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Kappa Mu Epsilon, national honorary mathematics fraternity, was founded in 1931. The object of the fraternity is four-fold: to further the interests of mathematics in those schools which place their primary emphasis on the undergraduate program; to help the undergraduate realize the important role that mathematics has played in the development of western civilization; to develop an appreciation of the power and beauty possessed by mathematics, due, mainly, to its demands for logical and rigorous modes of thought; and to provide a society for the recognition of outstanding achievement in the study of mathematics in the undergraduate level. The official journal, THE PENTAGON, is designed to assist in achieving these objectives as well as to aid in establishing fraternal ties between the chapters.

THE OUTLOOK FOR WOMEN IN MATHEMATICS AND STATISTICS[1]

Women's Bureau, United States Department of Labor

The term "mathematician" is usually reserved for those who have a Ph.D. or its equivalent in mathematics and are engaged almost exclusively in research or in college teaching.[2] Engineers and those engaged in the physical sciences also need preparation in higher mathematics, which they apply to specific problems within their fields. This discussion, however, is confined to the mathematician, the mathematical and applied statistician, and others whose principal preparation for their occupation is college-level training in mathematics or statistics. Among them are actuaries, teachers of high-school mathematics, statistical clerks, computers, mathematical aids and assistants. Engineering aids and engineering draftsmen, similar in their requirement and use of mathematics, are discussed in the bulletin on engineering. (See Bull. 223-5.)

Although the exact number of mathematicians and of others engaged in mathematical occupations is unknown, some idea of the size of the total group may be gained from the maximum number registered with the National Roster of Scientific and Specialized Personnel during the war, in April 1944: those in the field of mathematics numbered 17,357; in statistics, 3,737; and in actuarial science, 839. Only 3 percent of the latter were women, while 12 percent of those in mathematics and 14 percent of those in statistics were women (*15*). Since registration with the Roster is voluntary, there is no way of knowing how complete or how representative these figures are. But these percentages of women members correspond to those in the principal mathematical societies. About 15 percent of the members of the Mathematical Association of America and about 13 percent

[2]In civil service and very occasionally in industry, however, the term is used also for the beginning professional level which requires the bachelor's degree with a major in mathematics.

of those of the American Mathematical Society are women. Approximately 10 percent of the members of the American Statistical Association are women, and 3 percent of the fellows and associates of the two actuarial societies are women (8). However, among high-school teachers of mathematics, estimated at some 40,000 in 1947, women are in the majority, and they predominate in the National Council of Teachers of Mathematics. Many of these are trained principally in education, rather than in mathematics, and they are probably not among those on the National Roster list.

Prewar Distribution

In 1940, according to an American Council on Education study, there were 695 living recipients of Ph.D. degrees in mathematics conferred in the preceding decade. Of the 647 who reported their occupation, 85 percent were teaching, and an additional 4 percent combined teaching and research. Less than 6 percent were engaged solely in research, and no other single type of work claimed as much as 2 percent of the group (6).

The exact number of mathematics teachers before the war is not known. But the first Roster count in December 1942 revealed that there were 3,483 mathematics teachers in institutions of higher learning; and 686, nearly one-fifth, of these were women (14). Mathematics was taught in some 28,000 high schools in the country (7). In many of these, there was only one mathematics teacher, who also taught one or more subjects; in others, there were several full-time mathematics teachers on the faculty, sometimes as many as 25 or even more.

The relatively small number of mathematicians in industrial research before the war is indicated by Thornton C. Fry's estimate that in 1940 there were about 150 mathematicians doing consultative work on mathematical problems in industry (4). The largest prewar demand for women trained in mathematics was reported consistently by college placement bureaus to be in teaching or as statistical clerks in insurance or other business firms. Mathematics

majors with special training in mathematical statistics or such applied courses as mathematics of finance, for example, were especially in demand. A few women, however, were employed even before the war in calculating or computing jobs with firms manufacturing such products as instruments and electrical equipment.

Some of this work was only arithmetical, and some women saw little difference, except in location, between their work as computers in an engineering department and that of cost clerks or calculating machine operators in the office. Several employers reported that they hired college mathematics majors not because of the need for higher mathematics on the job but because such training indicated accuracy and a liking for computing. However, even before the war, there were some exceptional women who were doing responsible mathematical work in industry. For example, one woman with a Ph.D. in mathematics from a large women's college has been engaged in research in the mathematical research department of a utility company for about 15 years. Although such cases are unusual, they indicate that opportunities do exist for the woman with ability.

In 1938, only 85 women mathematicians and statisticians were employed by the Federal Government (*16*). The Civil Service Commission reported that the demand for women mathematicians before the war was never great.

Annual Addition to the Supply

A small but steadily increasing number of persons took doctorates in mathematics before the war, and in 1940, 103 persons obtained Ph.D.'s in mathematics, the largest number in any one year up to that time (*5*). In the relatively new field of mathematical statistics, only 5 or 6 doctor's degrees were awarded annually before the war, according to recent estimates (*10*).

No figures are available on the number of persons receiving first degrees in mathematics in 1940. But the United States Office of Education reports the combined number of graduates with majors in mathematics and in

physical science in 1941-42 as 3,053, of whom one-third were women (*19*). In the same year, almost 1,000 people prepared to teach mathematics were graduated from colleges and universities, and about 45 percent of these graduates were women (*19*). For the most part, their degrees were from schools of education.

Wartime Changes

During the war there was a tremendous increase in the demand for women trained in mathematics in industry, in Government, and in research institutions working on Government projects. One women's college reported that every mathematics major had her choice of 25 jobs in industry or Government, and that the demand was overwhelming in research work. A coeducational university, which before the war had few outlets for mathematics majors except in routine calculating jobs, found many attractive jobs available to mathematics majors during the war, mostly in Government-sponsored research. This same story was repeated in a number of college placement bureaus throughout the country. There was a definite shift from the usual type of employment for mathematics majors in teaching and in clerical jobs in business firms to computing work in industry and on Government war projects.

Of 81 industrial firms visited by Bureau representatives near the end of the war or after its close, only 15, less than one-fifth, had employed college women in mathematical occupations during the war either in the research laboratory or in the plant, usually in the engineering department. Among them were gas and electric power companies, and manufacturers of transportation equipment, communications and other electrical equipment, instruments, metal and metal products. The foods, paper products, and chemical industries were also represented, but the principal employment of women mathematical aids or assistants, computers, and calculators (as they were variously called), like that of engineering aids, was found in the industries in which engineering and physical problems rather than chemical problems were paramount. None were found in the 18 commercial laboratories visited.

Since their work consisted primarily of assisting engineers or research personnel with calculations or of performing inspecting or checking operations involving computations, their duties varied from purely routine arithmetical work to the solution of difficult problems requiring the use of calculus and other forms of higher mathematics. Graph and chart making was sometimes involved. In an aircraft plant, for example, beginning "computers" read blueprints and made weight calculations on simple parts, using slide rules and calculating machines. More experienced computers employed in the same plant were working under the supervision of test engineers and assisted them by working out solutions of differential and integral equations, by plotting test data, and by preparing data sheets and charts. The only industrial establishment visited in which women were called mathematicians was another aircraft plant. The requisite training was 2 years of advanced college mathematics, or, for "senior" mathematicians, 4 years of training and experience. More routine work was done by technical computers, who were required to have at least 1 year of college mathematics.

On Government-sponsored projects farmed out to university and other private research laboratories during the war, like those carried on at the Radiation Laboratory at Massachusetts Institute of Technology and the Manhattan project work at the University of Chicago, women mathematicians, especially those who combined physics with their mathematical training, were employed in relatively small numbers, along with a larger number of computers with only the bachelor's degree. Because such demand was virtually nonexistent before the war, it made a sizable impression. Some women transferred from college teaching to this type of work during the war period.

The women's military services, especially the WAVES, in the early expanding phase of their programs, were particularly eager to recruit college graduates with training in mathematics and science. Approximately 1,500 college graduates, most of them with mathematics or science majors, became WAVES officers who were trained for

technical work in communications, air navigation, and aerology, often by other WAVES, whose earlier scientific training and teaching experience had resulted in their selection for such work.

A large group of the women became aerological officers and were engaged in meteorogical work. (See Bull. 223-7, on Meteorology.) Others were assigned to such jobs as instruction in air navigation and work in ordnance. One woman supervised naval personnel assigned to a ballistics laboratory; another worked on computations of ballistic range tables and bomb tables, making computations from penetration charts and of various problems of exterior ballistics. A few others were assigned to survey work in radio, radar, and electronics, checking specifications and obtaining information from radio companies for complete identification of radio parts.

Mathematician, computer, geodetic computer, and cryptographer were among the job titles of a small group of WAC personnel who had the needed mathematical background for such work. Those who had some statistical training worked as statistical clerks, financial clerks, and financial technical clerks (*23*).

In the Federal Civil Service, women trained in mathematics were sought for many jobs, beginning at the junior professional level, which required only the bachelor's degree with a major in mathematics. They were employed not only in the War Department (Ordnance, Signal Corps, Engineer Corps) and in the Navy Department, including the Naval Research Laboratory, but also in the National Advisory Committee for Aeronautics, the Bureau of Reclamation, the Federal Bureau of Investigation (as cryptographers), the National Bureau of Standards, and the Coast and Geodetic Survey. Special courses in mathematics were given in the Engineer Corps, Ordnance, and the Signal Corps, all in the War Department, to train needed personnel (*22*).

In Government, as in industry, the work varied from simple calculations to more complex assignments. Much of it was routine, but, as one research man long in Government service puts it, most mathematical work, no matter the

degree of difficulty, involves routine. However, the difference between the mathematician and the routine computer, according to a well-known woman mathematician, "is precisely in handling the nonroutine aspects of the problem * * *. The distinctive contribution of the mathematician is either in clarifying the structure of a problem which has confused the engineer or physical scientist, and formulating it in mathematical language; or in creating a new mathematical theory, or extending a branch of an old one."

The increased Government and industrial demand, plus the drafting of men into military service, resulted in shortages of qualified teachers. Early in the war, on the basis of reports from 1,060 colleges and universities in the fall of 1942, the United States Office of Education stated that mathematics was one of the subject fields in which there was a great number of vacancies, 57, on these college and university faculties (*17*).

The demand for statisticians and statistical clerks increased tremendously during the war. In 1944, the American Statistical Association had requests for more statisticians than it could supply, at salaries of $2,000 to $6,000 annually (*12*). College placement bureaus reported that women mathematics majors had their choice of a wide variety of jobs as statistical clerks or computers. The War and Navy Departments, medical centers, public health departments and agencies and other medical groups, as well as insurance companies, and at least one Federal Reserve bank were among the employers of recent trained statisticians.

A study of the employment of the members of the American Statistical Association in 1945 showed that the largest proportion of them, nearly two-fifths, were in Government, most of them in the Federal Government. Almost one-fifth were in colleges and universities, and another one-fifth were in manufacturing industries and financial institutions. About half of the members lived in two areas, the Washington, D.C., area and New York State, chiefly New York City. There was an approximately equal number in each of these areas (*8*). In the Institute of Mathe-

matical Statistics the proportion of members in academic positions was much higher; more than one-half of them were so employed (10).

The lack of teaching personnel made it necessary for some schools to curtail their course offerings in mathematics. This was especially serious for those who wanted to go on with advanced training, but who found that only standard mathematics courses were being offered (3).

The number of doctorates awarded in mathematics, never large, declined sharply during the war as prospective students were withdrawn into military service. More than 100 were earned in 1940; only 41 in 1944 (5). The number of persons receiving first degrees in mathematics and science also declined from 3,053 in 1941-42 to 2,709 in 1943-44. The number of women in the group, however, increased from 1,012 to 1,141 (19).

Under the special Engineering, Science, and Management War Training programs, a number of women were given special training in mathematics to equip them for war jobs in industry and Government, according to the United States Office of Education. Among these courses were: engineering mathematics and calculus, as well as such specialized applied courses as mathematics for aircraft workers, for high-school teachers, for engineering aids (18). In addition, approximately 3,500 production and inspection engineers and other industrial personnel, from over 800 of the larger industrial corporations, were trained in the use of some of the simpler statistical methods of quality control, in short intensive courses given throughout the country (10).

The wartime emphasis on sciences, particularly the physical sciences and mathematics, stimulated enrollments in regular college mathematics classes. Prof. G. B. Price, in a study of enrollments in mathematics courses for the Mathematical Association of America, found substantial increases in enrollment between 1941-42 and 1942-43. The increase was usually 30 percent for men's colleges and ranged from 25 to 40 percent in eastern women's colleges (3). But coeducational schools, with few exceptions, re-

ported little or no increase in the number of students taking mathematics. Despite the higher enrollment of women in mathematics courses, the number of women majoring in this field remained very small. Reports from 24 colleges and universities on women graduating with majors in mathematics indicated no abnormal fluctuation in the number of such graduates during the war period.

Earnings and Advancement

The earnings of a college graduate with a degree in mathematics depend upon the type of work that she does. They are low in the largest field, that of teaching, although they have been increasing recently. According to scattered college placement bureau reports, most of the beginning jobs in teaching and in business pay less than $2,000 per year; during the war, many beginning jobs in industry paid $2,000 or more per pear, and this was the beginning rate for mathematicians in Government. In 1947 the entrance salary in the Federal Civil Service for mathematicians and statisticians was $2,644 per year.

Teachers' salaries vary considerably, not only in different sections of the country but also in cities of different size. In 1940-41, the median salary of $2,768 paid to high-school teachers in cities having a population over 100,000 was nearly twice as large as the $1,428 received by those in cities of 2,500 to 5,000 population. By 1946-47, the median salary of teachers in the largest cities had increased to $3,593. For those who taught in cities whose population was 2,500 to 5,000, the median salary in that year was $2,274. Although the difference between the earnings of teachers in the largest cities and those in the smallest cities was less in 1946-47 than in 1940-41, nevertheless it remained a substantial one (9). According to the United States Office of Education: "The median salaries of professors in different types of publicly controlled institutions ranged in 1939-40 from $2,900 to $5,000, and in different types of privately controlled institutions, from $1,800 to $5,000. Associate and assistant professors, and instructors, on an average, received less" (20).

Statisticians, at the Ph.D. level, are paid somewhat higher salaries than are mathematicians. This is partly a result of their scarcity. Only about 50 Ph.D.'s in mathematical statistics have been awarded so far, according to a recent estimate (10). It is also due in part to a difference in type of employment. Most persons who have the Ph.D. in mathematics teach in colleges and universities, where salaries are relatively low. On the other hand, professional statisticians are more likely to be employed in industry or in Government, often at higher salaries. This is particularly true of actuaries. At the bachelor's level, salaries are more nearly equal to those in mathematics, although the opportunities are broader for the graduate trained in mathematical and applied statistics.

Women mathematics majors with the bachelor's degree sometimes become statistical clerks, whose jobs usually pay about the same as those of computers. Although salaries for statistical clerks with college background were as low as $1,000 per year before the war, in 1946 placement bureaus reported that mathematics majors were being hired as statistical clerks by State agencies and private industry at $140 and $150 per month, or about $1,680 to $1,800 per year.

Except for Ph.D.'s women trained in mathematics tend to be employed at the assistant level. In the industrial establishments and in the Government agencies visited in connection with this study, only a few women mathematicians were found in high-level jobs, and they usually had also specialized in one of the physical sciences. However, one woman in industry was supervising a large group of women computers; another was found on independent research work of a Government research project. In the teaching field, women are appointed to college faculties, but only a few reach the professorship level. They seldom become heads of departments, either in colleges or in secondary schools, except in colleges and schools for women. That it is possible for competent, well-trained women to attain positions of responsibility is indicated by the achievements of a few. Listed in the 1938 edition of American Men of

Science, among the 80 mathematicians who have made outstanding contributions to scientific progress, were 4 women (*2*).

Because there are many more outlets for statisticians and because there is a shortage in this field, advancement is usually more rapid for qualified women in statistics than in mathematics. The possession of the Ph.D. is important for recognition in this field, too. Because of their background and understanding of the insurance business, men actuaries frequently move into high executive positions in insurance firms (*1*), but this is seldom true of women.

Organizations

Among the largest professional mathematical societies are the Mathematical Association of America, the American Mathematical Society, and the National Council of Teachers of Mathematics. Each of the first two groups has more than 3,000 members. The teachers' group has about 6,000 members, most of whom are women. Most of these have mathematical training, although there may be some who do not, since the only requirement for membership in all of these groups is an interest in mathematics.

There are a number of professional societies for statisticians, some of them confined to the special fields in which statistics is applied. In addition to the Institute of Mathematical Statistics, which includes statisticians interested in statistical theory and technique, there are, for example, an Econometric Society and a Psychometric Society, whose members have specialized in statistical measurements in the field of economics and psychology respectively. All of these are of comparatively recent origin and have had a great increase in membership in a relatively short time. The American Statistical Association is an all-inclusive group, which in 1946 had some 4,000 members, about 10 percent of them women. The Institute of Mathematical Statistics, organized in 1935, had about 900 members in 1946; interest in statistics is the only requirement for membership in the Institute as well as in the American Statistical Association (*10*). Membership in the principal organizations of actu-

aries, the Actuarial Society of America and the American Institute of Actuaries, on the other hand, is restricted to those passing a series of examinations given jointly by the two societies. Candidates become associate members upon passing five examinations and full members or fellows after passing 3 more. In these two groups combined, in which the membership is largely duplicating, there are only about 565 fellows, including actuaries in the United States and Canada. There are 562 fellows and 301 associates of the Actuarial Society, of whom 12 fellows and 11 associates are women.

The Outlook

Although, during the war, production firms and Government projects were important outlets for women trained in mathematics, the emphasis, following the end of hostilities, shifted back to the more usual channels. Teaching and employment with insurance and other business firms again became the principal outlets for women college graduates with mathematical training. The wartime shortage of high-school teachers has continued, particularly in mathematics and certain other fields (*20*). Placement officers throughout the country in 1947 noted a continuing demand at the wartime level for women mathematics teachers in secondary schools. At least 40,000 teachers of mathematics were teaching in junior and senior high schools in 1947, according to the chaiman of the Commission on Postwar Plans of the National Council of Teachers of Mathematics. The preponderance of women in this organization is indicative of their numerical importance in high-school teaching. Because men appear to be leaving this field, it will become increasingly important for women.

Most high-school teachers give instruction in more than one subject, and existing teaching vacancies can often be filled only by persons proficient in several related fields. Certain subjects tend to be grouped together. Since mathematics teaching is usually combined with that of the physical sciences, the woman who plans to teach high-school mathematics will have wider opportunity if she is also able

to teach high-school science, particularly physics or chemistry.

In colleges and universities, too, opportunities for women mathematics teachers continued. The secretary of the American Mathematical Society stated in 1946 that there were not enough well-trained women to fill all the first-class mathematical positions available to them in colleges and universities. Some graduate work is practically essential for appointment to college faculties, and, before the war a Ph.D. was considered necessary to attain professorial rank. However, the Women's Bureau found, in 1947, that of a sample of women with the rank of assistant professor or above in mathematics, less than one-half had the Ph.D. Shortages will probably continue in this field for several years; but as more persons with the Ph.D. become available it will become more difficult to attain professorial rank without it. A report to the President in 1945 predicted that there will be, due to the war, a total deficit of 1,200 Ph.D.'s in mathematics by 1955 (*21*).

Most of the wartime research projects sponsored by the Government were dropped after VJ-day. In the few that continued, the small number of mathematical jobs were filled by the staffs of the institutions at which the research was being done and by men with mathematical skills who were being released from military service. The women's military services, which utilized women with mathematical training during the war, were reduced to very small staffs. One, the SPARS, ceased to exist, and the continuance of the others will depend upon the passage of special legislation. In any case, only a few mathematical jobs will be found in peacetime in these agencies.

Federal civil-service demand for women mathematicians continued after the war. In 1947 a few women mathematicians were still employed in such agencies as Ordnance in the War Department, the Naval Research Laboratory, the Coast and Geodetic Survey, the National Bureau of Standards, the National Advisory Committee for Aeronautics, and the Tennessee Valley Authority. It appeared that the demand from the Federal agencies would continue for

some time to outstrip the supply of those qualified. At the National Bureau of Standards there were almost as many women mathematicians employed in 1947 as there were during the war. On the other hand, at the Coast and Geodetic Survey, women were being displaced as men veterans returned. The Federal Bureau of Investigation, also, had already dropped many of the women who had been hired for cryptographic work during the war.

Women mathematicians and computers in 1947 were working on the National Bureau of Standards mathematical tables project, located in New York. In the spring of 1947, this project employed seven mathematicians, excluding the Director; three of them were women, two of whom contributed work on a research level. There were also 24 women computers, about two-thirds of all the computers on the project. However, in 1946, most of the vacancies on the computing staff had been filled by male veterans. Turnover is low, and it is not expected that there will be many openings for men or women computers there in the near future.

In industry, 14 of the 15 establishments covered in this study that had women mathematical workers on the pay roll during the war continued to employ some of them following the war. The number of women in mathematical occupations in these firms even during the war was small, seldom over 25, although one very large corporation employed about 100 women in mathematical work. These were computers doing calculations for the technical staff; some of them have been employed in these same jobs for many years.

Most of the industrial jobs available to women will continue to be in computing, but this demand is almost negligible as compared with that during wartime. Calls from industry for women trained in mathematics were reported to be rare in 1947. A large aircraft company, for example, which during the war asked one college for 100 or more women at a time, was asking for groups of only a half dozen after the war's end.

Some of the employers expressed a preference for men, although they planned to retain the women mathematical workers they had hired during the war. As the women leave, however, men will be hired to replace them. College placement officers also reported that some well-qualified graduates had been dropped from industrial research jobs held during the war. Although many women are continuing on their wartime mathematical jobs, it is difficult to say how much of the gain will be in terms of permanent opportunities for women. Much depends on the success of those who remain on the jobs which opened up during the war.

From 1940, when there were in industry about 150 mathematicians trained to or nearly to the Ph.D. level, to 1947, there was an appreciable increase in such personnel, according to the statement of a prominent research mathematician in the communications industry. Not only is normal industry research going forward, but a considerable amount of postwar military research is continuing, partly in industry, partly in Government laboratories, and partly in universities. Many of the mathematical questions raised in this type of research are akin to those raised in normal industrial research. A substantial number of mathematicians are engaged in this work, although few of them are women.

Although the demand for highly trained mathematicians in industry will increase, scientists seem to agree that it will never be comparable in volume to that for engineers, chemists, or physicists (4). Opportunities for the woman Ph.D. in industry are few compared with those on college faculties. However, entrance into industrial research will be easier for women Ph.D.'s in the next few years than it is likely to be later when a greater supply of men with the doctorate will be available.

Employers complain frequently that men as well as women with degrees in mathematics enter industry with no knowledge of applied mathematics or of the problems and the terminology of the industry (24). Women who want a career in mathematical research in industry can increase

their opportunities by taking some engineering or other applied courses that will increase their understanding of the practical problems requiring mathematical solutions in industry. For consulting or research work in industry, a Ph.D. degree and a knowledge of the industry are essential.

Although the United States assumed world leadership in pure mathematics between World War I and World War II, mathematicians in this country have tended to ignore applied mathematics, and not much emphasis has been placed upon it by institutions of higher learning. But the wartime situation emphasized the importance of applied mathematics, which was used in the solution of problems relating to aircraft design, explosion theory, exterior ballistics, and nuclear physics, among others. Partly as a result of its prominence during the war, universities are giving somewhat more attention to applied mathematics than formerly. There is a School of Applied Mathematics at Brown University and an Institute of Mathematics and Mechanics at New York University; and other universities are offering courses in this field. In addition, it has been proposed that a unit, to be known as the National Applied Mathematics Laboratories, be established as part of the National Bureau of Standards. The purpose of the unit is described by the Bureau as follows: "It will specialize in numerical and statistical analysis, and will undertake to offer various services in these fields, and carry on a broad program of research and training. Particular emphasis will be placed on the development of high-speed automatic computing machinery and the mathematical theory needed for its effective use." The projected program for the laboratories also includes a training program, to consist of instruction and work experience, for graduate students in applied mathematics.

The industrial demand for statisticians, which increased tremendously within recent years, especially in the last decade (*10*), appears to be continuing. This growth was further stimulated by the wartime use of statistics in statistical control work and in planning. Sampling methods, for example, developed by mathematical statisticians,

made it possible and safe to substitute inspection of only one of a number of units produced in a war plant for the inspection of every unit. The saving of time and manpower was tremendous. This is only one of the many applications of statistics that has resulted in accelerating the demand for statisticians.

The National Roster of Scientific and Specialized Personnel reported that, in a 9-month period in 1945-46, for every 1,000 persons registered in statistics, there were 30.7 vacancies reported to the Roster, as compared with 4.4 vacancies per 1,000 registrants in mathematics and 23.9 in physics. The openings in statistics were divided about equally between industry and Government; there were none from colleges, which usually recruit directly (*10*).

The postwar demand for statistically trained personnel was studied by the National Research Council's Committee on Applied Mathematical Statistics, which in April 1946 made an inquiry concerning requests for statisticians received by 30 leading authorities in this field. Although undoubtedly some of the requests were duplicating, their number and type illustrate the demand. About 140 requests were received from business and industry, most of them to fill positions in industry quality control and in engineering, but there were also many for sampling experts in market research organizations. The educational requirements ranged from the bachelor's degree to the doctorate (*10*).

Almost as many requests, 135 in all, came from academic institutions for persons with Ph.D.'s in mathematical statistics, or in such fields as agronomy, biology, economics, or psychology, if combined with a minor in statistics. The positions offered ranged from instructorships to full professorships. One of the 30 authorities reported 12 requests for men trained in agronomy and statistics; another had received requests for mathematical statisticians from 21 colleges and universities (*10*).

Women mathematics teachers in 1947 numbered 355 in 330 colleges and universities which comprise a United States Office of Education enrollment sample of the 1,749 institutions of this type in the United States. Most of them,

304, were teaching mathematics only; the others were instructing in some other subject as well. If these institutions are as representative of the faculties of all institutions of higher education as they are of enrollments, 1,710 women college teachers of mathematics were employed in 1947, 85 percent of whom taught mathematics only. The others usually taught a science, such as physics or chemistry, but sometimes a language, or economics, or some other subject was combined with mathematics in the teaching schedule. A very few combined the duties of counselor or dean with mathematics teaching. Two women included in the sample headed mathematics departments. Unlike women teachers in some of the sciences, women mathematics teachers were found in all types of institutions, in larger universities as well as in women's colleges.

Government was also represented among the requests for statisticians reported by selected authorities to the National Research Council's Committee on Applied Mathematical Statistics. Approximately 90 requests for statisticians came from Federal and State government agencies in a 6-month period. Most of these were from the Federal Government (*10*).

In the fall of 1944, David M. Schneider made a survey of 164 governmental agencies in 23 States, representing all areas of the country. He estimated that State agencies needed, at that time, a total of over 600 statisticians and nearly 1,100 statistical clerks. This included both current employed personnel and vacancies. Since there has been a trend toward greater utilization of statistical personnel, it is likely that the total need in State agencies is at least as great as it was in 1944. State departments of labor employ the largest number of statistical clerks; public welfare departments and health departments rank second and third in employment of statistical personnel, who are also employed in State departments of highways, agriculture, taxation, education, banking and insurance. Comments from the States indicated that, although practically all municipal governments perform some statistical functions, few technically trained statisticians are employed for such activities (*11*).

According to the National Research Council, in recent years the growth in statistical opportunities has been especially great in the fields of: (a) industrial statistics (quality control, research, and development); (b) research in the biological sciences; (c) collection and analysis of government statistics; (d) market research and commercial sample surveys; and (e) psychological testing (10). However, there are jobs for statisticians in many and varied fields, including that of teaching to prepare additional needed statisticians.

The 1947 count of women faculty members in 330 institutions of higher learning, as mentioned previously, revealed only 10 women teaching statistics and 3 teaching biostatistics in these schools. This would indicate that there are about 45 women teaching statistics primarily in all colleges and universities, two-thirds of whom are in publicly and private controlled universities and the others in technical and professional schools. There are probably a great many more who teach statistics courses along with other subjects such as economics or mathematics. These would not show in the count, since such faculty members would be listed as instructors or professors of economics or mathematics.

For at least a few years to come, then, there will be ample opportunity for statistically trained women, who will not encounter as much discrimination in this relatively new and growing field as women in many other professional fields have had to combat.

The inadequacy of present facilities and teaching personnel for the training of statisticians has received attention in a special study of the Committee on Applied Mathematical Statistics of the National Research Council. In 1946, only 10 colleges and universities were reported to have programs in mathematical statistics adequate for the training of Ph.D.'s (10). Among the schools at which outstanding work is being done in this field are Princeton, the University of California, Columbia, and Iowa State College. Another school which has recently emphasized this field is the University of North Carolina, where an Institute of

Statistics is directed by Prof. Gertrude Cox. Only 14 institutions, including most of the 10 that were prepared to offer the Ph.D. in mathematical statistics, were equipped also for advanced training in applied statistics (*10*).

For Government workers and others living in Washington, D.C., a variety of courses in statistics are offered at the Graduate School of the United States Department of Agriculture. Evening classes are held, and in addition to classwork, students can get experience in sampling at the Bureau of Census and other agencies.

A specialized group of statisticians are the actuaries, whose opportunities are limited chiefly to insurance companies, although there are expanding opportunities for them in business and industry, because of the increasing trend toward pension and retirement plans. In addition, there are jobs in many State insurance departments, which supervise and regulate the insurance business, and in such Federal agencies as the Bureau of the Census, the Social Security Administration, and the Railroad Retirement Board. There are also occasional calls from Latin-American and other foreign countries for American-trained actuaries. In spite of the limited number of organizations which employ actuaries, this field is not overcrowded. There are over 350 life insurance companies in the United States and Canada; most of them are growing in size, and their business is becoming more complex. There are only about 565 fellows of the Actuarial Society of America and the American Institute of Actuaries, and many more are needed (*1*). "In the next few years the 350 insurance companies in the United States will require several hundred more actuaries than they now have," according to the Committee on Applied Statistics of the National Research Council (*10*).

Those who plan to enter this profession usually major in mathematics but often study economics or business administration in addition. They frequently take the first three of the eight examinations necessary to qualify themselves as Fellows of the actuarial societies while they are in college, taking the other examinations later while employed,

usually with an insurance company (*1*). Only the woman of superior ability should be encouraged to take the very difficult actuarial examinations, which only a small proportion of the candidates pass.

Although women fill most of the clerical jobs in insurance offices and some become actuaries' assistants, they rarely become actuaries. One young woman who worked as an engineering aid for an aircraft company during the war and had excellent recommendations from that company was recently hired by a firm of consulting actuaries and hopes to become an actuary. But insurance companies have traditionally preferred men for these positions, and only the exceptional woman will pass beyond the position of assistant to an actuary. Two women, one of them a Negro, are actuaries of small companies, although others have reached the mid-ranges of associate actuaries and mathematicians in larger companies. This is a field in which women must have unusual ability to succeed. A prominent actuary says that, "A woman can succeed in this field, but she has to be 50 percent better than her nearest male competitor to do it." An outstanding woman who has combined actuarial training with a Ph.D. in economics suggests that the woman actuary's best chance for success lies in doing the unusual, in finding a relatively unexplored area and specializing in it. She attributes her own success to her ability to handle problems which a person trained solely as an actuary or solely as an economist would not be prepared to handle.

Although the shortage of Ph.D.'s in mathematics and statistics is expected to continue for some time, there appeared in 1947 to be a satisfactory adjustment in the demand for and supply of women with the bachelor's degree in mathematics. According to reports from college placement bureaus, even before the war, the number of women mathematics majors graduating from college each year, although small, was just about enough to meet the demand for people with such training. Recent reports indicate a return to this tendency to equilibrium following the wartime distortion. But the shortage of statisticians, train-

ed at both the bachelor's and the Ph.D. level, will continue for some years to come.

Women as well as men who have the capacity to do doctoral work in mathematics, however, are needed in greater numbers than ever before, and training is readily available in a number of institutions of higher education. Theoretical mathematics is basic to scientific progress, and the ability to contribute to knowledge in this field is so exceedingly rare that an oversupply is almost inconceivable.

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WHAT ABOUT HIGH SCHOOL TEACHING?

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Because of adverse publicity, some individuals are missing an opportunity of entering a field of endeavor which would be a satisfying life experience. Like other professions, teaching has its bright spots as well as unattractive phases but the general public is inclined to cast its eyes on the mediocre teacher and exclaim, "Not for me!" We grant there is too high a percentage of teachers who have settled into a deep rut and have lost their enthusiasm for teaching; however, the bright, ambitious college student should set his sights on the conspicuously successful of this calling. The profession will then look quite different to him. Teaching as a life work can run the gamut from a dull, numbing, tiring, futile experience to that of an exciting, interesting, gratifying and worthwhile career. A number of factors must be considered when one is contemplating teaching as a lifetime work. Therefore let us look at the situation with open eyes and minds.

There are two reasons for embarking on any career: one is self, the other, society. A profession must be satisfying in both respects if the normal, intelligent human being is to live well and happily. Obviously, employment should offer some degree of security and comfort to the worker and, in turn, the worker should contribute to the well being of society in general if he is to feel wanted.

Assuming that an individual is interested in teaching as a career, the first problem to investigate is the necessary technical qualifications. The department of education of any collegiate institution is equipped to supply this information. Since states vary in their educational requirements, it is safer for the prospective teacher to secure such information for neighboring states as well as for his own to avoid the possibility of some attractive position being closed to him because of lack of fulfillment of necessary requirements.

During the depression of 1932-33, if one wished to teach he took the first offer which came his way and asked no questions because this might be his only chance. The tables have turned. Now there is such an acute shortage of well-prepared teachers that the applicant, as well as the administrator, finds himself in a position to be able to ask a few questions.

Some of the points which should be considered by the applicant follow: (1) What is the size and number of classes? Overcrowding would lead to a frustrating experience. (2) Is there provision for the exceptionally slow pupils? exceptionally bright? Or must one try to find a vocabulary and mathematical experience which will span this wide gap in student ability? (3) What kind of person is the department head? Is he the type of individual for whom it would be pleasant to work? Does he distribute the good classes and poor classes among people of his department or does he reserve all the interesting ones for himself and have most of the fun? (4) In what type of community is the school located? Is it composed, at least in part, of the type of people with whom one can be happy and contented? Does the area offer some opportunities for personal living which the prospective teacher enjoys? That which is attractive to one individual might not be to another. This depends upon whether one likes city life and the opportunities peculiar to it, or organizing Four H Clubs, or fishing. (5) What are the local living conditions? Does housing shortage necessitate inadequate living arrangements? (6) What can one reasonably expect in the matter of salary and increases? Is the local school board generous and understanding or is it rife with politics? (7) What are the state and local pension plans?

All of the above points should be taken into consideration when one is deciding upon a permanent position, but some are relatively unimportant for the first three or four years of teaching. It is much more essential that the school give an opportunity for work with the right kind of people and for success and happiness in service than that the salary schedule and pension plan be ideal. These two points

may be considered more seriously when one has successful experience to offer along with other credentials. No school system will be perfect in every way, but there may be a vast difference between the possibility of a happy and useful experience in two schools apparently alike on the surface.

Three rumors have done much to discourage people from entering the teaching profession. These rumors are (1) low salaries, (2) taboos, and (3) long hours.

Salaries are still low. They are out of line with the incomes of garbage collectors, janitors, and dock hands in most communities, but the shortage of well-trained teachers is forcing substantial raises all over the United States. This shortage is becoming critical. The law of supply and demand is beginning to operate. Furthermore, many mathematically trained persons are being drawn into government work and industry, causing further shortages. True, one will never become rich on a school teacher's salary but adequately paid positions are on the increase.

In the past, far too many communities have set their teachers apart as being some sort of strange creatures who should never do anything the most conservative of the community wouldn't do. Consequently, teachers have felt shut off and not accepted socially. Even their children were looked upon as something only once removed from the hall of curiosities. Definitely, these taboos no longer exist in metropolitan areas, and are disappearing rapidly from the smaller communities. Local residents are beginning to understand that if they don't want their children taught by women with plain white handkerchiefs and black cotton stockings, they must provide opportunity for their teachers to live normal lives. Why, a few years ago, if a teacher in a small community admitted that he belonged to a political party, he was branded as a propagandist and considered to be a bad influence upon the young. Now, except in a few backward regions, teachers are expected to take their rightful place in the political life of the community.

Overwork. Unfortunately, this still operates in all too many communities. Local leaders expect the teachers to do more than their share to carry on community campaigns,

plan and execute excursions, run week-end parties, keep children off the streets, and assume too much responsibility for their manners and morals. Some constructive work is being done on this problem, although results are not generally as satisfactory to date as with the two preceding problems.

Every teacher should have a good sense of humor and physical stamina. The former rarely exists without the latter and both are necessary to the well being of the teacher when adolescents become a nuisance. This lighter touch is the prize asset of a well-adjusted individual in general, of course, and the teacher in particular. Heaven help the teacher who is tense and can't enjoy the funny little things which happen every day, and be entertained by them.

One very important aspect of high school work is that a teacher must live amiably with other adults. As large a part of the frustration and unhappiness in teaching comes from the inability of the teacher to work agreeably with his colleagues as from the lack of spark in the actual classroom work. For the sake of the inexperienced teacher, a comment here might be useful. Any teaching staff will be composed of several types of individuals, from those who irritate to those whom one likes and admires. Professional ethics dictates that an individual should refrain from criticizing another teacher or administrator. This is a sound plan to follow. One can be enthusiastic and friendly, but at the same time very discreet with co-workers, thus avoiding difficult situations.

The foregoing remarks would apply to a prospective teacher of any subject in a standard high school. Now let us proceed to consider the qualifications of a teacher of mathematics, in particular. First he must be competent in mathematical capacity and training. Knowledge of mathematics should be broad and substantial. The prospective teacher must have a major in collegiate mathematics if he is to be able to point up the high school work properly and know what to emphasize. Theory of equations, history of mathematics, college geometry along with college algebra, trigonometry, analytic geometry and calculus are essential.

A course in college geometry is especially useful. This course is strongly recommended since (1) most of the collegiate courses in mathematics give excellent practice in the use and theory of algebraic principles but neglect the finer points of geometry and (2) geometry is infinitely harder to teach in high-school than algebra. Added to the above specific requirements, one should continue to study, review text books, read standard mathematics periodicals, watch for practical applications of mathematics in other periodicals and in the operation of industrial concerns and business houses. Acquaintance with the literature of mathematics should be a part of one's equipment also.

A broad cultural background is necessary these days if a teacher is to place his subject in proper perspective with reference to the rest of the curriculum. He should exhibit interest in many fields not allied to his subject. This general interest helps the teacher to greater popularity and influence with his colleagues as well as with the parents.

On the bright side of our consideration, teaching mathematics in high school can be a very pleasant, satisfying occupation. It affords one a chance to work with interesting, stimulating people. Employment is steady and assured. In fact, many states now have tenure laws. In particular, there is opportunity for the teacher with imagination to experiment with different materials and procedures. Watching the development of mathematical thinking on the part of the pupils from day to day and following the successes of these students later in college, graduate schools, and life afford one rewards which cannot be measured in any tangible fashion but exist nevertheless. The feeling of having contributed to the growth of an intelligent, useful generation cannot be matched for satisfaction in very many lines of endeavor. If one likes adolescents, is intrigued by mathematics, and thinks he would enjoy teaching, then the position of instructor of mathematics in a good high school offers a great opportunity for happy living and service and affords opportunity for an enjoyable place in the social order. It is a great experience if one likes it; if not, pray do something else!

PYTHAGORAS: MATHEMATICIAN AND PHILOSOPHER

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The histories of mathematicians and of philosophers might be thought of as surfaces which intersect in the lives of many men. Pythagoras was the first man to make the study of geometry part of a liberal education and he was something of a philosopher. Plato, who first developed a complete philosophy, was more mystical and poetical than mathematical, yet he wrote over the door of his Academy, "Let no one enter here who is ignorant of geometry." Aristotle, the founder of Formal Logic, was mathematical and scientific in his thinking. Euclid, a sort of neo-Socratic philosopher, organized all the existing geometry into a logical chain. To mention a few modern philosophers, consider that Descartes was the father of modern philosophy and of analytic geometry; Spinoza used a geometrical method frequently, proving the existence of God mathematically; Leibniz, the co-discoverer of the calculus, was accounted a philosophical genius; Kant made geometrical space a part of mind; and today Bergson makes mind entirely spatial, speaking often of "natural geometry."

Much has been written on the philosophy of mathematics, but little has been written about the influence of mathematics on philosophy. Yet it seems evident that a man could not at once be a good mathematician and a good philosopher without the one influencing the other.

Today, philosophy is a subject of which many of us are afraid—we are not quite certain what it means and are like the practical engineer who ran whenever he saw an integration sign. It is true that philosophy is burdened with many difficult systems and has much confusing terminology, but still no subject is more thought provoking and fascinating. Perhaps, though, one does not wish to think, preferring to be a happy pig rather than an unhappy Socrates.

At all events, the study of philosophy makes one think because it shows him the thoughts of those who have probed deeply into the problems which confront him. Philosophy is a synthesis between branches of knowledge, or rather a criterion by which one may find Truth when he is plunged into a sea of facts and sensations. To be able to philosophize or even to think well, one must draw out of a mass of details a few essential guiding principles and deal with those principles. Is not this exactly what the mathematician does in his ceaseless search for general deductive principles, or even when he represents unknown quantities by means of letters? Mathematics may be thought of as a logical shorthand by which ideas are dealt with symbolically. It seems natural that when a man understands mathematics, he has at his command a method which can readily lead him into philosophy. Galileo expressed the idea very well when he said, "Philosophy is written in the great book which ever lies before our eyes—I mean the universe—but we cannot understand it if we do not first learn the language in which it is written. This book is written in the mathematical language."[1] David Eugene Smith expressed the same idea in a slightly different way: "In the history of the world, mathematics had its genesis in the yearning of the human soul to solve the mystery of the universe in which it is a mere atom . . . Mathematics had its first real development in the effort to grasp the Infinite."[2] Aristotle explained it by saying that there are three stages of philosophy: the *physical* stage when one looks entirely at individual things; the *mathematical* stage when he classifies objects according to their size, shape, and form; and finally the *metaphysical* stage, most abstract of all, in which one considers "being" as such and sees the ultimate reality or universal features of things. As C. G. Shaw says, "Cast in a mathematical mold and carrying on her operations mechanically, the natural order is to be understood only as the mind utilizes suitable methods."[3]

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[1] *Galileo Opere*, Vol. IV, p. 171. Quoted from R. P. Phillips, *Modern Thomistic Philosophy*, p. 4.

[2] D. E. Smith, "Mathematics in the Training for Citizenship," *The Third Yearbook of the National Council of Teachers of Mathematics*, p. 18.

[3] C. G. Shaw, *Outline of Philosophy*, Vol. I, p. 12.

Let us turn now to Pythagoras and regard him as a symbol representing Man as he learned to make abstractions. Primitive man had to learn to use the material world in which he found himself. "His initial efforts in making . . . instruments out of inorganic matter let him into the secret of the physical world, that of geometry, which is eminently fitted to express the genius of matter, and just as well adapted to the operations of the intellect. Once this geometrical method has been adopted, man is astonished to observe how it puts his mind on an equal footing with matter. He tears himself away from practical operations and begins to grasp the whole universe in a geometrical system of astronomy. He pursues this further . . . . When the Cave Man made a club, little did he dream that he would become the ultimate model of Plato and Aristotle, of Newton and Einstein."[4]

Little is known definitely of the life of Pythagoras, who died about 500 B.C., and it would probably be more correct to speak always of "the Pythagoreans," as Aristotle did. It might be contended that Pythagoras was no philosopher, but he certainly influenced later philosophy for he taught Parmenides and probably influenced Empedocles and Plato. Aristotle quite frequently linked the Pythagoreans with Plato. To Pythagoras is attributed the word philosophy—*love* of wisdom rather than sophos, *attainment* of wisdom.

The exact facts of his life are unimportant, but let us try to see how he thought and how mathematics led him to philosophize. The tradition is that the Egyptian rope-stretchers knew how to use the Pythagorean theorem in their surveying to form a right angle. But Pythagoras went farther than the Egyptians. He observed that the rope of length five could balance the other side of lengths three and four when all three of the sides were squared. When the number three, four, and five were doubled, trebled, quadrupled and so on, the same relation still was maintained. Pythagoras had discovered a universal truth—he was thinking in general, or philosophizing. "Pythagoras had stum-

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[4]*Ibid.,* p. 164.

bled upon something, but that something was gold . . . .
What he proved was not something about existing triangles
made of rope or any other material, but something about
triangularity in the pure space of geometry. The theorem
was applicable to real objects in physical space, but was
demonstrable with thought-of objects in ideal space.

"Once this proposition was proved by Pythagoras, it
was true for all time and all places . . . . The fact that Euclid
redemonstrated the principle . . . and the fact that from
the days of Pythagoras geometers have corroborated the
truth about the triangle, has nothing whatsoever to do with
the truth in question."[5]

Geometry influenced the philosophy of Pythagoras, as
illustrated by the theory of the music of the spheres and by
Aristotle's statement, "[The Pythagoreans] think the limits
of body, i.e. surface, line, point, and unit, are substances,
and more so than body or the solid."[6] However, it was *num-
ber* which had the greatest influence on the way of think-
ing of the Pythagoreans. Pythagoras lived at a time when
it was fashionable for the Greeks to speculate as to the
fundamental "stuff" of the universe; or more accurately,
they studied the question of cosmology. Pythagoras re-
jected the earlier beliefs that the beginning of all things
was water, air, or the "boundless," and decided that the
primary constituent of the material world was number. In
reflecting on the quality that all things must have in com-
mon, he decided that all things could be counted. To him
numbers were everything—even when a man had indiges-
tion it was because the numbers in his stomach were not
properly straightened out. He was properly led to this
view because of his remarkable mathematical researches.
"This doctrine, fantastic as it is—though it has marked
affinities with the way in which the universe is regarded
by modern mathematical physics—is nevertheless some
advance on the teaching of the Ionians, since it declares that
the ultimate material of the universe is something more
abstract and so more universal . . . ."[7]

[5]*Ibid.,* pp. 77-78.

[6]W. D. Ross. *The Works of Aristotle,* "*Metaphysics,*" Book Z, 102b, 1.16.

[7]R. P. Phillips. *Modern Thomistic Philosophy,* p. 5.

Perhaps the best way to describe the Pythagorean Number Philosophy is to consider some passages from the writings of Aristotle:

. . . In numbers they seemed to see many resemblances to the things that exist and come into being—more than in fire and earth and water (such and such a modification of numbers being justice, another being soul and reason, another being opportunity—and similarly almost all other things being numerically expressible) ; since again, they saw that the modifications and the ratios of the musical scales were expressible in numbers ;— since, then, all other things seemed in their whole nature to be modelled on numbers, and numbers seemed to be the first things in the whole nature, they supposed the elements of numbers to be the elements of all things and the whole heaven to be a musical scale and a number. And all the properties of numbers and scales which they could show to agree with the attributes and parts and the whole arrangement of the heavens, they collected and fitted into their scheme; and if there was a gap anywhere, they readily made additions so as to make their whole theory coherent.[8]

. . . They thought that finitude and infinity were not attributes of certain other things, . . . , but that infinity itself and unity itself were the substance of the things of which they are predicated. This is why number was the substance of all things.[9]

For, as the Pythagoreans say, the world and all that is in it is determined by the number three, since beginning and middle and end give the number of an "all", and the number they give is the triad. And so, having taken these . . . , we make further use of the number three in the worship of the Gods.[10]

[8]W. D. Ross, *op. cit.*, "*Metaphysica*," 985b-986a.
[9]*Ibid.*, 987a.
[10]W. D. Ross, *op. cit.*, "De Caelo," 268a.

> The Pythagoreans [speak] ... as if the word "cen-
> tre" were quite unequivocal, and the centre of the
> mathematical figure were always the same with
> that of the thing or the natural center.[11]
> Pythagoras first attempted to speak about virtue,
> but not successfully; for by reducing the virtues
> to numbers he submitted the virtues to a treat-
> ment which was not proper to them. For justice is
> not a square number.[12]

Of course Pythagoras never heard of the divisions of
philosophy, but it appears certain that any branch of phi-
losophy upon which he made an assertion was influenced by
mathematics. He made his mistake in being too deductive
and in carrying his abstractions too far. The fact that
everything is enumerable does not mean that numbers
themselves are the substance of material bodies. Pythag-
oras confused an attribute or what Aristotle called an
"accident" of an object with the object itself. Numbers
cannot be separated from the thing which they describe
even as much as adjectives. For example; if we say, "The
man is fat and short," we can then say, "The man is short";
but if we say, "Five is equal to three and two," we cannot
then infer, "Five is equal to two."

In spite of his mistake, Pythagoras was a brilliant
thinker and made an undying impression on the world.
"However vague such conceptions as aspects of the real
world or our means of understanding it, the discovery of
Forms was one which was destined to play a great role in
mathematics and philosophy. A study of the properties of
numbers and figures is indeed no longer regarded as a
direct means of revealing the nature of things. But the na-
ture of things is revealed in the mathematical definiteness
which they display."[13]

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[11] *Ibid.*, 293b.
[12] W. D. Ross, *op. cit.*, "Magna Moralia," 1182a.
[13] John Warbeke, *The Searching Mind of Greece*, p. 32.

TOPICS FOR CHAPTER PROGRAMS—VII

20. AMICABLE NUMBERS

Two numbers are said to be amicable if each equals the sum of the aliquot parts of the other. The first pair discovered, 220 and 284, played a prominent role in ancient number magic. The search for other pairs was taken up by Fermat, Descartes, Euler, and others. Indeed, a sixteen-year-old Italian lad contributed a pair in 1866. At present, there are 433 known pairs of amicable numbers.

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21. PTOLEMY'S THEOREM

Among the mathematicians of the famous Alexandrian School was Claudius Ptolemy who flourished in the second century. His great work, the *Almagest*, contains a theorem which may be stated: If $ABCD$ be any quadrilateral inscribed in a circle, then $AC \cdot BD = AB \cdot DC + AD \cdot BC$. This

theorem has interesting applications, particularly in the derivation of certain trigonometric formulas.

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22. THE FOUR-COLOR PROBLEM

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During a lecture Professor Huxley said to a student, "Did you follow me?" "Yes, sir," was the reply, "except when you were between me and the blackboard." "I always try to make myself clear," replied Huxley, "but I can't make myself transparent."

THE PROBLEM CORNER

EDITED BY JUDSON W. FOUST

Central Michigan College of Education

The Problem Corner invites questions of interest to undergraduate students. As a rule, the solutions should not demand any tools beyond the calculus. Although new problems are preferred, old problems of particular interest or charm are welcome provided the source is given. Solutions of the following problems should be submitted on separate sheets before October 1, 1949. The best solutions submitted by students will be published in the Fall 1949 number of THE PENTAGON. Credit will be given for all correct solutions received. Address all communications to Dr. Judson W. Foust, Central Michigan College of Education, Mount Pleasant, Michigan.

PROBLEMS PROPOSED

(Solutions are invited for Problems 1, 2, 5, 7, and 8 proposed in previous numbers of THE PENTAGON.)

15. *Proposed by Geoffrey B. Charlsworth, Hofstra College, Hempstead, N.Y.* (*From the* American Mathematical Monthly, *March, 1946.*)

You are given twelve coins identical in appearance and a pair of scales without weights. Eleven of the coins are the same weight and the twelfth is different in weight from the others. How could you identify the coin of different weight and tell whether it is heavier or lighter than the others in three weighings? A weighing consists of placing a certain number of coins in each pan of the scales and discovering which set of coins is heavier or lighter than the other; no removals are allowed during each operation. (As a warm-up exercise for this, see if you can discover a light-weight coin from among eight coins if only two weighings are allowed.)

16. *Proposed by Geoffrey B. Charlsworth, Hofstra College, Hempstead, N.Y.*

Let ABC be an isosceles triangle with $AB = AC$, D any point on BC or BC produced, and E the intersection of AD with the circumcircle of triangle ABC. Let O and P be the centers of the circles CDE and BDE. Find the locus of the midpoint of OP.

17. *Proposed by the Problem Corner Editor.*

A farmer has a calf, a goat, a colt, a pony, a sheep, and a pig to pasture in two fields. How many different ways can he divide them so that there is at least one animal in each field?

18. *Proposed by the Problem Corner Editor.*

B is a place in a city five blocks east and four blocks north of A. How many different routes, nine blocks in length, are there from A to B by following the streets?

SOLUTIONS

9. *Selected from the third Stanford University Mathematics Examination, April 10, 1948.*

Three numbers are in arithmetic progression, three other numbers in geometric progression. Adding the corresponding terms of these two progressions successively we obtain 85, 76, and 84, respectively; adding all three terms of the arithmetic progression we obtain 126. Find the terms of both progressions.

Solution by Lewis C. Workman, Drake University, Des Moines, Iowa.

1) Let the terms of the arithmetic progression be $a-d$, a, and $a+d$. The sum of this progression gives $3a=126$, or $a=42$.

2) Thus the arithmetic and geometric progressions are, respectively, 42-d, 42, 42+d and 43+d, 34, 42-d, since the

sums of corresponding terms are 85, 76, and 84.

3) By the definition of a geometric progression,
$$34/(43+d) = (42\text{-}d)/34,$$
from which $d=25$, or $d=\text{-}26$.

4) Therefore the two progressions are 17, 42, 67 and 68, 34, 17 or 68, 42, 16 and 17, 34, 68.

Also solved by Richard Burrows, Glenn Cline, Roy D. Cole, Wilbur Diehl, Albert Foster, William Fryer, Dan Harrington, Ewart Lockyer, Phil McKean, and Robert Warren.

10. *Proposed by the Problem Corner Editor. Seen in a newspaper in 1924.*

An automobile is twice as old as its tires were when it was as old as its tires are now. When the age of the tires equals the present age of the car the sum of their ages will be 2 1/4 years. How old is the car and how old are the tires?

Solution by Albert Foster, Albion College, Albion, Michigan.

1) Let x be the present age of the car and y the present age of the tires. Then from the first statement,
$$x = 2[y - (x-y)]$$
or
$$3x - 4y = 0.$$
2) From the second statement,
$$x + [x + (x-y)] = 2\ 1/4,$$
or
$$12x - 4y = 9.$$
3) Solving (1) and (2) simultaneously gives
$$x = 1 \text{ year}, y = 3/4 \text{ year}.$$

Also solved by Richard Burrows, Pat Collins, Fred Fischer, Rita Grogan, William Horn, and Ewart Lockyer.

11. *Proposed by Dr. C. C. Richtmeyer, Central Michigan College of Education.*

A city with a circular wall has two gates, one at each end of the north and south diameter. From the north gate

a road leads directly north and from the south gate a road leads directly east. What is the diameter of the city if from a point 3 miles north of the north gate it is just possible to see past the wall to a point nine miles east of the south gate?

Solution by Thom Simmons, Albion College, Albion, Michigan.
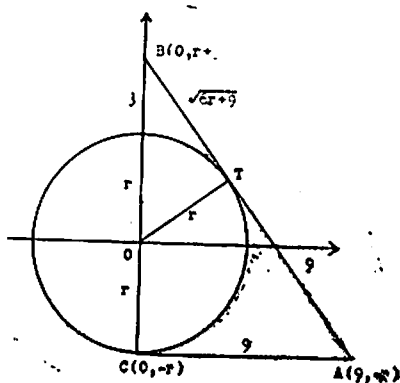
1) *Area* $\triangle OBA$ = area $\triangle OTB$ + area $\triangle OTA$.

That is, $9(r+3) = r\sqrt{(6r+9)} + 9r$

or, rationalizing,

$$2r^3 + 3r^2 - 243 = 0.$$

2) By synthetic division and the quadratic formula,

$$r = 9/2, -3 \pm i\sqrt{18}$$

so that the diameter of the city is 9 miles.

Also solved by Allen Bass, Thomas Brien, Matthew Chionchio, Ted Cornish, Harold Diebolt, Wilbur Diehl, Dan Harrington, William Horn, Phil McKean, Rex Miller, Robert Radford, and Robert Warren. Variations in the solution included using all right triangles and placing the area of triangle *ABC* equal to the area of the three component triangles. Another solution used the fact that triangles *OTB* and *ACB* are similar and hence the corresponding sides are proportional. This problem is found in the "Nine

Sections of Mathematics," written in 1247 by Ch'in-Chiu-Shoa.

12. *Proposed by Lester Serier, Central Michigan College of Education.*

The graph of a traffic count past a certain point is found to resemble a sine curve with a minimum of 30 at midnight and a maximum of 900 at noon. Write an equation which will give the traffic count at any time of the day. Also find how many cars passed the point between 11 a.m. and noon.

Solution by Matthew Chionchio, Albion College, Albion, Michigan.

1) Let the equation of the curve be of the form
$$y = a \cos(bx+c) + k.$$
Then the amplitude a is equal to $(900-30)/2$, or $a = 435$. Thus if $x = 0$ corresponds to noon, the equation becomes
$$y = 435 \cos bx + 465.$$
2) Since $y=30$ *when* $x=12$, $\cos 12b = -1$ *and* $b = \pi/12$. Thus
$$y = 435 \cos(\pi x/12) + 465.$$
3) The number of cars between 11 a.m. and noon is the same as the number of cars between noon and 1 p.m. This number may now be obtained by integrating our function between the limits of 0 and 1, giving 895 cars.

Also solved by Roy D. Cole.

13. *Proposed by the Problem Corner Editor.*

An iron band which just fits around the earth at its largest circumference is cut and after one foot is inserted it is adjusted so that it stands out from the earth equally at all points. Assuming the radius of the earth to be 4000 miles, how far out from the earth will the band be after the foot is inserted?

Solution by William Horn, Albion College, Albion, Michigan.

Let C be the original circumference, R the original radius, and d the distance the ring stands out from the

earth. Then $C = 2\pi R$ and $C+1 = 2\pi(R+d)$. Subtracting, we obtain $1 = 2\pi d$, whence $d = 1/2\pi = 0.159$ ft. The answer is independent of the radius of the original circle.

Also solved by Richard Burrows, Glenn Cline, Pat Collins, Fred Fischer, and William Fryer.

14. *Proposed by the Problem Corner Editor.*

A fish pole 10 feet long weighing 40 ounces is conical in shape and tapers uniformly. It balances at a point 30 inches from the large end. When a certain fish was caught it was noticed that with the weight of the fish on the small end the pole balanced at its midpoint. Find the weight of the fish.

Solution by Harold Diebolt, Central Michigan College of Education, Mount Pleasant, Michigan.

"In all problems that involve the weight of a body we may ignore the fact that the weight is distributed throughout the body, and treat it as a single force applied at the center of gravity." (Kimball's College Physics, 5th edition, page 34.) In problems of this sort the sum of the clockwise moments must be equal to the sum of the counter-clockwise moments. As the pole balances at a point 30 inches from the large end, this point is the center of gravity and the entire weight of 40 ounces can be considered hanging from this point.

Let x be the weight of the fish. Then the moment tending to cause rotation in a counter-clockwise direction is $60x$, since the midpoint of the pole is 60 inches from either end. The moment that causes the pole to rotate in a clockwise direction is 40 ounces times 30 inches. Setting the two moments equal to each other, we obtain $60x = 1200$, whence $x = 20$ ounces.

Also solved by Raymond St. Clair.

THE MATHEMATICAL SCRAPBOOK

I see now what great advantage there is in giving two years to mathematics; everything becomes clearer and easier.

—René Vallery-Rádot, THE LIFE OF PASTEUR.

$=\nabla=$

If a jeweler can put a crystal on my watch in two minutes, how long would it take a hundred jewelers?

$=\nabla=$

Hicks found the real positive root of $x^3 - 2x = 5$ to 152 places. $(x = 2.09455)$

$=\nabla=$

"[Descartes] had not much opinion of other people's work; he read very little—found it easier to think. He travelled through Florence once when Galileo was at the height of his renown without calling upon him."

—SIR OLIVER LODGE.

$=\nabla=$

Decode the following problem in cryptarithmetic:
$$SIX + SEVEN + SEVEN = TWENTY$$

$=\nabla=$

"[The new types of electronic computing devices] are, in flexibility and capacity, more like a human brain than like the traditional mechanical computing device of the past. They have 'memories' in which vast amounts of information can be stored. They can be 'told' to carry out computations of very intricate complexity, and can be left unattended while they go forward automatically with their task. The astounding speed with which they proceed is illustrated by the fact that one small part of such a machine, if set to multiplying two ten-digit numbers, can perform such multiplications some 40,000 times faster than a human operator can say 'Jack Robinson.' This combination of flexibility, capacity, and speed makes it seem likely that such devices will have a tremendous impact on science."

—WARREN WEAVER.

95

Test of divisibility by 7: Multiply the leading digit by 3 and add the next digit; multiply the result by 3, add the next digit, etc., at any stage subtracting or adding any multiple of 7. If the final result is a multiple of 7, so is the original number.

$= \nabla =$

Newton had begun his great mathematical discovery of the calculus at the age of twenty-one or two.

$= \nabla =$

$$\frac{18534}{9267} \times \frac{17469}{5823} = \frac{34182}{5697}$$

Here the nine digits occur in each fraction, each digit once and only once.

$= \nabla =$

"Gauss was in possession of non-Euclidean geometry ahead of both Lobachevsky and Bolyai, but he was loath to publish his results. He feared that such an unorthodox discovery might undermine the faith of the young in the validity of mathematics in general."

—N. A. COURT.

$= \nabla =$

The chances are better than even that at least two persons in a group of 25 will have the same birthday.

$= \nabla =$

"In conformity with general usage, I have used the word mathematics in the plural; but I think it would be desirable that this form of word should be reserved for the applications of the science, and that we should use mathematics in the singular number to denote the science itself, in the same way as we speak of logic, rhetoric, or (own sister to algebra) music."

—J. J. SYLVESTER.

$= \nabla =$

The number of possible bidding sequences in the game of bridge is 128, 745, 650, 347, 030, 638, 120, 231, 926, 111, 609, 371, 363, 122, 697, 577.
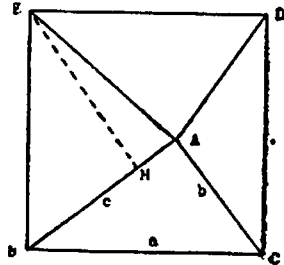
—KARL ITKIN.

$\pi = 3 + 1/8 + 1/60$, approx.

$= \triangledown =$

Complete the square $BCDE$ on the hypotenuse on the side towards A, and join AE, AD. The perpendicular EM on AB is equal to AB, for $\triangle BEM = \triangle CBA$. Therefore,

area of $\triangle ABE = \frac{1}{2}c^2$

and area of $\triangle ACD = \frac{1}{2}b^2$.

The two triangles AED, ABC have equal bases each a, and the sum of their altitudes is a, so their combined area is $\frac{1}{2}a^2$. But the four triangles make up the square, so $a^2 = (a^2 + b^2 + c^2)/2$, or $a^2 = b^2 + c^2$.

—MATH. GAZETTE.

$= \triangledown =$

To square a number in the fifties, simply add the unit figure to 25, and annex the square of the unit figure. Thus to square 56, we merely add 6 to 25, giving us 31, and annex the square of 6, which is 36, and thus we obtain $56^2 = 3136$.

If the square of the unit figure is less than 10, we must insert a cipher before the square of the unit figure. Thus to square 53, we add 3 to 25, giving 28, and annex a cipher and the square of 3, which is 9. Thus we get $53^2 = 2809$.

—JAMES McGIFFERT.

$= \triangledown =$

A square garden, sides 12 rods, is planted with trees, no two of which are less than one rod apart, and no tree less than one-half rod from the fence. How many trees can be planted? (It has been shown that there are at least 152 trees.)

—SCHOOL SCIENCE AND MATH.

Napoleon was fond of trying this problem out on his engineers: To construct the vertices of a square using compasses only.

$$=\nabla=$$

THEOREM: Any power of an integer N is expressible as a sum of N consecutive odd numbers.

Thus, $1^4 = 1, 2^4 = 7 + 9, 3^4 = 25 + 27 + 29$, etc.

$1^5 = 1, 2^5 = 15 + 17, 3^5 = 79 + 81 + 83$.

—SCHOOL SCIENCE AND MATH.

$$=\nabla=$$

A method of finding the day of the week of any given date: Let $p = $ the day of the month of the given date,

$q = $ the number of the month of the year, using 13 for January and 14 for February,

$N = $ the year.

Then $D = p + 2q + [3 (q+1)/5] + N + [N/4] - [N/100] + [N/400] + 2$, where $[x] = $ the largest integer contained in x.

$$=\nabla=$$

NAPIER'S BONES

Today Napier is remembered and honored for his invention of logarithms, but at one time he was more famous for the invention of certain computing rods for use in multiplication and division. Napier describes these rods, which became popularly known as Napier's "bones," in his *Rabdologia* published shortly after his death in 1617. In the dedication, Napier states that the rods had already gained great popularity and were even being carried to foreign countries, and that friends had induced him to describe their construction and use lest they should be put forth in some one else's name.

The word *rabdologia* was coined from the Greek *rhabdos*, rod, and *logia*, collection. As described by Napier, the rods consist of oblong pieces of bone or ivory with square ends. Each of the four faces of each rod contains multiples of one of the ten digits; the face is divided length-

wise into ten equal parts, nine parts in the middle, one half of a part above, and one half of a part below. Figure 1 illustrates a face containing the multiples of 3. Note that each square is divided by a diagonal, the units digit of a multiple being written on one side and the tens digit on the other side.

Fig. 1   Fig. 2   Fig. 3

According to Napier, a set of 10 rods suffice for calculations with numbers less than 11,111. The following table gives the arrangement of the various multiples appearing on such a set of rods, the faces being numbered in order starting with a face turned towards the eye and proceeding to the right.

Rod Number:	1	2	3	4	5	6	7	8	9	10
Face No. 1:	0	0	0	0	1	1	1	2	2	3
Face No. 2:	1	2	3	4	2	3	4	3	4	4
Face No. 3:	9	9	9	9	8	8	8	7	7	5
Face No. 4:	8	7	6	5	7	6	5	6	5	6

It will be noted that each column of multiples occurs four times, the numbers on opposite faces being complementary. Moreover, the columns on opposite faces are reversed in direction, faces 3 and 4 being inverted in direction to

faces 1 and 2. This arrangement is illustrated by Figure 2, which represents the four faces of rod number 7. In addition to the ten rods just described, there is also an index rod containing the digits from 1 to 9 in squares without diagonals.

The use of Napier's bones in multiplication may be explained by an example. Thus, in order to multiply 6,073 by 529, bones headed 6, 0, 7, 3 are placed side by side and next to them is placed the index bone (Fig. 3). With the bones in this position the multiples of 6,073 can be read off with little difficulty. Opposite the index 9 appears the line 5/4, /0, 6/3, 2/7 which is added diagonally to give the product 9 × 6,073 = 54,657. Similarly, 2 × 6,073 is found to the left of index 2, and is 12,146; 5 × 6,073 is found to be 30,365. Having obtained the required multiples of 6,073, they are set down as in ordinary multiplication and added:

$$
\begin{array}{ll}
54657 & (9 \times 6073) \\
12146 & (2 \times 6073) \\
\underline{30365} & (5 \times 6073) \\
3212617 & (529 \times 6073)
\end{array}
$$

It is observed that Napier's bones reduces multiplication to a series of additions.

The *Rabdologia* attacted considerable attention and many editions were published in various languages. The bones had a great vogue for several years after Napier's death, not only in Europe but also in China and Japan. "Nothing shows more clearly the rude state of arithmetical knowledge at the beginning of the seventeenth century than the universal satisfaction with which Napier's invention was welcomed by all classes and regarded as a real aid to calculation."

$$= \nabla =$$

Look beneath the surface; let not the several quality of a thing nor its worth escape thee.

—MARCUS AURELIUS.

KAPPA MU EPSILON NEWS

EDITED BY CLEON C. RICHTMEYER, *Historian*

At their initiation meeting on January 15, 1949, California Alpha initiated 16 new members. The speaker was Dr. Max Mason. Most of the regular meetings of this chapter are "open" meetings, that is the programs are open to anyone interested in mathematics.

—+—

In addition to initiations and meetings devoted to lectures, **Illinois Gamma** held two social meetings at which mathematical games were played.

—+—

In connection with the programs of **Illinois Delta**, students are assigned to bring in reports of articles in current issues of mathematical magazines.

—+—

An Alumni Homecoming Breakfast was held by **Iowa Alpha** on October 9, 1948. Initiations of this chapter are composed of two parts, one informal and the other formal. During the informal initiation, candidates are asked simple but confusing questions. Each new candidate is required to submit a paper of mathematical interest before being admitted to the fraternity.

—+—

Members of the **Iowa Beta** chapter have been divided into two teams to work problems and compete for points. The contest is to continue throughout the year, using problems submitted at each chapter meeting.

—+—

Kansas Beta sponsored a Mathematics Department "Open House" during March.

—+—

A mathematics float was prepared by members of **Michigan Beta** in connection with the fall homecoming parade. The float showed a large family with the father figuring out the budget, making use of a blackboard and large demonstration slide rule.

101

Funds were voted from the treasury of **Missouri Beta** for the purchase of Tuberculosis Seals in the name of the chapter. On January 10, all students of the college were invited to an "Open House." The talks were of such a nature as to be interesting to those not having taken college mathematics as well as to those who had.

— + —

New Jersey Alpha held a joint Christmas party with the mathematics club, to which alumni were invited.

— + —

Members of the **New York Alpha** chapter were invited to attend a meeting of the Mathematics club of Adelphi College, Garden City, New York, to hear Colonel Robert Beard speak on "Diagrams and Models." The chapter purchased for its use Colonel Beard's book containing many diagrams and drawings for the construction of solids.

Later the Adelphi Mathematics Club received a return invitation to hear Lieutenant Colonel Robert Yates speak on "Models and Methods." Models for construction of plane curves, diagrams, and linkages were presented. The chapter held an annual Christmas party in the form of a square dance.

— + —

For initiation, **Ohio Beta** had short talks given by initiates on some mathematical subject, either a historical bit or a mathematical curiosity, or some brief fact of interest.

— + —

During November, the **Ohio Gamma** chapter paid a visit to the Laboratory of the National Advisory Committee for Aeronautics at the Cleveland Airport. The trip included a tour through the world's greatest supersonic wind tunnel at the Lewis Flight Propulsion Laboratory, inspection of the Division of Turbines and Compressors, and the application of Bragg's Law of Refraction, atomic scattering and the use of X-rays in crystal structure.

— + —

A December quiz program was held by **Oklahoma Alpha.** It was conducted along the lines of a Dr. I. Q. program using mathematical questions.

Tennessee Alpha has adopted as minimum membership qualifications a quality quotient of 2.5 in mathematics and an average of 2.0 in all subjects. This makes the chapter of KME have higher academic requirements than any other organization on the campus.

—+—+—+—

PROGRAM TOPICS, FALL SEMESTER, 1948-49

Alabama Alpha, Athens College

Pythagorean Theorem—Garfield Method, by Raymond Trafton

Pythagorean Theorem—Bhaskara Method, by Thomas Collier

Applied Mathematics in Analytical Chemistry, by Professor T. J. Carter

Mathematics Applied to Physics, by Elree C. Culps

The Mathematical Method, by Lloyd O. Stone

The Four Most Interesting Numbers in Mathematics, by Lena Faye Hughes

Alabama Gamma, Alabama College

Napier's Bones, by Elaine Coplin

Magic Squares, by Lida True

Ruler and Compass Construction, by Doris Williamson

Trisection Problem, by Hortense Barnes

Squaring a Circle, by Henriella Kornegay

Duplicating a Cube, by Mary Sue Ellenburg

Non-Euclidean Geometry, by Mamie Braswell

California Alpha, Pomona College

Mathematical Models, by Dr. Chester G. Jaeger and Charles Halberg

Catenary, by Langhorne Withers

Nomography, by David Line

Michelson-Morely Experiment, by Ed Chopin

Soap Films, by Don Walter

Colorado Alpha, Colorado A & M College

Minimal Surfaces, by Tyre Newton

Some Problems in Logic, by David Hughes

Illinois Beta, Eastern Illinois State College
>*Gas Ionization Laws,* by Robert Garner
>*Approximate Computaton,* by Robert Zeigel and Richard Dickerson
>*Number Systems and Their Bases,* by James Gindler
>*Navigation Methods,* by Charles Brown

Illinois Gamma, Chicago Teachers College
>*History of the Atom,* by Mr. Henry Patin
>*Introduction to Modern Algebra,* by Dr. J. M. Sachs
>*Mathematical Symbolism,* by Mr. Joseph J. Urbancek

Illinois Delta, College of St. Francis
>*The Pastures of Wonder,* by Sister Claudia, OSF
>*Alfred North Whitehead,* by Mary L. Hodor
>*Cassius J. Keyser,* by Katherine Lux
>*The Human Worth of Rigorous Thinking,* by Mary J. LaFond
>*Educational Ideal that are Most Worthy of Loyalty,* by Lillian Rafae
>*Nature and Life,* by Sister Rita Clare, OSF
>*Business Adrift,* by Anne Hutchings

Iowa Alpha, Iowa State Teachers College
>*Regular Solids,* by George Mach
>*Bishop Berkley and His Interest in Mathematics,* by Royce Neiting
>*The Four Color Problem,* by Orval Knee
>*Non-Commutative Processes,* by Loren Sheldahl
>*Paper Cutting,* by Betty Sayre and Donna Whiting
>*Mathematical Induction,* by Bill Boettcher
>*Postulates of Ordinary Geometry,* by Jim McGrew
>*When you Fly,* by Robert Lankton

Iowa Beta, Drake University
>*Archimedes,* by Louis Workman

Kansas Beta, Emporia State Teachers College
>*History of KME,* by Professor C. B. Tucker
>*Demonstration and History of The Abacus and Early Adding Machines,* by Stanley Martin

Kansas Gamma, Mount St. Scholastica College
>*Mathematics and Its Relation to the Modern World,* by G. Jaskowiak

Development and Modern Uses of Statistics, by M. A. Weir

Non-Euclidean Geometry and Its Uses in the Modern World, by Sister Evangeline Anderson, OSB

Michigan Alpha, Albion College

Identification of Conic Sections by Invariants, by Ralph Powers

Algebra and the Abacus, by Richard Vetter

Contributions to Mathematics by the Ancient Egyptians, by Richard Carver

Fallacies in Mathematics, by Wendell Martin

Linkages, by Harold Wakelin

Flatland, by Betty Marshall

LaGrange and LaPlace, by Jean Hayward

Michigan Beta, Central Michigan College

The Game of Nim, by Mary Wright

Russian Peasant Multiplication, by Glenn Clark

Some Mathematical Puzzles, by Guy Coykendall

Computation of Pi, by Don Chinnery

Missouri Alpha, Southwest Missouri State College

A Finite Geometry of Twenty-five Points, by Carl Gubriel and Edward Rykowski

Solution of Problem One from the Third Stanford University Competitive Examination in Mathematics, by Roy Dale Cole

Missouri Beta, Central Missouri State College

Geography and Mathematics, by James Schmer

Pythagorean Number Triples, by Harold Woods

Calendars of the Past and Present, by Donna Lee Chitty

Calendrical Computations, by Vol A. Russ

History and Construction of Magic Squares, by Robert F. Boothe

Computational Short-Cuts and Checks, by Quentin C. Smith and H. Keith Stumphff

New Jersey Alpha, Upsala College

Nomography, by Frances Rischmiller, Martin Moore, and James Giel

Zeno of Elea, by Dr. E. Vedova, Newark College of Engineering

New York Alpha, Hofstra College

Nomograms, by Mr. Leonard Hinder

Introduction to Vector Analysis, by Dr. L. F. Ollman

Projectiles and Parabolae, by Frank Hawthorne

Ohio Alpha, Bowling Green State University

Mathematics and Engineering, by Lorin Janzer, Urschel Engineering Co.

Paradoxes of Infinity, by Dr. F. C. Ogg

Ohio Beta, College of Wooster

Moving Picture on *Relativity.*

Ohio Gamma, Baldwin-Wallace College

Boolean Algebra, by Don Parrish

Winning the 1947 Air Races and Some Mathematical Aspects of Aero-dynamics, by Cook Cleland, winner of 1947 Thompson Trophy Race

Oklahoma Alpha, Northwestern State College

Mathematics in Insurance, by Gregg James

How to Trisect an Angle, by Bob Shay

Tennessee Alpha, Tennessee Polytechnic Institute

Some Unsolved Problems in Mathematics, by Dr. R. O. Hutchinson

History of Arithmetic, by W. K. Kiracofe

History of Trigonometry, by F. Joel Witt

History of Algebra, by W. R. Harris

History of Slide Rule, by B. A. Limpert

History of Geometry, by H. F. Holmes

History of Analytic Geometry, by G. C. Green

History of Calculus, by H. B. Norman

Mathematical Poems, by Rebecca J. Gisham

Texas Alpha, Texas Technological College

Cryptography, by Ken Hancock

Texas Beta, Southern Methodist University

Old English Arithmetic, by Dick Furlong

Vector Algebra, by Paul Petty

The Value of the Mathematical Recitation as an Aid in Public Speaking, by Franklin Cooke

Wisconsin Alpha, Mount Mary College

    Rhythmic Mathematics, by Sister Mary Felice
    What About Copernicus?, by Betty Prossen
    Mathematical Ideas of Plato and Aristotle, by Norma
Harding

"I have never had the courage to open the many
mathematical books I brought with me; but what do you
think I would do if I had opportunity ever again? Attend
college and De Morgan's mathematical lectures! The utility
of mathematics is one of the most incomprehensible things
about it; but though I was never bright or successful in his
class, in spite of working hard, I feel the greatest benefit
from it. Mathematics are like the calesthenic exercises of
the mind, and make it vigorous and correct in form and
action; but it depends, of course, on the circumstances how
you apply and use your mind as well as your body. To go
figuring about with your arms and legs is not the object of
calisthenics. I think, therefore, you can not waste time or
trouble spent over mathematics."

                —STANLEY JEVONS in a letter to his sister,
                June 17, 1857.

THE SEVENTH BIENNIAL CONVENTION

The seventh biennial convention of Kappa Mu Epsilon was held in Topeka, Kansas, on April 10-12, 1949 with Kansas Delta chapter of Washburn Municipal University as host. The registration included 182 delegates from 35 chapters. The program follows.

SUNDAY, APRIL 10

During the afternoon, members of Kansas Delta furnished cars and early arrivals to the convention were taken on tours of the city. At 7:30 p.m. the Kansas Delta chapter entertained at an informal mixer at the Hotel Kansan. Miss Martinson's large collection of puzzles was of much interest to all present. The guests were further entertained by music and cards, and refreshments were served by Kansas Delta.

MONDAY, APRIL 11

9:00 A.M.—Registration ....MacVicar Chapel
10:00 A.M.—First General Session .....MacVicar Chapel

Address of welcome by President Bryan S. Stoffer of Washburn Municipal University.

Response by Professor C. B. Tucker of Kansas Beta.

Student Papers:

1. *A Finite Geometry of Twenty-five Points*, by Edward Rykowski, Missouri Alpha.

2. *A Geometric Representation of Indeterminate Forms*, by Lewis Keefer, Kansas Beta.

3. *The Development of Boolean Algebra and Some Applications*, by Donald Parrish, Ohio Gamma.

12:30 P.M.—Luncheon ....Benton Hall
1:30 P.M.—Group picture on steps of MacVicar Chapel
2:00 P.M.—Second General Session .....MacVicar Chapel

Address: *The Role of Generalization and Abstraction in Mathematics.* by Dr. L. M. Graves, University of Chicago.

Following the address, formal initiation ceremonies in honor of Dr. Graves were conducted by Dr. Van Engen, Pro-

fessor Mathias, Miss Hove, and Miss Greene. Dr. Graves and three students of Washburn University were initiated into the Kansas Delta Chapter of Kappa Mu Epsilon.

3:45 P.M.—Informal Tea ....Crane 21

This tea was given by the department of mathematics of Washburn University in honor of Dr. Graves. During the tea, some very interesting mathematical models were on display in an adjoining room. The plastic models exhibited by Charles Halberg, Jr., of California Alpha were of particular interest.

6:30 P.M.—Dinner ....Benton Hall

8:00 P.M.—Kappa Mu Epsilon Mixer ......Benton Hall

Dancing and cards provided opportunities for the delegates to become acquainted. Further entertainment was provided by the German Band of Washburn University, and a group from Kansas Gamma read in chorus, "An Ode to the Queen of the Sciences," written by Dr. B. Lloyd. Refreshments were served by Kansas Delta. All had such a fine time that it was difficult to get the delegates to leave so that Benton Hall might be closed for the night.

TUESDAY, APRIL 12

9:30 A.M.—Business Meeting ....Benton Hall

Reports were read by each national officer and the editor of the Pentagon. Charters were approved for Central College of Fayette, Missouri, and Mississippi Southern College of Hattiesburg, Mississippi. Invitations were received from Missouri Alpha and Nebraska Alpha for the next biennial convention.

10:30 A.M.—Group Discussions, "This is the Way We Do It."

The student group met in MacVicar Chapel with Raymond Gillespie of Michigan Alpha presiding and James Green of Missouri Beta acting as secretary. The faculty group met in Crane 21 with Dr. C. C. Richtmeyer of Michigan Beta presiding and Mr. L. E. Laird of Kansas Beta acting as secretary. Following the group discussions, all delegates reconvened in MacVicar Chapel to hear a report from each secretary.

12:30 P.M.—Luncheon ....Benton Hall

1:30 P.M.—Third General Session ....MacVicar Chapel

Student Papers:

4. *Inside the U.S.N.D.* (*United Sovereign Number Domain*), by Emma Fessenden, Texas Gamma.

5. *The Development of Calculating Machines*, by Jim Idol, Missouri Gamma.

6. *Straight Line Motion Linkages*, by Andrew J. Clark, Colorado Alpha.

7. *Certain Geometrical Aspects of Binary Quadratic Forms*, by Barbara Bellin, Michigan Gamma.

8. *Nomography for Science Students*, by Mary Alice Weir, Kansas Gamma.

9. *Ramifications in Cryptography*, by Ramona H. Goldblatt, Illinois Gamma.

Due to lack of time, the following student papers listed on the program were read by title.

10. *Logarithms of Complex Numbers*, by Austin H. Haygood, Alabama Beta.

11. *Modern Women in Mathematics*, by Noreen Hurter, Kansas Gamma.

12. *Topology*, by Wesley Moore, Missouri Gamma.

13. *Linkages*, by Donna Simmons, Kansas Delta.

14. *Euler's Formula for Complex Solids*, by George Mach, Iowa Alpha.

15. *Mystical Significance of Numbers*, by Dorothy C. Dahlberg, Illinois Gamma.

16. *Pythagorean Number Oddities*, by Kathryn Graham, Illinois Gamma.

17. *Elements of Lewis Carroll*, by Dorothea Reiffel, New York Alpha.

18. *Some Elementary Aspects of the Schwartz-Christoffel Transformation*, by Marving Snider, Michigan Gamma.

19. *Mathematical Applications of Cryptography*, by Kenneth M. Hancock, Texas Alpha.

20. *The Mathematical Contributions of Descartes*, by Charles A. Swallows, Tennessee Alpha.

21. *The Hagge Circles of a Triangle*, by Joan Daley, Wisconsin Alpha.

4:00 P.M.—Final Business Meeting ....MacVicar Chapel

Professor S. B. Murray, Mississippi Beta, read the report of the Evaluation Committee. Other members of the committee were Mrs. Margaret Blevins, Colorado Alpha, Charles Halberg, California Alpha, Willis Groth, New Mexico Alpha, and Mary Alice Weir, Kansas Gamma. This committee will continue its work of evaluating the convention.

Professor J. A. G. Shirk, Kansas Alpha, read the report of the Resolutions Committee. Other members of this committee were Professor T. H. Southard, Michigan Gamma, Professor S. B. Murray, Mississippi Beta, Howard Mielke, Ohio Gamma, Emma Fessenden, Texas Gamma, and James Green, Missouri Beta.

Professor C. V. Fronabarger, Missouri Alpha, read the report of the Nominating Committee. The following officers were elected: President, Dr. H. Van Engen, Iowa State Teachers College; Vice-President, Dr. H. D. Larsen, Albion College; Secretary, Miss E. Marie Hove, Hofstra College; Treasurer, Dr. L. F. Ollmann, Hofstra College; Historian, Dr. C. C. Richtmeyer, Central Michigan College.

6:00 P.M.—Banquet ....Roof Garden, Hotel Kansan

Toastmaster: Mr. Terry T. McAdam, Kansas Delta.

Address: *Some Famous Problems of Modern Mathematics*, by Dr. G. B. Price, University of Kansas.

Music was furnished by the Washburn University Singers who presented several numbers. Mr. Charles Halberg of California Alpha was called upon to discuss the mathematical models which he had exhibited to the convention. Greetings to the assembled delegates were extended by Dr. Paul Eberhardt of Kansas Delta and Dr. H. Van Engen.

The prize award for the best student paper published in The Pentagon during the past biennium was awarded to Miss Franklee Gilbert of Alabama Gamma. Announcement was made that the prize for the best student paper published in The Pentagon during the next biennium would be a life subscription.

The convention was brought to a close by an enthusiastic vote of appreciation to the Kansas Delta Chapter and members of the Washburn University faculty for their untiring efforts to make the seventh biennial convention a huge success.

"The world of ideas which it discloses or illuminates, the contemplation of divine beauty and order which it induces, the harmonious connexion of its parts, the infinite hierarchy and absolute evidence of the truths with which mathematical science is concerned, these, and such like, are the surest grounds of its title to human regard, and would remain unimpaired were the plan of the universe unrolled like a map at our feet, and the mind of man qualified to take in the whole scheme of creation at a glance."

—SYLVESTER.

THE PRESIDENT'S BIENNIAL REPORT*

H. VAN ENGEN

Iowa State Teachers College

It is customary for the officers of Kappa Mu Epsilon to give a report of their stewardship to the assembled delegates of the fraternity. In this report I would like to give you not only the details of some of the National Council's official acts pertaining to more routine matters, but I would also like to tell you what the National Council has been doing to implement the main objectives of Kappa Mu Epsilon.

Let me refresh your memories regarding the objectives of the fraternity. Your constitution states that the objectives shall be

A. to further the interest of mathematics in those schools which place their primary emphasis on the undergraduate program;

B. to help the undergraduate realize the important role that mathematics has played in the development of western civilization;

C. to develop an appreciation of the power and beauty possessed by mathematics, due, mainly to its demands for logical and rigorous modes of thought;

D. to provide a society for the recognition of outstanding achievement in the study of mathematics in the undergraduate level.

To achieve an objective one must have a program. Not only must one have a program that has been well thought out but it must be implemented by procedures, (i.e. things to do) by committee work and, in particular, by getting a goodly number of the members of the fraternity actively engaged in working toward the attainment of the objectives of the fraternity. A fraternity with only a few of its members at work is handicapped in achieving its objectives.

The National Council has done two things in order to get members, particularly students, to participate in the

activities of the fraternity. (1) In so far as possible students have been appointed to committees. We have student representatives on both the Auditing and Resolutions Committees. The practice of placing student members on committees can and should be expanded. (2) The Council has planned the program for this convention so that primary emphasis is given to student participation. The program not only emphasizes student participation but it has been built for the undergraduate student. I believe we have been fairly successful in getting students to participate in the program, but the major portion of the credit for our success must be given to the local chapters. The National Council recognizes that much good work is being done in the local chapters and charges each and every one of you with the responsibility of continuing to serve the interest of sound scholarship.

While participation in itself is very worthwhile, one must not fail to realize that it is only by this means that we can recognize outstanding achievement. The individual who has done a creditable piece of work deserves recognition. In the world of the arts and sciences this recognition comes from being privileged to share one's ideas with your fellowmen. This sharing of ideas is indeed a privilege. One need not go far afield to find times when it was impossible to share ideas. Neither does one have to search deeply for the damaging consequences of such practices. From times long past the man with the sword has realized that ideas are weapons much sharper than the sword. And so it is with the mathematical ideas; you as students are discovering they too are weapons which in the future may become sharper than the sword. But to sharpen these weapons one must have the privilege of presenting them to interested groups. Furthermore the group must provide the opportunity for the individual to sharpen his sword. In other words, the group must develop talents and interests which are beneficial to society. This Kappa Mu Epsilon is doing by holding biennial conventions and organizing local chapters.

As you undoubtedly have noticed, your objectives also state that our purpose is "to develop an appreciation of the

power and beauty of mathematics." What has been the program of the National Council for implementing this objective? The Council has placed on the program men of outstanding scholarship in the field of mathematics who understand the power and see the beauty of mathematics. Men of this kind most fully realize that "the Science of Pure Mathematics, in its modern developments, may claim to be the most original creation of the human spirit."[1] The Council has asked these men to speak to you at this convention with the thought that those who see beauty, those who see and feel the power of mathematics, are likely to be the more able to lead us to see this beauty and feel this power. It is upon men of outstanding scholarship that we must rely to show us the majestic sweep of mathematical thought. They are the ones who can interpret for us the part that America has played in the development of modern mathematics. Some of the students present today may be privileged to participate in this development in the near future.

These then are a few of the things your Council has done to achieve some of the more important objectives of Kappa Mu Epsilon. I use the word "important objectives" advisedly. While consideration of new chapters of Kappa Mu Epsilon, National dues, and convention arrangements are the more tangible acts of the Council, it is the more intangible, yet more ultimate and fundamental purposes that we must continually keep in mind. Having discussed the intangible objectives briefly, let us now turn our attention to the more tangible acts of the Council.

Since the last convention at Normal, Illinois, the Council has had the privilege of welcoming eight new chapters into the organization. These are California Alpha, Pomona College, Claremont; Colorado Alpha, Colorado A and M College, Fort Collins; Missouri Gamma, William Jewell College, Liberty; Missouri Delta, University of Kansas City, Kansas City; Ohio Gamma, Baldwin-Wallace College, Berea; Texas Gamma, Texas State College for Women, Denton; Texas Delta, Texas Christian University, Fort

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[1]. A. N. Whitehead, *Science In The Modern World.* New York, MacMillan Co. 1925.

Worth; and Wisconsin Alpha, Mount Mary College, Milwaukee. It is hoped that at this their first convention the delegates of these chapters will absorb as much of the spirit of Kappa Mu Epsilon as it is possible to absorb in one convention and carry it back to their local chapters. We the older members of the Kappa Mu Epsilon wish them much success and extend to them a welcoming and a helping hand.

The Council is submitting for your consideration the petitions of three other mathematics clubs. These are The Mathematics Club of Central College, Fayette, Missouri; The Mathematics Club of Madison College, Harrisonburg, Virginia; and The Mathematics Club of Mississippi Southern College, Hattiesburg, Mississippi. You will be asked to vote on these petitions at this convention.

In addition to sponsoring petitions for new chapters, the Council has carried to completion some of the projects initiated under the most able leadership of your immediate past president, Dr. E. R. Sleight of Albion College. These include the revision of the initiation ritual, the adoption of an official shield with free copies issued to each chapter, and the printing of the constitution and the initiation ritual of Kappa Mu Epsilon.

Your president wishes to take this opportunity to commend the work of the editor of The Pentagon. Dr. Larsen has done an excellent piece of work in serving as editor. The Council is pledged to support The Pentagon to the best of its ability. It is one of Kappa Mu Epsilon's most worthy projects. I will not give you any statistics on The Pentagon inasmuch as we will hear from Dr. Larsen himself. However I do want to take this occasion to urge you to write papers for our official publication. A student has much to gain in writing a brief paper for The Pentagon.

Just about one year ago the National Council met at Albion College, Albion, Michigan, to give careful consideration to many of the proposals then confronting the fraternity. The Council feels that personal contact is essential for making many of its decisions. The United States mail is a boon to business as well as to Kappa Mu Epsilon, but it has its limitations. In view of these limitations annual meetings

of the Council are almost essential. The adoption of such a practice would mean that only routine matters need be transacted by mail. The more important matters, such as granting new chapters, matters of policy pertaining to The Pentagon and revision of the constitution would be considered only when the Council was in session. Such a practice, I am sure, would enable the Council to serve the fraternity more efficiently.

What does your President recommend for the next biennium? It is the recommendation of your President that the fraternity continue to emphasize student participation in the convention programs as well as in the business matters of the fraternity. In view of the number of papers submitted for this convention it might be well to consider a different organization of the program so as to allow more of these papers to be presented. Your President would further like to see more mathematics clubs from the stronger schools of the nation petition for chapters. In this local chapters can give considerable assistance. I urge the local chapters to develop a strong program and let the mathematical world know about it. Send a record of your accomplishments to the *American Mathematical Monthly*. I am sure the *Monthly* would be glad to consider your report for publication. Such practices can be justified on other grounds. Our fraternity will grow strong only if the local chapters grow strong; it will achieve its objectives only if the local chapters achieve their objectives.

With the presentation of these official reports the present Council is in the process of "closing its books." Each delegate should carry home a report of this convention. Let the newly elected members of your chapter know what Kappa Mu Epsilon has done and above all, tell them what Kappa Mu Epsilon would like to do.

CHAPTERS OF KAPPA MU EPSILON

ALABAMA ALPHA, Athens College, Athens.

ALABAMA BETA, Alabama State Teachers College, Florence.

ALABAMA GAMMA, Alabama College, Montevallo.

CALIFORNIA ALPHA, Pomona College, Claremont.

COLORADO ALPHA, Colorado A & M College, Fort Collins.

ILLINOIS ALPHA, Illinois State Normal University, Normal.

ILLINOIS BETA, Eastern Illinois State College, Charleston.

ILLINOIS GAMMA, Chicago Teachers College, Chicago.

ILLINOIS DELTA, College of St. Francis, Joliet.

IOWA ALPHA, Iowa State Teachers College, Cedar Falls.

IOWA BETA, Drake University, Des Moines.

KANSAS ALPHA, Kansas State Teachers College, Pittsburg.

KANSAS BETA, Kansas State Teachers College, Emporia.

KANSAS GAMMA, Mount St. Scholastica College, Atchison.

KANSAS DELTA, Washburn Municipal University, Topeka.

MICHIGAN ALPHA, Albion College, Albion.

MICHIGAN BETA, Central Michigan College, Mount Pleasant.

MICHIGAN GAMMA, Wayne University, Detroit.

MISSISSIPPI ALPHA, State College for Women, Columbus.

MISSISSIPPI BETA, Mississippi State College, State College.

MISSOURI ALPHA, Southwest Missouri State College, Springfield.

MISSOURI BETA, Central Missouri State College, Warrensburg.

MISSOURI GAMMA, William Jewell College, Liberty.

MISSOURI DELTA, University of Kansas City, Kansas City.

NEBRASKA ALPHA, Nebraska State Teachers College, Wayne.

NEW JERSEY ALPHA, Upsala College, East Orange.

NEW JERSEY BETA, New Jersey State Teachers College, Montclair.

NEW MEXICO ALPHA, University of New Mexico, Albuquerque.

NEW YORK ALPHA, Hofstra College, Hempstead.

OHIO ALPHA, Bowling Green State University, Bowling Green.

OHIO BETA, College of Wooster, Wooster.

OHIO GAMMA, Baldwin-Wallace College, Berea.

OKLAHOMA ALPHA, Northeastern State College, Tahlequah.

SOUTH CAROLINA ALPHA, Coker College, Hartsville.

TENNESSEE ALPHA, Tennessee Polytechnic Institute, Cookeville.

TEXAS ALPHA, Texas Technological College, Lubbock.

TEXAS BETA, Southern Methodist University, Dallas.

TEXAS GAMMA, Texas State College for Women, Denton.

TEXAS DELTA, Texas Christian University, Fort Worth.

WISCONSIN ALPHA, Mount Mary College, Milwaukee.

JOIN THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

I. The National Council of Teachers of Mathematics carries on its work through two publications.

1. *The Mathematics Teacher.* Published monthly *except in June, July, August and September.* It is the only magazine in America dealing exclusively with the teaching of mathematics in elementary and secondary schools. Membership (for $3) entitles one to receive the magazine free.

2. *The National Council Yearbooks.* The only available yearbooks at present are the third on "Selected Topics in Teaching Mathematics," the fourth on "Significant Changes and Trends in the Teaching of Mathematics Throughout the World Since 1910," the sixth on "Mathematics in Modern Life," the eighth on "The Teaching of Mathematics in Secondary Schools," the fourteenth on "The Training of Mathematics Teachers of Secondary Schools," the fifteenth on "The Place of Mathematics in Secondary Education," the sixteenth on "Arithmetic in General Education," the eighteenth on "Multi-Sensory Aids in Teaching Mathematics," the nineteenth on "Surveying Instrumentals—Their History and Classroom Use," and the twentieth on "The Metric System of Weights and Measures." These may be obtained for $3 each, postpaid. Send check to *Bureau of Publications,* Teachers College, 525 West 120 Street, New York 27, New York—not to *The Mathematics Teacher.*

II. The Editorial Committee of the above publications is W. D. Reeve of Teachers College, Columbia University, New York, Editor-in-chief: Dr. Vera Sanford, of the State Normal School, Oneonta, N.Y.; and W. S. Schlauch of Dumont, N.J.

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