendations and physically fit for flying jet aircraft.

Candidates entrance examination.- Mathematics-Written, Mathematics-Oral, Physics-Oral, Russian Language-Written Essay, Russian Literature-Written Essay.

Curriculum.- The curriculum, as shown below, appears to be quite rigorous. A 17-year old in his first year will be studying physics, mathematics, theoretical mechanics, hydrothermodynamics, aerodynamics--just to highlight a few subjects. Notice also that in each of the four years there is a course related to communist indoctrination.

#### 1st Year:

General Topography	Hydrothermodynamics	Gunnery
Armed Forces Organization	Aerodynamics	Foreign Language
Higher Physics	Physical Training	(English or German)
Meteorology	Theoretical Mechanics	Higher Mathematics
Resistance of Metals	Radio Electronics	Navigation
Political Economics and Marxism	Descriptive Geometry	

2nd Year:

Topography	Meteorology	Higher Physics
Navigation	Higher Mathematics	Radio Electronics
Resistance of Materials	Aerodynamics	Descriptive Geometry
MIG-17 Engines	Hydrothermodynamics	MIG-17 Aircraft
Foreign Language	Physical Training	Marxism

3rd Year:

Foreign Language	Aerodynamics	Higher Mathematics
MIG-17 Aircraft and Engine	Higher Physics	Physical Training
Scientific Communism	Combat Principles	Meteorology
Air Force Tactics	Air Navigation	Radio Facilities

4th Year:

SU-7 Aircraft and Engine	Aerodynamics	Air Force Tactics
Air Navigation	Radio Facilities	Meteorology
Ballistics and Armament	Principles of Scientific Communism	

Some Soviet Textbooks

Space does not permit more than limited comments on some Soviet textbooks:

- o Aeromechanics of Aircraft by V. B. Baydakov and L. N. Ivanov-Emin, Moscow, 1965. Translated by USAF as FTD-MT-24-250-67. This book outlines the fundamentals of aeromechanics, properties of the atmosphere, characteristics of wings, modern methods of aerodynamic investigations, stability and control, aerodynamic and ballistic design. The book contains a section on interference effects including the theory and use of the transonic and supersonic area rule. The book is intended for use by students in technical aviation schools and medium-level technical personnel in the aviation industry. (It should be noted that there is ample evidence of the use of techniques such as the area rule in Soviet aircraft.)
- o Control of Supersonic Aircraft by F. I. Sklyanskiy, Moscow, 1964. Translated by USAF as FTD-MT-65-89. This book contains sections on the equations of motion, stability and controllability, transonic and supersonic effects, supersonic aircraft design methods, control forces, automatic control systems, future control developments (including electric controls), deformation effects, and aspects of safety of flight and emergency control.
- o Design Principles of Rocket-Ramjet Engines for Unmanned Flight Vehicles by B. V. Orlov, G. Yu. Mazin, et al, Moscow 1967. Translated by USAF as FTD-MT-24-208-68. This book, intended for students of senior courses of technical universities, contains sections on the design and characteristics of inlets, internal ballistics of rocket-ramjet engines, propellants, operating and working characteristics of rocket-ramjet engines, design of rocket-ramjet flight vehicles, automatic control systems for engines, and fields of application.

- o Vertical Landing and Takeoff Aircraft by V. F. Pavlenko, Moscow 1966. Translated by ACSI as FSTC-HT-23-887-68. This book, intended primarily for students at military and civil aviation institutes, sets forth features of design and performance of a variety of types of VTOL aircraft. Attention is given to power plants as the most important and decisive factor in VTOL design, stability and control, transition flight, jet interactions, and safety. It is interesting to note that one of the concepts included for a composite power plant VTOL design is quite similar to the YAK-36 Forger aircraft that was deployed on the Kiev cruiser in 1976.
- o Helicopters, Selection of Design Parameters by M. N. Tishchenko, A. V. Nekrasov, and A. S. Radin, Moscow 1976. Prepared for publication by W. Z. Stepniewski and W. L. Metz, International Technical Associates, Ltd. for AVRADCOM, Ames Research Center, Contract No. NAS2-10062, April 1979. This book may be of direct use to practicing engineers or for an academic course on the design of rotary-wing aircraft. The book deals primarily with transport-type helicopters and covers optimization parameters, effectiveness evaluation, maximum-payload criteria, technological factors related to blade weight, and cost criteria. One figure in the book is of interest since it illustrates an eight-blade rotor hub, and the new Soviet Mi-26 Halo heavy-lift helicopter uses, for the first time, an eight-blade rotor.

#### Some Educational Trends

Higher education.- A comparison of the total number of graduates in higher education (college/university) for the U.S. and U.S.S.R. (fig. 1) indicates generally similar growth trends over the past two decades. Keeping in mind the differences in higher education training previously discussed which indicated the Soviet degree to be more nearly comparable to the U.S. Master's degree, it should be noted that the number of U.S.S.R. graduates exceed the U.S. Master graduates. The U.S.S.R. graduates, however, are less than the U.S. Bachelor's and the U.S. Master/Bachelor total. It should also be kept in mind that some Soviet students proceed through either specialized secondary education or vocational technical schools and enter the work force with specialist training without higher education training. In addition, other Soviet students receive higher education in the military service schools.

Specialization.- A comparison of higher education graduates for the U.S. and U.S.S.R. by specialty area (fig. 2) indicates that, in engineering, the U.S.S.R. produces greater numbers of graduates at a persistently growing rate compared to the U.S. which produces a smaller number of engineers at an essentially constant rate. The U.S.S.R. indicates a progressive growth in numbers and an essentially constant growth rate for the fields of both natural sciences and social sciences. The number of graduates in natural sciences has been somewhat higher in the U.S.S.R. than in the U.S. There is a significant difference in social sciences wherein the U.S. graduates have consistently outnumbered those in the U.S.S.R. and the growth rate has been substantially higher than that of the U.S.S.R. and is the highest of the three fields in the U.S. Considering the differences in the educational systems of the U.S. and the U.S.S.R., it is probable that the higher education graduate trends (namely, emphasis on engineering and natural sciences in the U.S.S.R. and emphasis on social sciences in the U.S.) is a reflection of the national priorities and objectives as perceived by the state in the U.S.S.R. and as perceived by the student and the schools in the U.S.

Engineering graduates.- Another view of the higher education engineering graduate trend is shown in figure 3. The U.S.S.R. rate of growth and increasing number of graduates is readily apparent, having grown from about 100,000 in 1960 to over 300,000 in 1982. The U.S. rate of growth is imperceptible and the number of graduates has remained constant at about 50,000 for the past twenty years.

The number of U.S.S.R. engineering graduates in defense-related fields (fig. 4) has grown from about half the total engineers in 1960 to about two-thirds of the total in 1982. This again serves to indicate the emphasis placed on engineering, and particularly defense-related engineering, by the U.S.S.R. It may be noted that defense-related engineers in the U.S.S.R. were about equal to the total number of U.S. engineers in 1960 and are about 4 times the total number of U.S. engineers in 1982.

Graduate education.- First-level graduate (rough equivalent to U.S. PhD) enrollment in the U.S.S.R. (fig. 5) grew significantly between 1960 and 1970 and, at that point, essentially leveled off. The total number enrolled, however, has been about 100,000 for the past 10 years, of which approximately 75 percent are in the fields of engineering and natural sciences.

#### CONCLUDING REMARKS

It is not the purpose of this paper, nor is it even believed possible, to reach any definite conclusions concerning the relative merit of the scientific and technical training in the Soviet Union. However, it is the purpose to highlight the structure of the educational training process and to reflect some potential implications relative to Soviet objectives and priorities. At the heart of the matter, the Marxist view that economy and technology are directly proportional appears to be evident. There are also indications of adherence to the Leninist view that victory or defeat in war is directly related to the level of science and technology. The intensity and the organization of the academics, coupled with practical work experience, and the persistent political indoctrination, provides the potential for a highly-educated and highly-dedicated Soviet in the work force, military, or government. In any event, if the state-controlled system can be maintained, the Soviet Union will continue to be a dominant factor that cannot be ignored in world political, economical, technological, and military matters.

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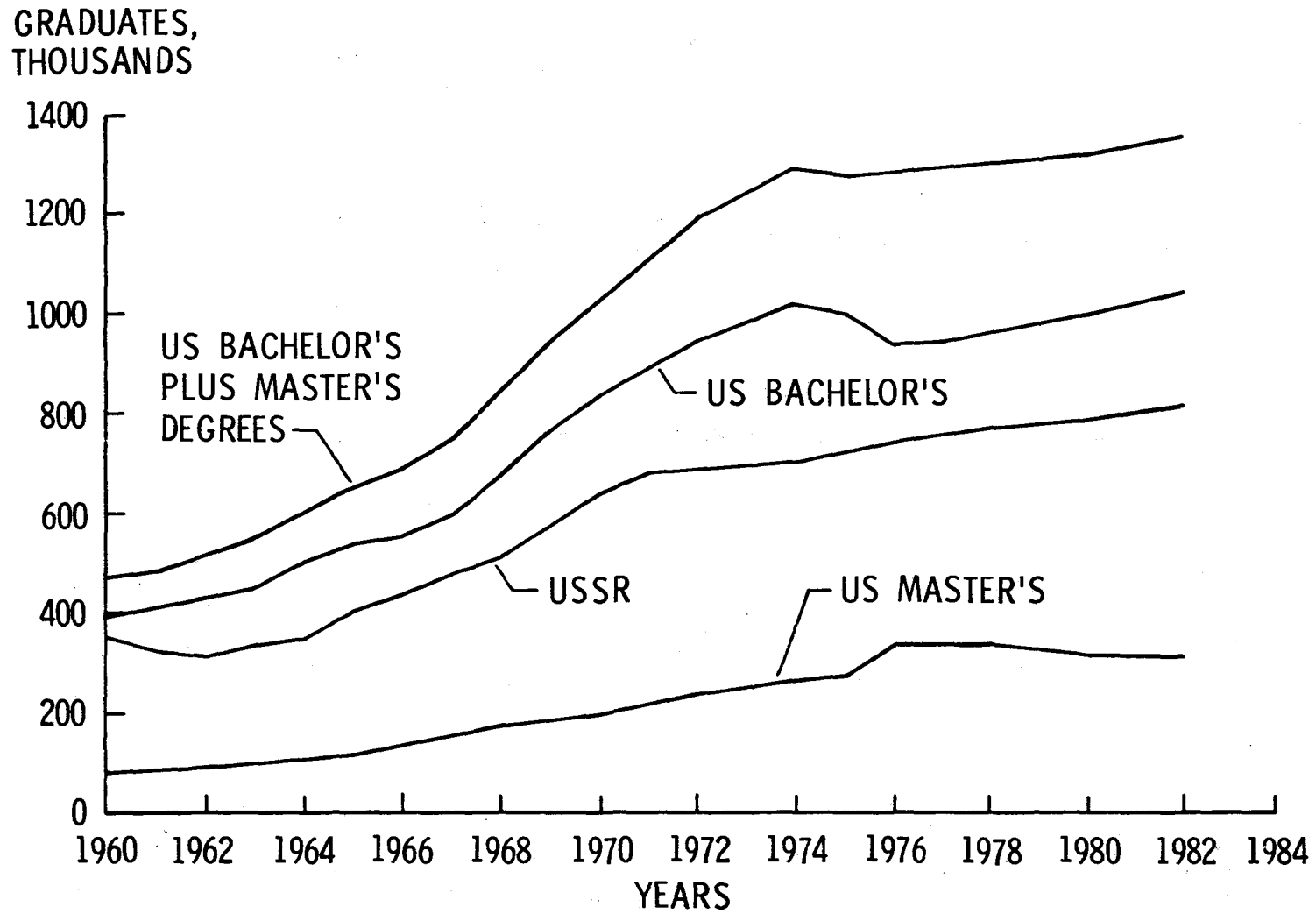


Figure 1.- US/USSR total higher education graduates.



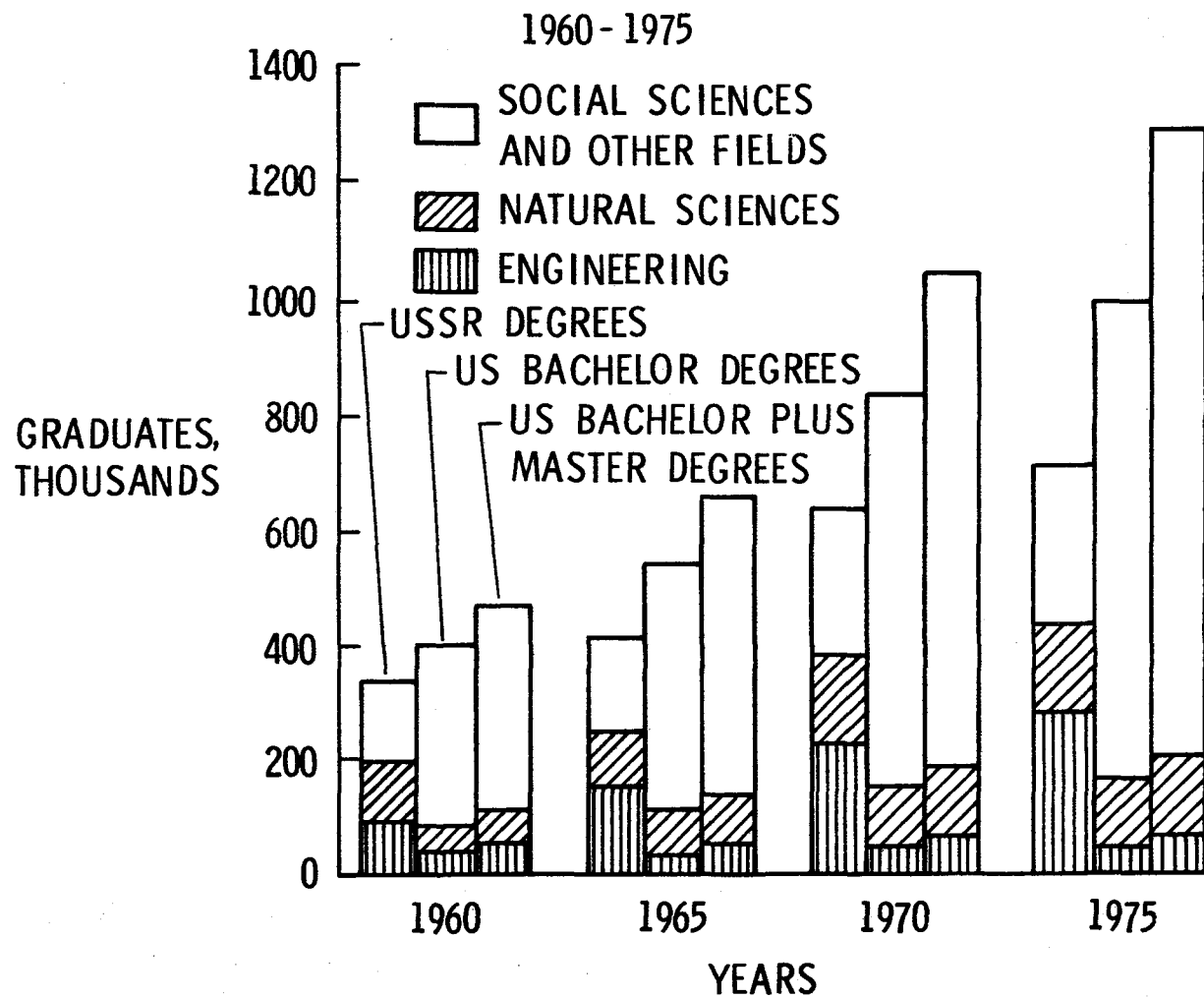


Figure 2.- US/USSR higher education graduates by specialization, 1960-1975.

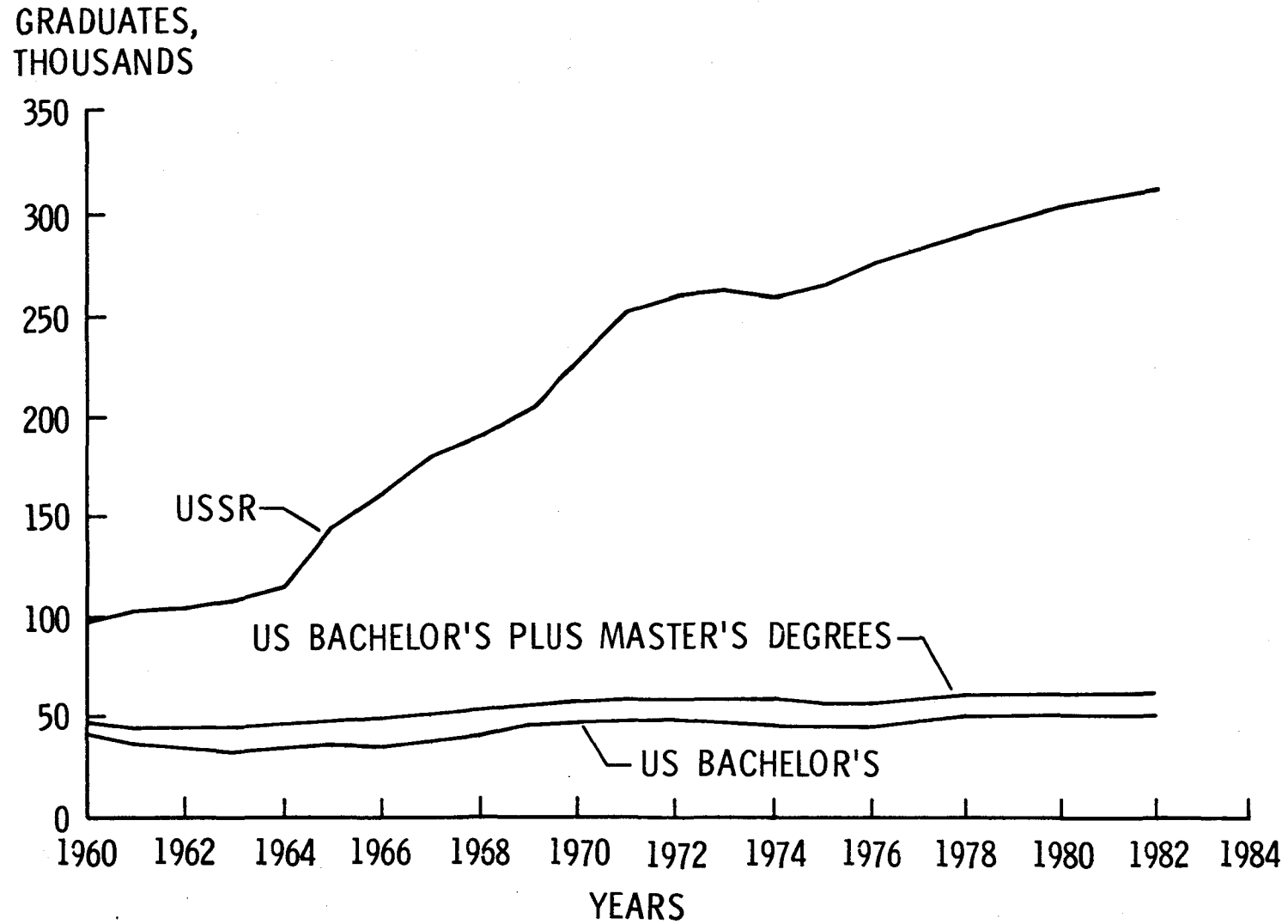


Figure 3.- US/USSR higher education engineering graduates.

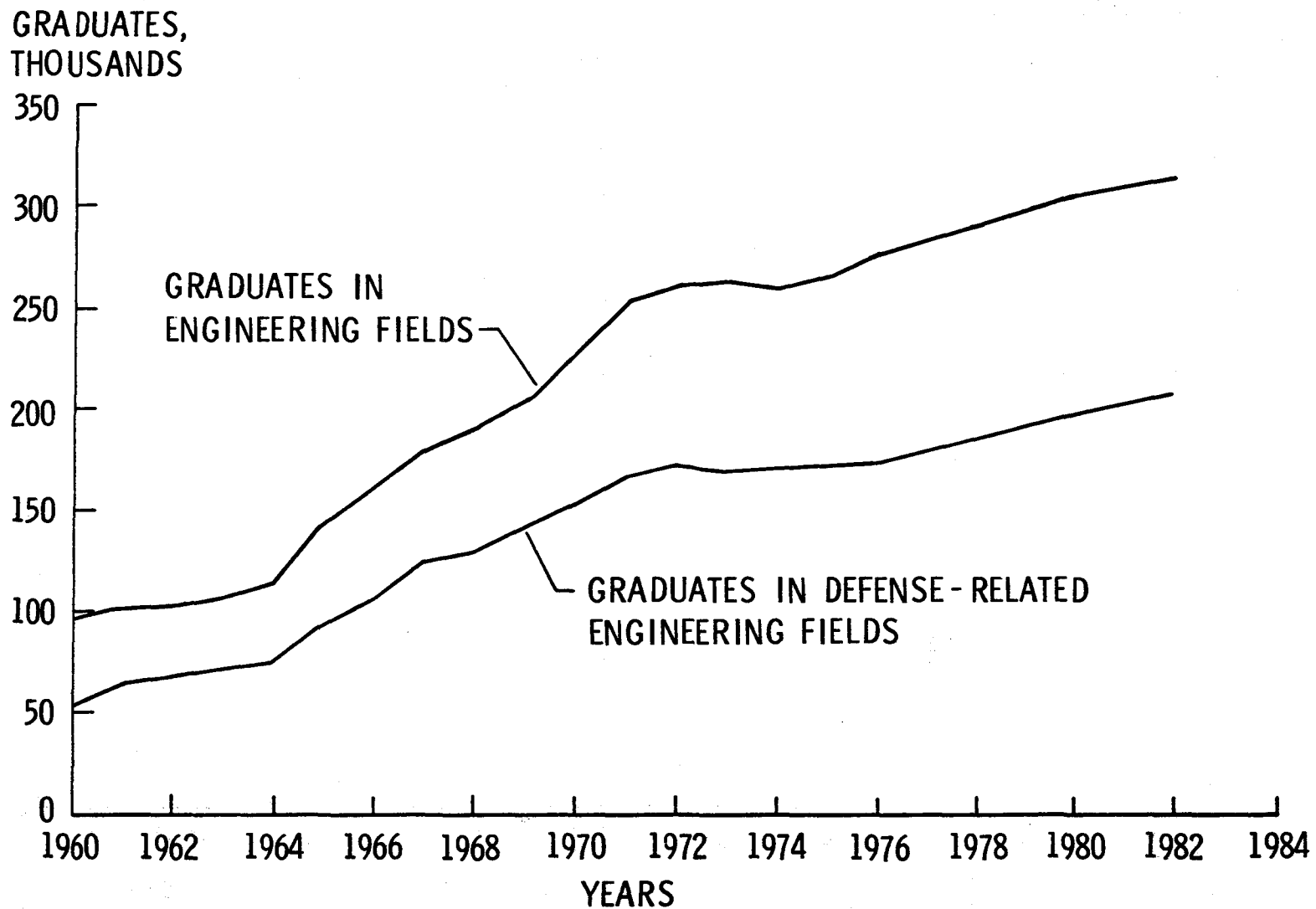


Figure 4.- USSR higher education engineering graduates in defense-related and other engineering fields.

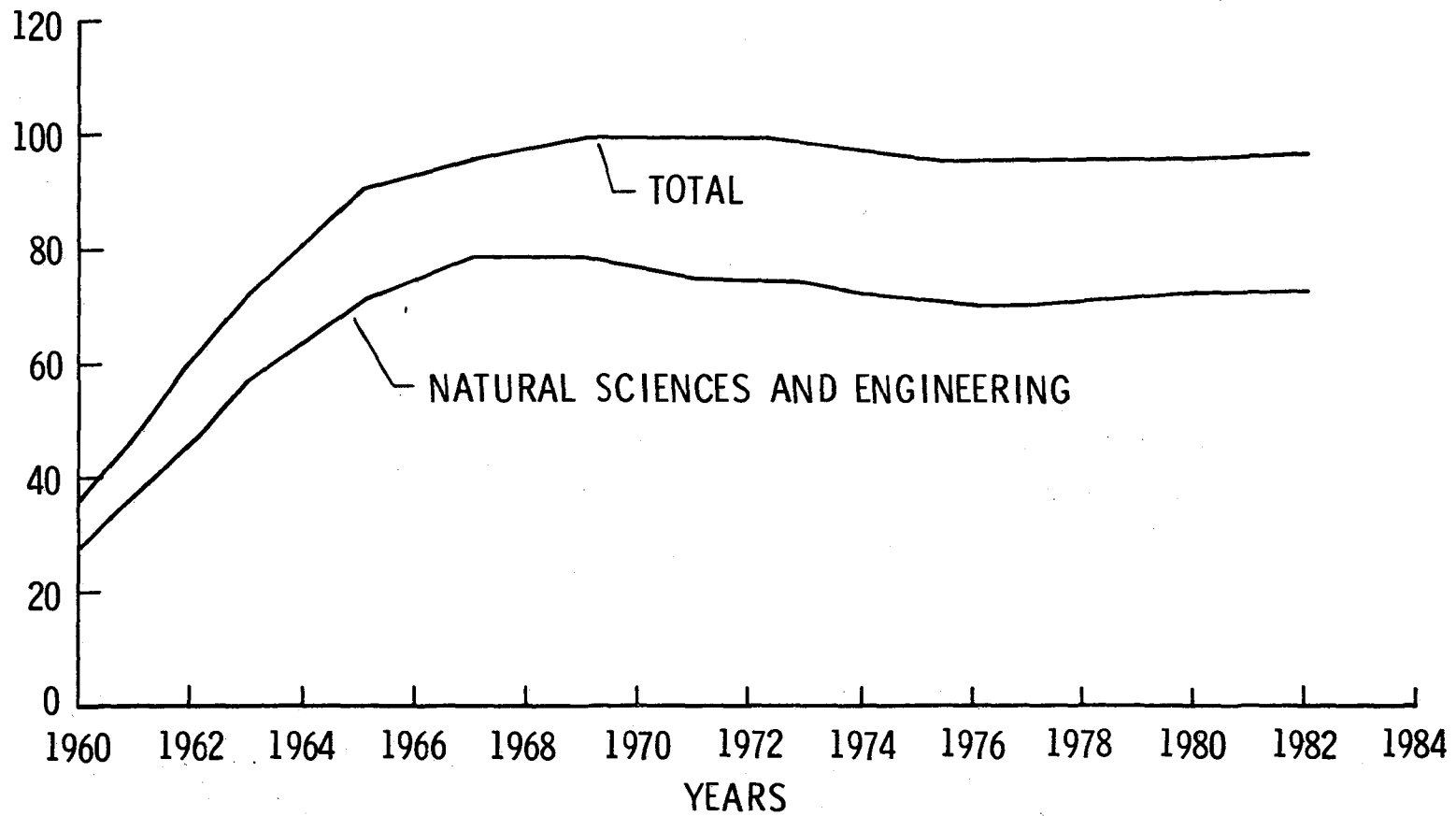
GRADUATE STUDENTS,  
THOUSANDS

Figure 5.- Soviet graduate education (first level)  
enrollment by specialization.



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