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A STUDY OF ACHIEVEMENT AND SUBJECT MATTER IN GENERAL SCIENCE

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CHAPTER I

INTRODUCTION

In 1864 when Fisher[1] attempted to establish some standards by which the achievement of school children in different elementary school subjects could be measured objectively, he started a new era in scientific school administration. The public, however, was not ready to receive Fisher's suggestions, so for approximately forty years nothing was done towards their fulfillment. Later, in 1894, when Rice[2] startled even the more progressive school men with his facts regarding the insignificance of such factors as (a) the amount of time, (b) the social status of the school or of the pupil, and (c) the time of day at which the subject was taught, as related to the success of the pupil in a given subject, the work of Fisher gained impetus. During the twenty-five years following Rice's monumental work, the American elementary and secondary schools have been the ground for many standardization, measurement, and curriculum studies.

Today the status of the subject matter of elementary and secondary school subjects varies anywhere from the practically established state of Latin to the most experimental state found in some of the vocational subjects. Standards in subject mat-

1. "See Jr. of Ed. Psy., vol. 4, pp. 551. A quotation from The Museum, a Quarterly Magazine of Education, Literature, and Science, vol iii, 1864, is reproduced as a communication" - Thorndike.
2. Rice, J. M. "The Futility of the Spelling Grind". The Forum: 23:163-172. PP 409-419, 1897.

ter range anywhere from the well established four fundamentals in arithmetic to the rather subjective standards used in General Science. Methods of measurement of achievement in the various subjects range anywhere from the scientifically established test and scales, as in spelling and reading, to practically none at all, as in manual training and civics.

In spelling, for instance, we have the work of Ayres, Thorndike and Buckingham, all of whom have attempted not only to ascertain what words in the English language are most necessary in the average adult's vocabulary but also to ascertain which of those necessary words the school children of different ages are capable of mastering. That information, once scientifically established, can be made the basis of selection of subject matter for each school grade, of method of presentation of subject matter, and of measurement of achievement in the subject. Such studies would serve to show what words can be most economically and usefully taught in different school years and what words the child will master in the natural course of events as the result of other similar words previously mastered. They would also serve to show the relation of achievement in subject matter to abilities, either special or general, and to other subjects simultaneously or previously pursued. It is clear that a study of this kind thoroly and completely carried out in any school subject, once that school subject is itself located in the school curriculum both as to time and place, would serve to secure maximum achievement and maximum usefulness with a minimum of effort.

The subject of "General Science" is a comparatively recent addition to the secondary school curriculum and as a result of its comparative youth is as yet unstandardized and undefined both as to subject matter and achievement. In spite of its newness and the generalized nature of its content, however, General Science has aroused a volume of popular interest sufficient, not only to warrant its place among the secondary school subjects but also to place it among the required subjects in numbers of secondary schools. Consequently, to the writer -- himself a teacher of General Science and keenly aware of the lack of standards and the lack of information regarding the relative values of different elements in the subject -- a scientific analysis of the subject matter of General Science seems distinctly worth while.

CHAPTER II

PURPOSE

In general, the purpose of this study is the development of a measure of achievement in General Science in order to ascertain the relative amount of General Science subject matter possessed by school children, both that which is already common knowledge to the pupils thru "experience" and that which is acquired specifically thru instruction in General Science or in other science courses. It would also serve to measure amount of information retained and would indicate factors which limit and modify the acquisition and retention of General Science subject matter.

More specifically, the purpose of this study has been differentiated as follows.

(1) To ascertain to what extent the material supposedly taught in the General Science course is already possessed by pupils before taking the course. It has been the experience of the writer that pupils in a given section, purposely selected for its homogeneity of ability, came to the class at the beginning of the year with various amounts of the subject matter already in their possession. In other words, certain portions of the generalized subject matter of General Science appear to be common knowledge, whether one has or has not taken the subject of "General Science".

(2) For this reason a diagnostic test is to be developed which will serve to place pupils into sections homogeneous as to the point at which their General Science course should begin and as to what it should include.

(3) To find out to what extent the subject matter of General Science has been mastered sufficiently by pupils, who have had General Science, to enable them to state it objectively.

(4) To ascertain how much of the material once mastered is retained one year, two years and three years later.

(5) To study the differences between boys and girls, both as to the common knowledge of and as to the acquisition of the subject matter of General Science.

(6) To investigate the relative difficulty of different items of the subject matter of General Science for boys and girls. This is important in order to determine whether there is any real difference in difficulty which would justify the popular belief that General Science is easier for boys, or that some parts of General Science are best mastered by boys.

(7) To compare achievement in General Science for different school grades, as determined by General Science test scores. The comparisons in General Science achievement of 8th grade pupils and of 9th grade pupils would be especially desired by Junior High School advocates.

(8) To ascertain what General Science information is acquired by pupils who do not take General Science. For this purpose control groups of pupils, who had not taken General Science, were used.

CHAPTER III

SURVEY OF LITERATURE ON GENERAL SCIENCE

A. History of General Science

The teaching of Chemistry as a college subject began in the United States as early as 1767 at Columbia College. As a secondary school subject Chemistry made its debut in 1819 at Hassam Private Academy, North Carolina.[1] Since then other sciences have appeared in the secondary school curricula. These sciences in the main tended towards such high specialization that about half a century later there began to be felt a need for a kind of science teaching which did not have as its goal specialization in science, but which did fill an immediate and perhaps even a local need.

Such a "reform" course was offered in 1869 by Thomas H. Huxley[2] who gave a series of illustrated lectures to London children at the Royal Institution and later published the course in a book entitled "Physiography". In this course Huxley dealt with the immediate vicinity of London and the Thames. His subject matter embodied the physiography and geology of the Thames' Basin and the activities of the London people. The course was informational and scarcely suited for the pupils of Edinburgh or Boston, but it filled a desired end.

1. Powers, S. R. "A history of the teaching of Chemistry in the secondary schools of the United States previous to 1850". Research Publications of the University of Minnesota. No.13, p. 16.
2. Twiss, G. R. "A textbook in the principles of science teaching". The Macmillan Co. N.Y. 1921.pp. 411-435.

It is interesting to note that Huxley gave as his aims of the introductory science course much the same objectives as are outlined today for General Science. To quote,-

1. "To furnish in the first year of the high school the information and the training in thinking that are fundamental to the special sciences and are necessary to the successful pursuit of these sciences later on in high school or college.
2. To impart information from the scientific standpoint about the useful and interesting things that are all about us, especially for the benefit of those who will not go on to college and may not go farther in high school, and who therefore would otherwise remain ignorant of scientific facts and of the scientific way of dealing with the materials and forces that are everywhere available for our use.
3. .....One writer regrets the failure of the schools to produce the crop of amateur scientists which is essential for keeping alive the popular interest in science so necessary to scientific progress in the nation. It would seem to be a worthy aimof a general science course to stimulate and foster such amateur interest in science.
4. .....He is free to organize these materials with reference to these interests and these needs and to make voluntary problem-solving and purposeful information-getting the proximate aim of the pupils. He may thus hope to train the youngsters in methodically gathering information and applying systematic thought to the things in the environment that they desire to comprehend and manage.
5. It is thought by some that a general science course may serve to show something of the relations of the sciences to one another, of the order and unity that exist in nature, and of the essential unity of the scientific method, and thus that it may appeal to imagination, contribute to a state of mental poise or balance, and perhaps develop some power of interpretation that could nott so well be gained by separate courses in the special sciences." (pp.415-417)[1]

From 1869 to the present, especially since 1900, an elaboration of Huxley's "Physiography" has been widely taught under the name of General Science. Few of these courses, according to Twiss,[1] surpass that of Huxley in organization and general local merit, because there are few "Huxleys" to teach them. From about 1912 to date, however, there have been many serious attempts to outline

1. Twiss, G. R. Ibid.

objectives for General Science which would satisfy the long felt need of a science course in high school which did not aim at developing Edisons, but rather at teaching youthful citizens how to make use of Edison's work. Typical of writers in this vein are Barber,[1] Eikenberry,[2] Hessler,[3] and Downing.[4]

B. Objectives of General Science

Because there have been few "Huxleys" to teach and to organize the courses, General Science has undergone numerous experimental changes, most of which have been for the better. At the present time courses of study and textbooks vary widely. In a recent study Webb[5-6] found that on classifying the subject matter of eighteen of the most commonly used textbooks of General Science that it could be divided among eight basic secondary school sciences as follows.

Subject	No. of Topics		
Physics	56	Chemistry	33
Physiography	22	Domestic Science	13
Botany	22	Astronomy	10
Zoology	17	Mscl.	9
Physiology	24	Total:	206

1. Barber, F. D. "Fundamental considerations in the reorganization of High School science". School Review 24:724-734. 1916.
2. Eikenberry, W. L. "Facts about the General Science situation". School Review 23: 181-191. 1915.
3. Hessler, J.C. "General Science in the first year". School Science and Mathematics. Vol. XVI. pp. 407-411, 1916.
4. Downing, E. R. "What standard tests in science should do". School Science and Mathematics. Vol. XIX. pp. 651-654, 1919
5. Webb, H. A. "General Science instruction in the grades". George Peabody College for Teachers Contributions to Education, #4, McQuiddy Printing Co. Nashville, Tenn. 1921.
6. Webb, H. A. "Quantitative analysis of General Science". School Science and Mathematics. Vol. XVII. pp. 534-45. 1917

Because of the wide range of subject matter which might be included in a course of General Science, there has been a growing feeling among science teachers that fairly concrete and definite objectives ought to be formulated, which could be used as guides for limiting or extending the work in General Science. Therefore, at the instigation of the Science Section of the North Central Association of Science and Mathematics Teachers, Miss Philipine Crecelius prepared a report on the objectives of General Science[1]. Miss Crecelius sent out a questionnaire formulated by S. R. Powers and from the returns was able to evaluate opinions of about 100 science teachers regarding the relative importance of 14 objectives of General Science. These objectives are given below in the order of the values assigned.

1. "To provide opportunity for acquaintance with such elementary laws of nature as are necessary for the health of the individual and the community.
2. To give children information about those appliances which science has developed and which are useful in making for greater comfort and convenience in the home and community.
3. To provide opportunity for acquaintance with the simpler applications of science in public utilities in order that the individual may more adequately fulfill the duties of citizenship.
4. To provide opportunity for acquaintance with the elementary laws of nature which aid in understanding those citizenship problems which arise in connection with such topics as conservation of our natural resources, smoke elimination etc.

1. Crecelius, Philipine "A report on objectives of General Science teaching". School Science and Mathematics. Vol 23: 313-319.1923.

5. To contribute such specific ideals, habits, and concepts as those of accuracy, persistance, open-mindedness, honesty, cause and effect which are essential to the study of science.

6. To give to pupils a broad and genuine appreciation of what the development of science means in modern social, industrial, and national life.

7. To provide opportunity for the student to explore the fields of science for the purpose of educational and vocational guidance.

8. To satisfy the natural interests in the things and forces of nature with which men are surrounded and with which they must deal; to give information interesting purely for its own sake.

9. To develop system, order, neatness, and possiblyother attributes to the end that they will function in the ordinary affairs of life.

10. To afford in some measure an opportunity to show the importance of scientific research and to stimulate the spirit of investigation and invention on part of student.

11. To make pupils able to read more intelligently and with greater interest, articles on science in magazines and scientific books of a popular character and to read with greater understanding literature containing scientific allusions.

12. To correct common superstitions and ignorant practices.

13. To give children a full opportunity to indulge in the playful manipulation of toys, tools, machines etc., in order that they may explore the world of reality as deeply and widely as possible.

14. To give such training as will result in increasing respect for the work of recognized experts."

It may be worth while to note that while these objectives were not available when this study was begun, the writer used a somewhat similar set of objectives in the construction of the original test and final Scale Forms for the measurement of achievement in General Science. The writer tried to make each item satisfy one or more of the Cardinal Principles of Education,[1] namely,

1. Health
2. Worthy use of leisure
3. Vocation
4. Citizenship
5. Worthy home membership
6. Command of the fundamental processes
7. Ethical character.

Recognition of the value of properly selected principles and facts of science for immediate, everyday use, has led to the development of courses in "Nature Study" for the elementary grades. Some of these courses in "Nature Study" are adapted for pupils as far down as the first and second grades. With the motto "Study Nature First: then Books about Her", Miss Conover[2] of the Detroit city schools has organized a "Nature Study" course for pupils in the first and second grades. This course of study is well worth the attention of General Science teachers as well as of first and second grade teachers. It is an excellent illustration of what can be accomplished in the construction of a course of study around specific objectives.

1. Cardinal Principles of Secondary Education. U. S. Bureau of Education Bulletin, 1918, No.35.
2. Conover, Lenora "Course in Nature Study". Board of Education. Detroit Public Schools, 1922.

C. Achievement tests in General Science

In the interval between the work of Rice and the present time, a time which has been characterized in Education by the development of tentative standards of achievement in school subjects and of tentative measuring devices for measuring the achievement of these standards, men in the field of secondary school science have contributed or attempted to contribute to the current test movement. To be sure the preliminary attempts were handicapped by the same conditions which characterized the preliminary attempts at measurement in the other subjects, that is, lack of consideration of the many factors involved in the development of a statistically accurate measuring instrument. They were also handicapped by the fact that teachers of science in colleges and secondary schools were trained more or less only in the field of the specialized science which they taught. A Physics teacher was trained in Physics and a Chemistry teacher was trained in Chemistry. Usually neither of them had any training in Educational practices and technique. This has frequently resulted, as stated under "History of General Science" in this Chapter, in a desire on the part of the teacher to emphasize the teaching of a specialized subject, Chemistry or Physics, as a preparatory course for pupils all of whom were assumed to be beginning a prolonged and specialized course of training in that science. In contradiction to this assumption is the common knowledge that a very limited percent of pupils taking a science course in the high school continue their work in science even to the extent of taking an additional course in college, much less

becoming specialists in that particular field. Because of this condition some of the attempts made to measure science achievement have not endured the effects of analytical educational criticism.

For instance, in a recent article by Doctor Foley[1] of the University of Indiana is a severe criticism of the achievement of high school pupils in Physics. Doctor Foley bases his criticsm on a ten item test which he gave to about 700 students entering the University and who presented high school credit in Physics. Doctor Foley's work is open to criticism itself because he says nothing about the difficulty of the ten items and their bearing on a high school course is not evaluated. Doctor Foley does not state whether or not students who have taken his University course in Physics would, one or two years later, do any better on his test than did the high school pupils.

In the field of Physics at least four other tests besides Doctor Foley's may be mentioned. Daniel Starch[2] prepared a test of Physics consisting of 75 questions, problems and incomplete statements differentiated among mechanics, heat, light, sound, magnetism and electricity. On the basis of a comparatively small number of pupils he then prepared standard scores in each of the differentiated aspects of Physics. This test of achievement in Physics is open to two main criticisms, namely (a) all the items are given equal value and (b) the standard scores were secured

1. Foley, Arthur L. "The College student's knowledge of high school Physics". School Science and Mathematics. Vol 22, No. 7 pp. 601-613.
2. Starch, Daniel "Educational Measurements". Macmillan Co. N.Y. 1916.

on too few cases.

J. Crosby Chapman[1] prepared a test of Physics in electricity, magnetism, sound, and light which consisted of 30 questions which were answerable by one word which the pupil was to write in. Criticism of this is that thirty words, the answers to the thirty questions, in the four fields of Physics mentioned, are a very small number of samples by which a pupil's achievement should be judged. The test was standardized by giving it to 158 high school pupils just finishing the study of Physics. As the author states, "This is meagre evidence as to the suitability of this type of test but from a large amount of evidence obtained when engaged in army work, the author is convinced that tests of this kind are well worth while (words underlined by writer) when employed for the limited purpose for which they are designed."

The Randall, Chapman and Sutton "High School Physics Test"[2] consists of 14 problems with spaces for the pupils to put the answers.

Franklin T. Jones[3] worked out a preliminary set of tests in Physics ("Union Science tests for practice and comparison"). These consist of twenty-eight individual tests of five to ten problems or questions each under different headings, such as "thermometers", "heat", "work", "light A", "light B", Each of these 28

1. Chapman, J. C. "The measurement of Physics information". School Review 27: 748-49. Dec. 1919.
2. Randall, Chapman, and Sutton. "The place of the numerical problem in high school Physics". School Review 26: 39-43. Jan.1918
3. Jones, F. T. "Practice exercises in Physics and Chemistry". School Review 26: 341-48. May 1918

tests could be better characterized as Chapter Test, to be given at the completion of each of the subjects mentioned. These tests if properly evaluated would be of much help to teachers.

Harold L. Camp[1] of the University of Iowa produced in 1921 some "scales for measuring results of Physics teaching". This work, a Doctor's thesis, is very well worked out with one exception, - that in many items as few as sixty cases, in no case more than one-hundred forty-nine cases, were used to secure standards.

L. L. Thurstone[2] also has prepared a test in Physics for college freshmen and high school seniors which consists of 25 short problems.

In Chemistry there are at least five tests for measuring students' achievement. J. Carleton Bell[3] has prepared a Chemistry test of 24 brief questions and 1 problem. Jones[4] has a Chemistry test (Union Science Series) which is of similar nature to his Physics test mentioned above.

Hanor A. Webb's test in Chemistry[5] consists of a series of names of Elements, Mixtures, and Compounds. The pupil's problem is to label these names "E", "M", or "C" as he judges them to be Elements, Mixtures or Compounds. Tentative norms have been worked out.

1. Camp, H. L. "Scales for measuring results of Physics teaching". Univ. of Iowa studies in Education. Vol. II #2. Pp.50
2. Thurstone, L. L. "Test V. Physics". Carnegie Institute of Technology, Pittsburgh.
3. Bell, J. C. "Study of the attainments of high school pupils in first-year Chemistry". School Science & Mathematics.18: 425-432, May 1918
4. Jones, F. T. Ibid
5. Webb, H. A. "A preliminary test in Chemistry". Jr. of Ed. Psy. 10: 36-43. January 1919

B. J. Rivett's Chemistry test[1] consists of (a) 31 elements, the problem being to label them with the proper symbols, (b) a list of the 20 elements, the problem being to give their valence and 20 of their compounds with their formulae, and (c) 20 formulae, the problem being to give the names of the compounds for which they stand and state whether the compound is an acid, base or salt.

The General Chemistry test by Henry L. Gerry[2] follows a somewhat more scientific procedure, but this test is still in its trial form and no results are available.

S. R. Powers'[3] Chemistry test, now completed, is one of the most elaborate and most scientific of all the science tests now being presented. It was constructed with consideration of the objectives of General Science, the items are evaluated, and the Scale is standardized with preliminary norms, now available, based on 1200 pupils.

A test in Biology by Leo M. Cossman[4] consists of a list of words which the pupil is asked to define and of spaces where the pupil is asked to make drawing of a typical "insect", a typical "flower" etc. There is no way of scoring the test objectively.

N. M. Grier[5] has prepared an achievement test in Physiology,

1. Rivett, B. J. "Testing results in Chemistry". School Science & Mathematics. 19:742-745. Nov. 1919
2. Gerry, H. L. "Trial test in general Chemistry". Graduate School of Education, Harvard University.
3. Powers, S. R. "Chemistry Test" (World Book Co.) University of Minnesota.
4. Cossman, L. M. "Biology". University of Oregon.
5. Grier, N. M. "Range of information test in Biology". Jr. of Ed. Psy. 9:210-16, 388-93. April-September, 1918.

Botany and Zoology, each of which consists of 100 words of technical nature pertinent to those subjects. Pupils' instructions are

" 1. Place a D before the terms you can define as exactly as words are ordinarily defined in the dictionary.
2. Place an E before the terms you can explain to one not familiar with their meaning
3. Place an F before the terms with which you are roughly familiar
4. Place an N before the terms which are new to you
5. At the bottom write out the definitions of the first five words you marked D, and the first five you marked E
6. Count the number of D's, E's, F's, and N's and record the result at the top of the page in the one inch space".

F. T. Ullrich[1] has a similar test in Agriculture. The main objections to the tests by Grier and Ullrich are the difficulty of properly scoring them and the fact that the person evaluating a paper cannot know, by a study of five samples of dictionary definitions, whether a "D" means that the pupil putting down a "D" really knows the dictionary definition or not. Furthermore, there is a question whether dictionary definitions are really what one is trying to teach in a science subject.

Glenn and Powers* were experimenting with a General Science test which will be discussed in the chapter on "Method".

G. M. Ruch,[2,3,4] after experimenting with a similar test in General Science, finally evolved a very commendable multiple answer test consisting of 50 statement of General Science facts and 20

1. Ullrich, F. T. "Tests in agriculture". State Normal Schools Platteville, Wisconsin.
2. Ruch, G. M. "A range of information test in General Science". General Science Quarterly 4:257-62. Nov. 1919
3. Ruch, G. M. "Range of information test in General Science; preliminary data on standards". Gen.Sci. Quarterly 5:15-19. Nov. 1920
4. Ruch, G. M. "A new test in General Science". General Science Quarterly 7:188-197. March, 1923.

* Earl R. Glenn, Teachers College, Columbia University
Samuel R. Powers, University of Minnesota.

lettered diagrams. Concerning these diagrams are a number of completion statements which the pupil is asked to complete with the proper diagram letter.

There are also the Caldwell[1] Science Tests, Downing's[2] Information Test in science, and Herring's[3] test in Scientific Thinking.

With the exception of the tests by Powers, Ruch and Camp, the tests for secondary school science measurement mentioned in the preceding paragraphs, have not developed beyond the preliminary steps of test construction. They are not, however, without value. They represent attempts in the scientific measurement of classroom products by men in the field of secondary school science. The writer has surveyed all this literature carefully and is indebted to the authors for valuable suggestions regarding procedure and for a few of the items actually used in his General Science test. To Ruch he is especially indebted.

1. Caldwell, O. W. "The Gary public schools: science teaching". The General Education Board, N.Y. 1919
2. Downing, E. R. "A range of information tests in science". School Science and Mathematics 19:228-83. March 1919
3. Herring, J. P "Measurements in scientific thinking". Jr. of Educational Psychology 9:535-58. December 1919

CHAPTER IV

METHOD

One of the first essentials in this study was to build up a preliminary measuring instrument of subject matter in General Science. Since economy of time, accuracy, and objectivity were considered valuable characteristics of this measuring device, the following criteria were considered in the construction of the preliminary test.

(a) The material selected should cover the field.

(b) The material should range from easy to difficult.

(c) The arrangement of the test should be such as to facilitate readability on the part of the pupils.

(d) The arrangement should be such as to facilitate accuracy in scoring.

(e) The items of the test should be definite and clear.

(f) There should be only one acceptable response to each item.

(g) The test should be given to as wide a range of pupils as possible in order to test its selective power.

For the purpose of developing such a measuring instrument the writer procured two unfinished studies begun simultaneously, the one by Earl R. Glenn, Lincoln School, New York, and the other by Samuel R. Powers, University of Minnesota. These studies represented a partial compilation of General Science material in the form of objective multiple answer statements, problems, and science vocabulary. To these the writer added material in the same subject matter which was pertinent but which was not included in the above compilations. This additional material was gleaned from various kinds of preliminary at-

tempts in General Science measurement*** and from a survey of General Science textbooks. The resultant total number of individual items amounted to about six hundred. Out of this total were selected three hundred items which seemed to be most definitely related to the subject, most objective in nature, and most justifiable in terms of the cardinal principles of education.[1]

These three hundred items were then reduced to the multiple answer type of statements. The list of three hundred statements when completed was reviewed by two science teachers at the University Highschool, University of Minnesota, who agreed that the choice of the three hundred items was inclusive and well differentiated among the different kinds of subject matter which go to make up General Science. In as much as the list of three hundred items was to be revised and worked over later on the basis of pupil achievement, it was deemed satisfactory when it passed the combined judgments of three University Highschool science teachers.

The three hundred items were arranged in as random an order as possible. No one knew the order of difficulty of the different items. For each item the number of multiple answers was five. As will be shown later, this number of possible answers reduced successful guessing to a negligible amount.

The General Science test* of three hundred items and a list of instructions for the person giving the test** were sent out to principals or superintendents of twenty-two school systems with whom arrangements for the giving of the tests had previously

* See Appendix I
** See Appendix II
*** See Chapter III

1. Cardinal Principles of Secondary Education. U. S. Bureau of Education Bulletin, 1918, No. 35.

been made by personal letter. The list of instructions was mimeographed but the test was printed in order to facilitate accuracy and speed on the part of the pupils and accuracy and speed in scoring. The schools selected to give the test represented large, medium and small school systems of Minnesota. All pupils in the 8th, 9th, 10th, 11th, and 12th grades of the twenty-two school systems, with the exception of the three largest school systems, were given the test provided they happened to be present at the particular hour on the day when the test was presented. The total number of pupils who took the test approximated eleven thousand. In each of the three largest school systems the 8th grades of two most representative grade schools and all the pupils in one highschool were given the test. All tests were taken by the pupils between the first and tenth of June, 1922. Table I shows number of returns of the test in terms of schools and grades.

In order to carry out comparative studies, control groups consisting of several schools where no General Science is taught were selected. One of these was the Johnson Highschool in St. Paul with about 800 pupils.

The test was also given to 339 University of Minnesota students in Physics and Chemistry classes and to 33 Normal School students attending the summer session, 1922, at Moorhead Teachers College.

In September, 1922, 140 pupils in the University Highschool were retested with the same test. Results of the retest and of the original test were compared for purposes of securing some idea as to the stability or reliability of the measuring device

TABLE I

TOTAL NUMBER OF RETURNS OF GENERAL SCIENCE TEST FROM 22 SCHOOLS

SCHOOL SYSTEM	GRADES 8th	9th	10th	11th	12th	TOTAL
Annandale	25	33	18	26	9	111
Alexandria	41	97	78	64	75	355
Crookston	80	87	74	50	46	337
Duluth	96	220	400	313	237	1266
Excelsior	29	44	25	14	17	129
Ely	109	105	63	62	57	396
Fertile	25	38	22	23	9	117
Glencoe	35	25	34	20	23	137
Hibbing	151	149	131	83	78	592
Hopkins	62	68	24	26	24	204
Mankato	115	131	168	126	128	668
Minneapolis	65	730	588	414	380	2177
Moorhead	92	99	81	67	48	387
New Ulm	30	73	56	42	50	251
Red Wing	93	138	89	79	61	460
St. James	34	73	50	40	32	229
St. Paul	66	317	187	132	92	794
Slayton	23	27	30	30	27	137
Swanville	12	24	12	6	7	61
University Highschool	61*	57	59	37	48	262
Virginia	197	238	135	148	85	803
Worthington	48	64	37	38	35	222
Normal school students						33
University students						347
TOTALS	1489	2837	2361	1840	1568	10475

*Pupils who were examined in June as prospective University High-school pupils.

in General Science with respect to a given group of individuals.

Procedure in handling the data.

(1) Fortunately a graduate student and science teacher, reliable and systematic, was enlisted as a paid assistant to sort and to score the entire set of approximately 11,000 tests. First all test papers were sorted for the purpose of eliminating those in which vital data, such as name, age, classification of pupil, and answers to questions about courses previously taken by the pupil, were omitted. Then the assistant scored each test by means of celluloid stencils, the use of stencils facilitating the scoring and increasing the accuracy, and entered the total score made by each pupil on the upper right hand corner of the first page of each test.

(2) After the tests were scored they were sorted according to (a) name of school, (b) the five grades within each school - 8th, 9th, 10th, 11th and 12th, (c) sex of pupils in each of the classes, and (d) whether each pupil in each grade had or had not taken General Science. This meant that each grade might be divided into four groups e.g. boys and girls who had taken General Science and boys and girls who had not taken General Science. This made it possible to have each school divided into twenty groups in order to facilitate the handling of data in the different group studies.

Since experimental work with the test results of these groups occupies a large portion of this study, considerable time would be saved by the use of a few descriptive terms for naming each of the twenty groups. Therefore, since this

study has to do with General Science achievement, it was decided to use the symbol "+" to characterize any group of pupils who had taken General Science, while any group of pupils who had not taken General Science was characterized by the symbol "-". Then, by adding to the "+" or "-" the sex initial e.g. "G" or "B" for Girls or Boys respectively, and the grade number, e.g. 8th, 9th, 10th, 11th, 12th, a complete, descriptive term for any one of the twenty groups was established. To illustrate, "-8B" is interpreted in this study to mean 8th grade boys who had not taken General Science and "+11G" is interpreted to mean 11th grade girls who had taken General Science. This system of nomenclature is used thruout the study in text, tables, and figures.

(3) Test score, age, length of time in school, time taken in doing the test, science courses taken, whether or not the pupil liked science, and mental test score (when available) were then tabulated for the different schools in terms of the twenty different groups already described.

(4) The frequency of correct responses for each of the 300 items of the test was secured by actual count of errors for each item in 1760 cases. The percentage of correct responses and the relative order of difficulty were secured for a group of 500 8th grade girls and for a group of 400 8th grade boys who had not taken General Science. Similar data were secured for groups of 430 9th grade girls and for 430 9th grade boys who had taken General Science. These data were then used as a basis for making three scales out of the original General Science test of 300 items. The number of cases taken for this

part of the study was sufficient to give as accurate results as would be given by an infinite number of cases. In the study each group was divided in two parts and the percent of correct responses for the first part was compared with the whole. Rank order correlations between the two distributions were over .99.

(5) The distribution of scores and the median score in the General Science test were secured for each of the twenty groups of each of the twenty-two school systems. From a combination of the median scores and the distributions of scores for the different schools, tentative grade norms for the General Science test were secured.

(6) Statistical evaluations.

The following are some of the correlations worked out for the purpose of establishing the reliability of the 300 item test as a measuring instrument in General Science

(a) The correlation between intelligence test results and the results of the General Science test.

(b) The correlation between chronological age and the General Science test.

(c) The correlation between time in taking the General Science test and success in the test.

(d) The correlation between general scholastic success and the General Science test, University Highschool.

(e) The correlation between marks in General Science and the General Science test, University Highschool.

(7) One hundred and sixteen pupils for whom both test and retest results were available were studied for stability in response.

(8) The median scores and distributions for +groups of pupils, pupils who had taken General Science, were secured. The same data were also secured for the -groups of pupils, pupils who had not taken General Science.

(9) Grade medians for 9th, 10th, 11th, and 12th grade pupils who had taken General Science were compared with medians in the same grades for pupils who had not taken General Science in order to isolate success in the General Science test due to having pursued a course in General Science groups under approximately similar conditions.

(10) Norms for pupils who had taken General Science in the 8th grade were compared with norms for those who had taken General Science in the 9th grade. The greater or less success of these pupils would tend to justify the placing of General Science up or down in the school curriculum, the latter being the tendency in junior high schools.

(11) A measure of the persistence of General Science material and of its acquisition in later science courses was secured from a study of the achievement of University and Normal school students, about 350 in number.

(12) Because not all of the pupils had been allowed sufficient time to complete the General Science test and because it was found that equally accurate comparisons could be made on the basis of the first three pages (the first 221 items of the test)

of the test, all the usable papers - about 9,000 in number - were rescored and retabulated on the basis of the 221 items and comparisons similar to those made with the 300 items were obtained.

(13) When the Scales had been made, for the purpose of comparing Scale and test scores for the same pupils and groups, a hundred of the original papers were selected at random from each grade for the + Boys and were rescored on the basis of only the items in the Scale.

(14) Finally, two forms of the finished Scales were mimeographed and given to General Science pupils in three schools--(a) Central Highschool, Minneapolis -250 pupils, (b) Stillwater Highschool -140 pupils, and (c) University Highschool -58 pupils. Two Scale Forms of equal difficulty were given to check up the reliability of the Scales themselves and to compare Scale achievement with marks in General Science, intelligence test scores, etc.

CHAPTER V

RELIABILITY OF THE GENERAL SCIENCE TEST

It is needless to say that if the General Science test were unreliable, any comparisons or developments of that test would carry with them the same unreliability. Therefore, before proceeding further with the exposition of this study, statement will be made concerning the reliability of the original 300 item General Science test given to approximately 11,000 pupils.

Study of results has shown that the original test with its inherent faults of extreme length and of a few valueless items was highly reliable. Evidence of this reliability of the test is presented in terms of the following criteria.

(1) Retesting
(2) Permanency or stability of the pupils' correct and incorrect responses
(3) High positive correlation with other criteria of known value
(4) Correlation between a part and the whole of the test.

(1) Retesting

In September, 1922, 116 pupils of the University High-school were retested with the same test. The majority of these pupils were beginning sophomores who had finished General Science the preceding June, a small number were freshmen who had been tested on June tenth as 8th grade pupils, and the remainder were juniors and seniors in science classes.

For the purpose of ascertaining the stability of the achievement as shown by one testing, the results of the second

test were compared with those of the first test given the preceding June. Since the first test had been given at the very end of the school year and the second test had been given at the beginning of the following school year, with only three months of vacation intervening, it would seem that rather ideal conditions were secured for establishing the reliability of the measuring instrument used. The three months of vacation were sufficient to allow the pupil to foregt enough of the details of the test taken in June to make the scores secured in September fair measures of the pupil's achievement at that particular time. At the same time the three intervening vacation months added little to the pupil's fund of General Science information other than that which he had gained by simply living three consecutive months outside of the schoolroom.

When the first and second test papers were examined it was found that while all the retest papers were completed, among the June tests there were only 75 papers in which all 300 items had been marked and 41 papers in which only the first three pages, or 221 items, or a little more were marked. Therefore it was deemed advisable first to compare the 75 completed papers with their 75 completed retests and then to rescore the whole 116 papers on the basis of the first 221 items and to compare those 116 scores with the retests for reliability.

Both in the complete test and in the 221 item test correlations with retests were very high, as can be noted on the following page.

	Number pupils	Sigma 1*	Sigma 2**	r	P.E.
Complete test...	75	42.7	36.0	.877	.02
221 item test...	116	35.6	28.0	.82	.02
Mean				.85(.847)	

These coefficients of correlation would indicate that the ability of the original General Science test to differentiate among pupils was fairly constant, that is, a pupil who scored high on the first test would also score high on the second test and a pupil who scored low on the first test would consistently score low on the second test. On account of the narrow range of the group tested, however, the correlations of .82 and .88 (.877) - mean .85 - are relatively high.

(2) Permanency or stability of the pupils' correct and incorrect responses

The papers of the 116 University Highschool pupils who had been retested were subjected to another examination for the purpose of determining whether a pupil's responses to particular items in June and in September showed variation. In other words, how permanent were the responses made in June to the various items?

It is conceivable, while not probable, that a pupil taking a 300 item test in June and making a score of 150, a score of 50% right, on taking the same test in September might again make a score of 150 or 50% right. It is further conceivable that an examination of the actual items failed the first time and items failed the second time might show a variation from

*Standard deviation on first test.
**Standard deviation on retest.

a condition where the same 150 items were right in each trial to a condition where no item of the 150 originally correct was correct the second time. In either case a correlation between first and second scores would be 1.00, whereas the reliability of the items would be zero. As a measure of the relative amount of achievement such a condition might be satisfactory, for it gave the same total score each time, but as an indicator of the kind of material on which the pupil failed such a condition would be highly unsatisfactory. - It is to be understood that the above assumptions are only theoretical possibilities and not what was even probable.

In the present study it was ascertained what percent of each of the 116 pupils' responses were identical in the two tests and what percent varied. This was done by taking note of all the individual errors made on the second test and all the individual errors made on the first test and then comparing the two sets to find out which errors were made both times and which errors were made only once. The method used in locating the errors was as follows.

The scored original test was spread over the scored retest paper, the two were clipped together securely and with a pencil point were punched thru on the item numbers where errors were marked on the original test. That is, on a retest paper, where an error persisted, the retest paper would have both a marked error and a hole punched thru from the original. Where the original paper had an error which had not persisted only a hole would be found. Where the retest paper had an error which did

not appear in the original, only a marked error would be found.

Results of actual count on the retest papers of holes alone and of marked errors alone showed that with the exception of a small percent the responses were uniform in both trials. In other words, an item correctly marked in June would be correctly marked in September and an item incorrectly marked in June would be incorrectly marked in September. The actual percents of pupils' responses in two trials which were not identical ranged from 3.9% to 16.5% - median 8.7% (Standard Deviation of 1.5). Since a deviation from identical response on one item would cause two counts of it to be taken, that is, if a pupil changed a wrong response up or down one place from the place of that wrong response in the original paper, there would be a hole punched thru from the original where no error was found and a marked error on the retest where no hole had been punched thru from the original. Both were counted as variations. Apparently from 1.9% to 8.2% - median 4.35% - of the responses varied from June to September. In as much as the scores made on the two tests varied from 57 to 256 or the number of "wrongs" varied from 243 to 46, it would seem that this 4.35% represents the median number of variations due to guessing. Underlining of the correct response twice at intervals of three months, when there are five possible responses, could not be attributed to pure guess. In short, the stability of the items, or their tendency to secure from the pupil the same response whether it be right or wrong, was such that uniform responses amounted to over ninety-five percent of the 300 items of the General Science test.

The P.E. of estimate, based on retest correlation, using formula P. E. of estimate equals the P. E. times square root of 1-r square, was 9 points. In other words, the true scores made by pupils if an infinite number of trials were given would not differ by more than 9 points from the score obtained at the first trial.

(3) High positive correlation with other criteria

It was first ascertained by retesting pupils with the 300 item General Science test that the test had a tendency to give individual pupils relatively the same ranking on its second test as it did on its first. In other words, the measurements of the original 300 item test resembled measurements of a steel ruler a much as is indicated by a positive correlation of .85 between two measurements. It was further ascertained that this positive correlation of .85 was made by identical responses to over 95% of the items. Just as the retest results showed that the test as a whole possessed a fair amount of reliability, the counting of actual errors made on each item showed the individual items to be very reliable. A test, however, might be reliable as a whole and also reliable in its parts and still be no measure of achievement in General Science. That is, a test might always give the same measurements but the measurements might have no relationship to the achievement in the subject it was supposed to measure.

To make certain that the original test was a measure of achievement in General Science, it was further correlated with other criteria which are known to have some validity as measures of General Science achievement. For instance, General Science achievement

is in part dependent on intelligence. Studies of the relationship between marks in school subjects and scores in standard intelligence tests show positive correlations ranging from about .30 to .70. That these correlations are not higher is usually explained by the fact that all pupils do not achieve in proportion to their native ability because of the influence of other factors such as industry, interest, and so forth. Further, if pupils did achieve in proportion to their native ability, there would still be many variations, since studies of school marks have shown certain inherent weaknesses in marks given by teachers. When, however, scores in standardized achievement tests of school subjects are correlated with scores in intelligence tests, the result, while a little better, is still far from a perfect correlation. A positive correlation between achievement test and mental test scores of .50 is quite usual.

When achievement in the 300 item General Science test was correlated with mental test scores for the University High School pupils, results given on the following page were secured. Examination of the figures shows that when the achievement on the whole 300 item test was correlated with intelligence the relationship was relatively high. Further, when the achievement on the first three pages of the test (221 items) was used the relationship was also uniformly high, and even slightly more valid because of the larger number of cases involved. Scores made by these pupils in the Miller Mental Ability Test, Form A, and in a large number of cases for both Form A and Form B (in which case the average of the two Forms was taken) were available as well as

mental ages and intelligence quotients. For the juniors (tenth grade) an average of five mental tests given in the freshman year was secured.

Correlation between	Grade	Pearson r	P.E.	No.Cases
1. Miller Mental Test scores & 300 item General Science test scores	8	.70	.055	39
	9	.43	.116	20
	10	.585	.07	31
	11	.73	.067	26
	12	.501	.08	38
2. Miller Mental Test scores & 221 item General Science Test scores	8	.61	.06	52
	9	.47	.09	34
	10	.41	.075	56
	11	.483	.085	36
	12	.45	.08	45
3. Mental Ages in months & 300 item General Science Test scores	8	.67	.06	38
4. Mental Ages in months & 221 item General Science Test scores	8	.642	.054	52
5. Intelligence Quotients & 300 item General Science Test scores	8	.573	.072	39
	9	.43	.106	27
	11	.64	.098	15
	12	.54	.075	38
6. Intelligence Quotients & 221 item General Science Test scores	8	.576	.062	52
	9	.43	.075	54
	11	.62	.09	20
	12	.494	.075	45
7. Ave. Five Mental Tests & 300 item General Science Test scores	10	.61	.09	18
8. Ave. Five Mental Tests & 221 item General Science Test scores	10	.48	.08	40

Examination of the pupils' achievement in General Science as indicated (a) by marks in General Science and (b) by an average of marks in all subjects and (c) in the case of seniors also of honor points*, the latter two being taken as criteria of general scholarship, also showed a decided degree of positive relationship. In the case of the 8th grade pupils, who had taken the General Science test on June tenth as a part of their preliminary examination before entering the University High School, the scores on the General Science test and only the first two quarters' marks were considered. Therefore, the correlation for these pupils indicates the degree with which the original test gave an accurate prognosis of what marks teachers gave those pupils after they had taken the course in General Science. In the case of the 9th, 10th, 11th and 12th grade pupils, all of whom had taken General Science in the 8th grade, the correlation is between the average marks earned in their freshman year in General Science and the achievement in the General Science test taken June first, 1922. In the case of 12th grade pupils, their contact with General Science as a subject was three years removed.

Correlation between	Grade	Pearson r	P.E.	No. Cases
1. General Science marks & 300 item General Science test scores	8	.61	.065	39
	9	.835	.039	28
	10	.76	.05	30
	11	.47	.11	22
2. General Science marks & 221 item General Science Test scores	8	.62	.057	52
	9	.60	.059	54
	10	.64	.055	54
	11	.44	.10	29

*Numerical basis for awarding scholarship honors.

Correlation between	Grade	Pearson r	P.E.	No.Cases
3. Percentile Rank, 1st yr.'s Marks & 300 item General Science Test scores	10	.59	.10	19
4. Percentile Rank, 1st yr.'s Marks & 221 item General Science Test scores	10	.43	.085	40
5. Honor Points & 300 item General Science Test scores	12	.40	.09	38
6. Honor Points & 221 item General Science Test scores	12	.46	.08	45

(4) Correlation between a part and the whole of the test

In the case of the University Highschool pupils data were available for 164 pupils whose papers were evaluated both on the basis of their achievement on 300 items of the General Science test and on the basis of their achievement on the first 221 items of the General Science test. In a later part of this study it was necessary to make comparisons on the basis of the first three pages of the test only. Justification for doing so is to be found in results of this study of University Highschool pupils on the 300 and 221 item bases. For instance, when the results of the 300 and 221 item General Science test of a group consisting of from 26 to 40 pupils were correlated by the rank order method, the correlation was practically perfect. When the achievement on a part and on the whole of the General Science test was correlated by the product-moments method, the results while not perfect were very close to 1.00, as can be noted in

the following figures.

Correlation between	Grade	Pearson r	P.E.	No.Cases
300 item General Science Test scores & 221 item General Science Test scores	8	.97	.003	40
	9	.90	.025	28
	10	.99	.002	31
	11	.996	.001	26
	12	.995	.001	39

From these figures it is evident that for purposes of group comparison, the first three pages of the General Science test gave practically as accurate relative results as did the whole test. This of course was due to the fact that the items as arranged in the original test were placed in absolutely random order.

In resume it might be said that the original General Science test as a measure of achievement and information in General Science was a fairly reliable measure. Its self-correlation by a retest of 116 pupils was .85. By the use of Brown's formula, a desired r equals $\frac{Nr}{1+(N-1)r}$ when N equals the number of repetitions necessary to get a desired coefficient of correlation. If a self-correlation of .95 were desired, then .95 equals $\frac{N(85)}{1+(N-1).85}$. Solving, N equals 3.4. In other words, another repetition of the same test would have given a correlation of almost .95. Or, were two more repetitions given, then r would have equalled $\frac{4(.85)}{1+(4-1).85}$. Solving, r would equal .96. When to this are added the facts that identical responses after three months equalled 95 percent of all responses made by a pupil on two trials,

the high correlations secured with known criteria, and also high correlations between a part and the whole of the test, the preliminary and original 300 item General Science Test was considered satisfactorily reliable.

CHAPTER VI

DEVELOPMENT OF THE GENERAL SCIENCE SCALE

In the preceding chapter it was made evident that the original 300 item General Science Test was fairly reliable. In fact the test proved more reliable when compared with certain known criteria than are some achievement tests for various school subjects which have been standardized and placed on the market today.[1]

It might have been possible, on the basis of the large number of pupils for whom data were available, to establish norms and to use the test in its crude form. This original test, however, had certain inherent faults - faults which are bound to occur in every test of its kind. In the first place, in order to be inclusive, the test had 300 items. That is too many. The median time for doing this test computed on 600 cases was fifty-nine minutes with a range of thirty-five to one hundred ten minutes, and a quartile deviation of eleven minutes. Besides the fact that the test took longer than the average pupil is able to maintain interested effort, the work of scoring and recording of results was decidedly laborious. Efficiency in giving requires a shorter test and one which is also easier to score. Further, some of the items in the original test turned out to be decidedly valueless.

In the original test it was possible to find class, grade, and school medians, but for purposes of comparison it was im-

1. Henmon, V.A.C. "Some limitations of educational tests". Jr. of Ed. Research. Vol. VII. No.3 March, 1923. Pp.185-198

possible to tell whether a difference of twelve items between two medians was a real difference or due to chance, unless one entered into statistical procedure to ascertain the fact. This fact when ascertained was, however, still open to the question of quantity - How much of a difference is a difference of twelve items on the original test? A study of data presented later will show that this difference of twelve items might mean a difference due to chance and therefore negligible when occuring in one part of the scale, and a difference which might easily represent the difference between the median and the seventy-fifth percentile when occuring in another part of the scale. A study of the value of individual items, which appears later, also shows that succeeding in twelve items in one part of the scale might be due to chance whereas succeeding in twelve items in another part of the scale would represent ability of practically genius type.

It was also found that the original General Science test contained enough material which, if properly evaluated and arranged, would make a General Science Scale composed of three Forms of known difficulty, which could be used interchangeably with long or short periods intervening for purposes of checking up progress of teaching and accuracy of testing. To be sure, if a test with a smaller number of items were to be used, in order to secure as accurate results as those secured by the three hundred items, the lesser number of items would necessarily have to be selected and evaluated accurately. Moreover,

as stated before, in the 300 item test it was possible, owing to the large number of items of more or less equal difficulty, for two boys to achieve equal scores up to 150 items each and still leave no single item which had been done correctly by both of them or failed by both of them. From the standpoint of diagnostic quality this was a decided weakness, the remedy for which was the development of three or more standardized forms of the General Science test, each Form of known difficulty.

Furthermore, were the original General Science test used, because of varying difficulties of the different items the various items represented various amounts of achievement. That is, the 300 item test represented a measuring tape with 300 units, very few of which were of equal length (difficulty). Succeeding in five items in one part of the scale was not equal to succeeding in five items in another part of the scale. These facts besides being annoying in the interpretation of results would be unknown to the person using the test, hence the necessity for developing scale Forms of known difficulty from the items at hand.

There are at least three methods possible for developing a scale from a set of unselected items containing possible material for the construction of a scale. The first of these methods is well characterized by the English Composition Scale developed by Doctor Van Wagenen.[1] In the construction of this Scale Doctor Van Wagenen had English compositions on the same subject,-

1. Van Wagenen, M.J. English Composition Scale. World Book Co.

"How I earned some money", rated by numbers of competent judges on Structure, Mechanics, and Thought Content. The compositions were rated by judges simply by placing them in order of merit on the basis of each of these three criteria. The rating of one composition was then secured by comparing the number of judges who decided that that composition was better, without any regard as to how much better, than the one of slightly poorer quality. Since the judges did not agree as to which of two compositions was better, the amount by which the better one was assumed to be superior to the poorer one was determined on the relative unanimity of the decisions. That is, if fifty percent of the judges decided that composition A was better than composition B and vice versa, the two compositions were assumed to be of equal merit. If 37½ percent of the judges decided that composition A was better than composition B and 62½ percent decided that composition B was better than composition A, there was then a difference of 25 percent of the judges in favor of composition B which, according to the table of frequencies on a normal surface of distribution, represents a difference of 1 quartile or 1 P.E. and composition B was given a rating of 1 P.E. superiority over composition A. It is evident, however, that starting with original compositions, the ultimate values while obtained by a thoroly reliable method would show various unequal intervals between individual compositions in the scale. This scale represents a steel tape in which all lengths are known and marked, but, instead of always starting at the end of one unit and at the beginning of the other - like 1,2,3 inches etc.-, it was divided

thus - 1, $3\frac{1}{2}$, $3\frac{3}{4}$, 7 etc inches at the distances so indicated. In using this Scale the composition to be graded is first compared with the different compositions in the scale whose values are known. Decision is then made that the composition in question is like composition B in structure, rating 77 on Structure, like composition F in mechanics, rating 85 on Mechanics, and like composition H in thot content, rating 95 on Thot Content. While a scale of this form has certain merits it did not seem feasible for a General Science scale.

Another method of scale development is that used by Woody in the development of the Woody Arithmetic Scale.[1] This method has also been used by Trabue in the Language Completion Scale[2] and by Posey and Van Wagenen in the development of their Geography Scale.[3] In this method the unit is the difference of difficulty of an item which will cause the correct responses to that item to vary one-tenth of a P.E. (.1 P.E.) in a normal surface of frequency from the item one unit easier or more difficult. Since this method was adopted for use in the development of the General Science scale, its description will be left to be given in detail for the various steps in the construction of the scale.

1. Woody, Clifford "Measurements of some achievements in arithmetic". Teachers College. Columbia University. Contributions to Education, No.80. 1916. Pp. 1-63

2. Trabue, Marion R "Completion-Test Language scales". Teachers College. Columbia University. Contributions to Education #77 1916

3. Posey-Van Wagenen "Geography Scales". Public School Publishing Company, Bloomington, Illinois.

There is, however, another method for scale construction which consists in taking a number of questions not necessarily related to fundamental elements of a subject (in this case the subject would be General Science), giving them to a considerable number of pupils who have just completed the subject (in this case General Science), and ascertaining for each question the number of pupils who succeeded in that question and who were rated "A" (in this case rated "A" in General Science), the number who succeeded in that question and were rated "B", the number who succeeded in that question and were rated "C", and so forth. In this method the ability of the question to differentiate among pupils of varying abilities - its diagnostic ability - is ascertained. A scale is then made up of a number of such questions which combined are able to differentiate among those pupils who receive grades of "A", "B", "C" etc. Such a diagnostic test method was used in some of the army trade tests during the war. For instance, where questions were selected to differentiate between an expert carpenter and a journeyman carpenter or an ordinary laborer who desired to be a carpenter, oftentimes questions which had little to do with the actual work of the carpenter but which could only be answered by the expert were used to differentiate different levels of trade ability.

A method of scale construction similar to this, if used for a General Science scale, would be dependent for its accuracy on the accuracy of the marks given in General Science. In view of recent studies of the unreliability of school marks this method would be far less accurate than the method which has been employed.

For some purposes it seems that while both the first and third methods described, being the only methods available for certain subjects, are more satisfactory than no method at all, they carry the weakness which is inherent in dealing with an unknown from the standpoint of another unknown. In the method adopted for the General Science scale there are at least two things certain, namely, that (a) the questions or items selected are from the subject to be measured and can be rated right or wrong, and (b) it is possible to ascertain what percent of any particular group or classification of pupils can do each item correctly.

Derivation of the Scale

When the 300 item test for each pupil had been scored and the score clearly indicated on it, the test papers were divided according to the classification described in previous chapter, namely, according to grade, sex, and whether or not the pupil had taken General Science. This made in all twenty classifications. In Table II (DISTRIBUTION OF SCORES OF 5980 CASES ON THE 300 ITEMS OF THE GENERAL SCIENCE TEST) are the distributions of the scores made by 5,980 8th grade and highschool pupils in the 22 school systems that had co-operated in this study. From this Table it is evident that one 8th grade girl and one 9th grade girl, neither of whom had studied General Science, made scores between 25 and 29 inclusive. It is also evident that the best scores secured by -8G were two between 180 and 184. A glance at the Table shows the gradual slope of the bulk of the frequencies towards the lower right hand corner, indicating a gradual increasé of the median.

TABLE II

DISTRIBUTION OF SCORES OF 5980 CASES ON THE 300 ITEMS OF THE GENERAL SCIENCE TEST.

Score	-8G	-8B	+8G	+8B	-9G	-9B	+9G	+9B	-10G	-10B	+10G	+10B	-11G	+11G	-11B	+11B	-12G	+12G	-12B	+12B
20- 24	.	.	.	.	..	.	...	.	.	.	.	.	.	.	.	.	.	.	.	.
25- 29	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30- 34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35- 39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40- 44	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
45- 49	1	..	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
50- 54	3	3	1	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.
55- 59	2	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
60- 64	4	5	.	.	1	1	.	.	2	.	.	.	.	1	.	.	.	.	.	.
65- 69	5	5	.	.	4	.	.	.	1	.	.	2	.	.	1	.	.	.	.	.
70- 74	7	7	.	.	.	1	.	.	3	.	.	.	1	.	1	.	.	.	.	.
75- 79	6	9	.	.	2	3	.	2	1	.	.	.	1	1	.	.	.	.	.	.
80- 84	23	7	.	.	7	3	2	5	3	1	.	1	2	.	.	.	1	.	.	.
85- 89	24	10	1	.	9	3	2	3	3	2	.	.	2	.	1	.	.	.	.	.
90- 94	27	9	1	.	16	2	5	2	8	2	.	.	1	.	.	.	.	.	.	.
95- 99	26	16	1	3	13	6	4	9	8	1	.	1	3	.	.	.	3	1	.	.
100-104	33	21	1	.	29	9	4	3	13	5	2	.	6	.	.	.	3	1	1	1
105-109	46	21	1	2	33	9	10	10	21	4	3	1	11	2	3	.	3	2	1	.
110-114	48	19	2	1	24	19	13	4	27	6	3	3	13	5	3	1	4	.	.	.
115-119	49	25	4	.	38	16	18	13	46	14	2	4	16	8	3	.	7	5	.	.
120-124	39	25	2	4	49	17	18	16	29	17	13	6	15	3	5	1	8	2	1	.
125-129	44	33	5	1	50	28	20	16	41	20	8	6	19	8	2	1	8	4	3	.
130-134	25	39	5	1	41	28	28	11	46	11	12	10	28	7	10	1	12	3	.	1
135-139	14	26	3	4	34	18	24	19	46	18	23	13	36	8	8	2	17	6	6	3
140-144	23	23	1	3	26	16	33	27	42	19	14	10	29	8	14	1	17	8	3	.
145-149	24	32	3	3	26	19	33	20	38	24	16	14	35	16	8	5	23	11	2	3
150-154	7	19	1	2	29	19	34	22	33	18	19	10	30	17	10	6	25	4	7	.
155-159	4	11	4	5	12	15	31	29	21	21	29	14	29	17	14	6	30	7	8	5
160-164	3	16	5	1	12	12	32	24	19	20	22	14	34	17	21	2	24	6	9	6
165-169	4	8	2	4	7	9	31	26	18	20	26	18	24	12	17	9	26	8	13	7
170-174	4	4	.	3	6	9	22	21	10	10	12	15	30	9	21	8	19	19	15	5
175-179	2	3	1	4	7	6	15	23	11	14	12	12	22	11	19	7	27	22	13	10
180-184	2	3	.	5	1	13	15	29	8	8	10	18	12	13	16	15	17	14	9	15
185-189	.	.	.	1	3	3	13	17	4	4	9	8	15	5	17	8	13	16	9	12
190-194	.	.	.	1	1	3	6	18	2	7	8	16	4	8	15	13	12	11	17	14
195-199	.	.	.	1	.	5	6	22	2	6	9	13	10	5	11	8	11	10	24	8
200-204	.	.	.	.	1	1	7	6	4	2	2	5	5	5	9	8	11	9	13	8
205-209	.	.	.	.	.	3	3	8	1	3	2	4	3	2	9	7	15	6	9	8
210-214	.	.	.	.	.	1	3	10	.	5	2	6	1	2	8	7	5	7	16	11
215-219	.	.	.	.	.	.	3	6	.	3	1	4	2	3	6	7	.	3	9	4
220-224	.	.	.	.	.	.	.	4	2	.	1	5	..	3	6	7	2	1	4	3
225-229	.	.	.	.	.	.	.	3	.	2	1	3	.	1	3	3	2	.	9	8
230-234	.	.	.	.	.	1	.	.	.	1	.	4	.	1	2	3	.	.	2	3
235-239	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	2	4	1	1
240-244	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	3	.	.	2	4
245-249	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	2	3	.
250-254	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.
255-259	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
260-264	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Total Number	500	400	44	49	482	300	437	430	513	289	261	242	440	197	263	143	347	192	210	141

In as much as General Science is almost universally a 9th grade or freshman subject in four year highschools and an 8th grade subject in Junior highschools, it was deemed satisfactory to take for the purpose of standardizing the items for the different Scale Forms (a) the 500 -8G and the 400 -8B and (b) 430 +9G and the 430 +9B. (Actually there were 437 +9G who had turned in completed papers). All of these pupils had turned in papers in which all of the 300 items had been marked.

At this point it might be explained that the use of 900 8th grade pupils who had not had General Science for the purpose of standardizing a General Science Scale, while not at first self-explanatory will become clear when it is considered that (a) the Scale was intended as a diagnostic test, (b) even with -8th grade pupils a considerable percentage exceeded the median achievement for +9th grade pupils, and (c)a pupil's success in General Science is to a certain extent quite as much dependent on what he knows before entering the course as it is on what he learns in the course.

The unit of measurement in this Scale was to be that difference of difficulty of items which would cause the correct responses to any item to differ one-tenth of a P.E. (.1 P.E.) on a normal surface of frequency from the items one unit more easy or more difficult. The next problem, therefore, was to reduce the difficulty of all items to P.E. values, all of which were known to have normal surfaces of frequency.

Having selected the four groups which were to form the basis for the valuation of items, responses for the total of

1760 papers were tabulated so as to secure the number in each group that made correct responses to item 1, the number that made correct responses to item 2, and so on. The result of this tabulation is given in TABLE III (FREQUENCIES WITH WHICH EACH OF THE 300 ITEMS WAS DONE CORRECTLY BY 500 EIGHTH GRADE GIRLS etc.). In this Table the items are not arranged in numerical order because it was found desirable to arrange them in order of increasing frequency for at least one group, hence the items are arranged in the order of difficulty for the -8G.

The number of pupils in each group was found to be large enough to insure the stability of the item placement. This was done by dividing each of the four groups into two parts when counting the number of correct responses, treating the first part as one distance one distance and the whole group, the second part, as another distance. The rank order of each item of the 300 was then determined, first on the basis of the first part and then again on the basis of the whole group. The rank order correlation between a part and the whole group in each case was over .98. Thus correlation between

(a)	350	-8G	and	500	-8G	gave	coefficient	of	.9964
(b)	300	-8B	"	400	-8B	"	"	"	.9968
(c)	215	+9G	"	430	+9G	"	"	"	.981
(d)	215	+9B	"	430	+9B	"	"	"	.984

The significance of these figures is clear, namely, that for most purposes, had the selection of data stopped with the 350 -8G,

TABLE III

FREQUENCIES WITH WHICH EACH OF THE 300 ITEMS WAS DONE CORRECTLY BY 500 EIGHTH GRADE GIRLS AND 400 EIGHTH GRADE BOYS WHO HAD NOT HAD GENERAL SCIENCE, AND BY 430 NINTH GRADE GIRLS AND 430 NINTH GRADE BOYS WHO HAD HAD GENERAL SCIENCE.

Item	-8G	-8B	-9G	-9B
78	14	46	75	122
27	16	20	23	28
35	19	21	95	78
128	19	29	87	108
173	21	33	92	120
16	24	67	24	152
87	27	21	13	19
228	27	15	32	18
39	29	16	65	60
57	31	39	27	36
134	31	23	85	58
67	31	63	28	70
18	33	36	105	118
143	34	47	69	57
144	37	45	53	71
164	37	41	140	134
81	38	56	166	192
249	40	42	175	178
28	44	59	144	179
43	47	43	131	104
58	48	37	32	38
38	48	35	115	119
6	49	36	51	40
66	49	48	54	65
224	50	44	92	108
64	52	28	158	158
135	54	41	60	55
180	55	53	164	140
208	55	40	116	100
219	57	51	109	140
273	57	45	176	166
15	59	117	153	262
34	59	60	58	64
90	59	57	88	111
280	61	172	162	288
124	62	59	61	53
10	63	45	198	172
217	63	55	75	72
278	63	55	103	109
270	63	49	183	137
121	65	75	146	141
258	65	51	89	98
170	66	74	141	197
88	66	31	99	89
110	66	62	27	40
140	70	45	89	77
290	70	63	79	116
260	71	97	186	239
56	72	90	149	145
251	73	71	135	138
149	74	52	115	80
89	74	58	161	162
9	74	41	86	110
86	75	71	103	160
191	76	64	152	162
244	76	68	45	64
11	78	62	156	202
283	80	134	183	215
4	81	94	57	137
267	81	133	120	187
194	81	68	236	214
300	82	89	75	142
243	82	95	178	116
92	83	90	129	193
163	83	67	125	143
214	84	52	83	82
259	84	79	89	128
50	85	73	192	196
44	86	99	159	128
177	86	90	168	166
235	87	44	135	72
210	88	75	157	141
19	88	143	206	280
69	88	56	126	123
298	89	112	109	150
125	90	41	102	100
127	90	83	124	118
207	93	84	185	157
61	95	114	181	203
47	96	85	135	155
171	96	96	114	149
241	96	89	79	86
5	98	117	315	310
85	98	105	116	116
91	102	115	92	159
205	102	102	134	153
253	102	88	112	139
53	103	86	193	188
174	103	128	273	283
179	103	110	93	109
204	103	86	117	110
74	106	78	28	88
294	106	72	73	119
108	107	96	158	157
212	111	87	117	115
282	113	123	201	236
36	115	177	205	273
138	115	81	110	202

TABLE III CONT'D

Item	-8G	-8B	-9G	-9B Cont'd
159	115	103	173	134
130	116	85	199	175
70	118	92	82	93
284	119	87	138	158
288	120	146	176	202
52	121	99	171	169
261	121	104	215	223
206	122	111	111	154
26	123	111	194	167
7	123	92	94	126
17	123	118	135	192
266	124	91	234	204
37	125	129	158	179
227	126	103	108	114
8	126	179	290	322
73	126	86	118	113
80	127	169	310	337
12	127	100	226	201
41	127	122	214	233
276	127	79	169	174
268	130	146	197	190
226	132	88	189	141
167	133	133	150	189
22	134	134	239	357
231	134	95	156	96
77	135	137	236	245
30	136	146	242	295
146	136	109	115	117
116	139	156	134	215
29	139	116	218	214
157	140	126	156	157
236	140	117	284	239
293	140	126	244	303
82	141	166	172	254
218	143	155	199	213
223	144	145	125	120
193	145	201	142	259
49	146	99	250	276
46	147	100	80	113
233	147	150	196	248
289	147	154	135	172
160	148	179	212	274
31	149	141	248	268
106	149	109	111	107
45	150	141	185	229
178	150	132	202	221
136	151	107	140	146
2	151	112	356	316
166	151	115	248	234
33	152	130	167	216
117	152	119	241	213
182	152	142	166	169
21	159	165	150	253
162	159	147	168	230
84	162	143	298	275
93	163	155	211	233
152	164	152	192	196
232	164	189	324	348
291	165	264	127	337
59	168	273	218	308
158	168	199	223	254
101	170	140	223	256
264	170	146	251	233
72	171	239	218	230
181	171	137	165	185
175	173	169	259	275
155	177	146	154	159
286	177	283	178	357
75	182	169	228	264
42	182	155	249	243
71	182	268	188	220
245	183	203	243	304
151	185	169	205	199
105	185	130	182	182
139	187	130	129	163
165	188	111	106	129
176	190	189	232	240
209	190	143	306	271
281	191	158	223	216
97	193	186	179	193
272	193	244	207	207
184	195	193	268	299
201	195	136	152	128
239	195	123	157	167
285	195	225	268	298
252	197	201	243	293
20	200	231	279	275
187	200	197	324	318
25	204	164	202	217
199	205	158	201	191
172	207	239	262	304
277	207	271	330	370
242	208	142	218	196
271	208	173	223	200
94	211	228	282	298
95	214	146	214	167
211	214	184	319	293
119	217	186	256	278
255	218	234	275	324
213	219	161	204	204
13	220	204	159	216
215	220	117	219	202
63	222	162	206	201
195	222	199	215	263
216	222	244	330	344
1 86	223	154	222	184

TABLE III CONT'D

Item	-8G	-8B	-9G	-9B Cont'd
147	224	179	218	225
262	228	235	363	363
141	229	197	252	243
265	229	197	263	269
55	232	199	312	339
154	232	184	286	260
115	233	215	255	277
197	235	232	228	233
274	240	209	234	248
279	241	253	266	338
99	244	211	270	260
256	247	227	317	341
200	248	238	216	253
137	250	198	252	223
263	251	236	279	278
153	257	176	218	166
238	258	212	263	273
196	263	217	238	275
297	263	244	308	318
112	263	229	264	261
65	265	250	258	300
240	269	195	283	235
54	270	228	368	364
68	270	282	383	388
287	273	243	216	306
1	277	231	327	338
113	278	231	269	264
96	280	209	250	242
14	284	259	252	293
109	287	243	310	343
222	288	300	232	390
40	289	222	249	249
220	291	216	239	218
168	292	260	358	384
161	294	294	257	338
237	296	158	281	294
299	296	251	292	311
156	297	231	302	273
120	298	258	349	319
169	299	265	270	317
60	301	208	329	306
142	314	246	341	293
247	315	276	310	305
189	318	266	350	321
111	319	305	324	328
221	319	281	352	362
114	325	297	386	390
32	325	240	280	280
269	328	291	348	364
118	330	239	385	356
257	330	304	316	327
203	331	343	340	335
48	334	279	311	324
275	338	345	307	310
295	339	304	329	349
234	342	297	334	363
150	348	289	352	344
129	349	246	307	269
192	352	295	387	367
202	364	256	326	305
248	367	305	360	352
132	374	266	354	317
183	374	264	383	337
225	376	253	369	319
98	377	264	370	312
51	379	310	372	361
107	385	294	397	377
188	385	329	351	374
230	386	277	407	359
198	388	329	323	334
250	389	334	356	384
103	396	304	423	406
76	398	268	351	301
296	399	336	366	356
292	405	315	388	371
100	411	343	383	368
102	417	355	407	397
246	417	317	394	360
123	418	341	420	409
23	423	366	361	393
126	423	338	396	389
79	424	349	387	403
104	429	311	394	372
185	430	297	384	352
229	433	328	420	376
190	438	339	383	367
83	445	369	374	403
3	446	375	415	410
254	448	350	402	392
62	450	346	413	381
133	459	338	418	390
131	462	378	428	413
122	465	361	413	415
145	471	361	420	408
24	485	396	424	422
148	491	389	427	417

the 300 -8B, the 215 +9G, or the 215 +9B, the order of difficulty would not have changed enough to have made any appreciable difference as the P.E. of P with such high coefficients and large numbers of cases is negligible.

It is in order at this time also to show that the combining of these four groups of data into a composite source of data for the Scale is not as lacking of homogeneity as would be indicated by the fact that pupils who have not had and pupils who have had General Science were used to standardize a General Science Scale. In Table XII (PERCENTILE SCORES ON 300 ITEMS MADE BY 6053 CASES) the medians for these four groups are 114, 127, 150, and 162 respectively. An examination of the medians would indicate considerable dispersion of results. Examination of the following data, however, shows that while the +9B whose median was 162 did as a group 48 items more than the -8G whose median was 114, the order of difficulty of items for all four groups was relatively similar. This is indicated by the fact that the rank order correlation of items for

(a) 500 -8G and for 430 +9G was .87 with a P.E. of .007

(b) 400 -8B and for 430 +9B was .916 with a P.E. of .005

(c) 500 -8G and for 400 +8B was .95 with a P.E. of .003

(d) 430 +9G and for 430 +9B was .91 with a P.E. of .005

Mean ..... .912 ..... .005

Reduction of frequencies of correct responses to percentages

Having in Table III the number of times each item was done correctly by each of the four groups selected, the next step was to convert each of the frequencies into percent of the total group and into the P.E. value for that group. Reference to

Table IV (COMPUTATION OF ITEM VALUE OR DIFFICULTY WORKED FROM TABLE III - See Appendix IV) will show that whereas the first item, number 78 in Table III, was done by 14 -8G, 46 -8B, 75 +9G, and 122 +9B, in Column 2 of Table IV the 14, the number of correct responses in the -8G group, has been converted into percent by dividing 14 by 500, which gives 2.8%. In Column 5, the 46, the number of correct responses in the -8B group, has been converted into percent by dividing the 46 by 400, which gives 11.5%. In Column 10, the 75, the number of correct responses in the +9G group, has been converted into percent by dividing the 75 by 430, which gives 17.4%. In Column 15, the 122, the number of correct responses in the +9B group, has been converted into percent by dividing the 122 by 430, which gives 28.4%, and so on for each item. In Columns 2, 5, 10, and 15 the first number is the percent of correct responses made by each of the four groups on Item 78. Similarly, for each item the frequency of correct responses indicated in Table III divided by the number of pupils in that group, namely, 500, 400, 430 and 430 respectively, for the -8G, -8B, +9G, and +9B respectively, is given in the columns of percents,- columns 2, 5, 10, and 15.

Reduction of percents of correct responses to percent of deviation from median

In as much as the unit of measure adopted was the P.E. from the median, the next task was to convert the percents of correct responses into P.E. values from the median. For this purpose it was found convenient to use the Table of P.E. Values given by

Woody[1] - See Table V(P.E. VALUES CORRESPONDING TO GIVEN PERCENTS OF THE NORMAL SURFACE OF FREQUENCY, PERCENTS BEING TAKEN FROM THE MEDIAN). In this Table are given the P.E. values corresponding to given percents of the normal surface of frequency, percents being taken from the median. It was therefore necessary to ascertain for the percent of each item the percent of deviation from the median, or fifty percent, which the percent of correct responses represented. As stated in the preceding paragraph, 14 correct responses for item 78 on the part of the 500 -8G represents 2.8% of correct responses. Two and eight-tenths percent, however, is 47.2% below the median (50%-2.8%). Forty-six correct responses on the part of the 400 -8B represented 11.5% of correct responses which was in turn 38.5% below the median (50%-11.5%). The 75 correct responses on the part of the 430 +9G represented 17.4% correct responses which was 32.6% below the median, while the 122 correct responses on the part of the 430 +9B represented 28.4% correct responses which was 21.6% below the median. Therefore in columns 3, 6, 11, and 16 are given the deviations from the median of each of the percents in columns 2, 5, 10, and 15.

Reduction of percents of deviation from median to P.E. from median

To convert the deviations from the median was a matter of looking up in Table III each of the deviations from the median. Thus, 47.2% below the median, indicated by -47.2 in column 3, is equivalent to 2.834 P.E. below the median and is indicated in column 4 by -2.834. In column 6 -38.5% is equivalent to -1.780

1. Woody, C. "Measurements of some achievements in arithmetic". Page 37. Table X -("taken directly from B. R. Buckingham's Spelling Ability, Table XLVII. It is a modification of the table given in E. L. Thorndike's Mental and Social Measurements (page 200)".)

TABLE V

P.E. Values corresponding to given per cents of the normal surface of frequency, per cents being taken from the median.

%	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	.000	.004	.007	.011	.015	.019	.022	.026	.030	.033
1	.037	.041	.044	.048	.052	.056	.059	.063	.067	.071
2	.074	.078	.082	.085	.089	.093	.097	.100	.104	.108
3	.112	.115	.119	.123	.127	.130	.134	.138	.141	.145
4	.149	.153	.156	.160	.164	.168	.172	.175	.179	.183
5	.187	.190	.194	.198	.201	.205	.209	.213	.216	.220
6	.224	.228	.231	.235	.239	.243	.246	.250	.254	.258
7	.261	.265	.269	.273	.277	.280	.284	.288	.292	.296
8	.299	.303	.307	.311	.315	.318	.322	.326	.330	.334
9	.337	.341	.345	.349	.353	.357	.360	.364	.368	.372
10	.376	.380	.383	.387	.391	.395	.399	.403	.407	.410
11	.414	.418	.422	.426	.430	.434	.437	.441	.445	.449
12	.453	.457	.461	.464	.468	.472	.476	.480	.484	.489
13	.492	.496	.500	.504	.508	.512	.516	.519	.523	.527
14	.531	.535	.539	.543	.547	.551	.555	.559	.563	.567
15	.571	.575	.579	.583	.588	.592	.596	.600	.603	.608
16	.612	.616	.620	.624	.628	.632	.636	.640	.644	.648
17	.652	.656	.660	.665	.669	.673	.677	.681	.685	.689
18	.693	.698	.702	.706	.710	.714	.719	.723	.727	.731
19	.735	.740	.744	.748	.752	.756	.761	.765	.769	.773
20	.778	.782	.786	.790	.795	.799	.803	.807	.812	.816
21	.820	.825	.829	.834	.838	.842	.847	.851	.855	.860
22	.864	.869	.873	.878	.882	.886	.891	.895	.900	.904
23	.909	.913	.918	.922	.927	.931	.936	.940	.945	.949
24	.954	.958	.963	.968	.972	.977	.982	.986	.991	.996
25	1.000	1.005	1.009	1.014	1.019	1.024	1.028	1.033	1.038	1.042
26	1.047	1.052	1.057	1.062	1.067	1.071	1.076	1.081	1.086	1.091
27	1.096	1.101	1.105	1.110	1.115	1.120	1.125	1.130	1.135	1.140
28	1.145	1.150	1.155	1.160	1.165	1.170	1.176	1.181	1.186	1.191
29	1.196	1.201	1.206	1.211	1.217	1.222	1.227	1.232	1.238	1.243
30	1.248	1.253	1.259	1.264	1.269	1.275	1.279	1.286	1.291	1.296
31	1.302	1.307	1.313	1.318	1.324	1.329	1.335	1.340	1.346	1.351
32	1.357	1.363	1.368	1.374	1.380	1.386	1.391	1.397	1.403	1.409
33	1.415	1.421	1.427	1.432	1.438	1.444	1.450	1.456	1.462	1.469
34	1.475	1.481	1.487	1.493	1.499	1.506	1.512	1.518	1.524	1.531
35	1.537	1.543	1.549	1.556	1.563	1.569	1.576	1.582	1.589	1.595
36	1.602	1.609	1.616	1.622	1.629	1.636	1.643	1.649	1.656	1.663
37	1.670	1.677	1.685	1.692	1.699	1.706	1.713	1.720	1.728	1.735
38	1.742	1.749	1.757	1.765	1.772	1.780	1.788	1.795	1.803	1.811
39	1.819	1.827	1.835	1.843	1.851	1.859	1.867	1.875	1.884	1.892
40	1.900	1.909	1.918	1.926	1.935	1.944	1.953	1.962	1.971	1.979
41	1.988	1.997	2.007	2.016	2.026	2.035	2.044	2.054	2.064	2.074
42	2.083	2.093	2.103	2.114	2.124	2.134	2.145	2.155	2.166	2.177
43	2.188	2.199	2.211	2.222	2.234	2.245	2.257	2.269	2.281	2.293
44	2.305	2.318	2.331	2.344	2.357	2.370	2.384	2.397	2.411	2.425
45	2.439	2.453	2.468	2.483	2.498	2.514	2.530	2.546	2.562	2.579
46	2.597	2.614	2.631	2.648	2.667	2.686	2.706	2.726	2.746	2.767
47	2.789	2.811	2.834	2.857	2.881	2.905	2.932	2.958	2.986	3.015
48	3.044	3.077	3.111	3.146	3.182	3.219	3.258	3.300	3.346	3.395
49	3.450	3.506	3.571	3.643	3.725	3.820	3.938	4.083	4.275	4.600

P.E. from the median, indicated in column 7. In column 11, -32.6% is equivalent to -1.391 P.E. from the median, indicated in column 12. In column 16, -21.6% is equivalent to -.847 P.E. from the median, indicated in column 17. Therefore an examination of columns 4, 7, 12, and 17 will show that they represent the P.E. value of each of the percents of deviation from the median of correct responses for each group for each item. The direction from the median is indicated by positive and negative P.E.s. That is, any P.E. value for a deviation from the median of a percent of correct responses which is less than 50 is indicated by a negative number. The P.E. value of deviations from the median for any percent of correct responses which is over 50 is indicated by a positive number.

Examination of the P.E. values for item 78, the first item in Table IV, shows that for the four groups selected this item had P.E. values of -2.834, -1.780, -1.391, and -.847. It is evident that this item was not of equal difficulty for each of the four groups, since it has been seen that the percent of correct responses for the four groups ranged from 2.8% to 28.4%. A similar condition is to be found for each of the succeeding items. For instance, item 27 has P.E. values of -2.746, -2.439, -2.397, and -2.245 (columns 4, 7, 12, 17) for each of the four groups. Obviously each item has four P.E. values instead of one, and unless some method of equating these P.E. values be found, four separate scales,-one for each of the four groups - would be necessary. If eight different groups were to be measured and the same conditions were true, eight scales would be necessary, etc.

Computation of average P.E. difference between groups

This apparently confused state of affairs, however, was easily adjusted. It was decided to ascertain the mean P.E. difference on all 300 items between each of the groups, then using this mean P.E. difference to convert each of the groups to the level of the lowest group. Therefore, in column 8 is the difference between the P.E. value of item 78 for -8B (-1.780) and the P.E. value of item 78 for -8G (-2.834), which is 1.054 P.E. Since a greater number of the -8B did item 78 correctly than did the -8G this difference is positive. In the next line, column 8, is the P.E. difference on item 27 for -8B and -8G (-2.439) - (-2.746) or .307 P.E. This process is repeated for each of the 300 items. At the bottom of the Table is to be found the algebraic sum of all the P.E. differences occuring in column 8, which is equal to 49.295. This sum divided by 300, the number of P.E. differences in column 8, gives a mean P.E. difference of .164. In other words, on 300 items the P.E. values of the correct responses of the 400 -8B exceeded the P.E. values of the correct responses of the 500 -8G by .164 P.E.

In the same way column 13 is a column of the P.E. differences between the P.E. values of the +9G and the -8B. Thus (-1.391)- (-1.780) is equivalent to .389 or the P.E. value of the superiority of the responses to item 78 of the 430 +9G over those of the -8B and (-2.397) - (-2.439) or .042 is the P.E. value of the superiority of the +9G over the -8B on item 27. Repeating the same process for each item one finds at the bottom of the

Table the algebraic sum of all the P.E. differences in column 13, namely, 124.308. This number divided by 300 gives an average P.E. difference of .414 or the amount in P.E. by which the responses of the 430 +9G are superior in accuracy to those of the 400 -8B.

In the same way column 18 is the column of the differences between the P.E. values on each item of the +9G, column 12, and the P.E. values on the same items for the +9B, column 17. Thus, (-.847) - (-1.391) is the equivalent of .544 found in column 18 and (-2.245) - (-2.397) is equivalent to .152 found in column 18. Repeating the same process for each item and totaling the P.E. differences, at the bottom of the Table is found the algebraic sum of all the P.E. differences in column 18, which is 25.821. This sum divided by 300 gives .086, which is the mean P.E. difference between column 17 and column 12 or the amount in P.E. by which the +9B are superior to the +9G on these items.

The computation of the mean P.E. differences between the different groups has shown in P.E. amounts what would be evident from the examination either of the individual number or of the percent of correct responses made by each group on each item. Namely, that from the standpoint of achievement in the General Science test the -8G — 8th grade girls who have not had General Science — group is the lowest, the -8B group the next higher, the+9G next, and the -9B group stands the highest of all four groups. The advantage, however, of results of columns 8, 13, and 18 is that this difference in achievement among the four groups is given in P.E. amounts. It can be said, therefore, that

the -8B are .164 P.E. superior to the -8G, that the +9G are .414 P.E. superior to the -8B, and that the +9B are .086 P.E. superior to the +9G.

Reduction of all scores to 8th grade level

In order to have the items all evaluated to an average P.E. value, the next step was to reduce the achievement of each group on each item to a common level. The necessity of this procedure can be easily illustrated by the following hypothetical case. Suppose A, B, C, and D were each given a tape measure in which the units were all of uniform length - inches in the case of the tape measure, P.E. amounts in the case of this test -. But suppose that A's tape measure began with the inches numbered at 0, B's tape measure had 164 inches torn off, C's tape measure had 414 inches more torn off than had B's, that is 414 plus 164 inches or 578 inches torn off, while C's tape measure had 86 inches more torn off than had C's, that is 164 plus 414 plus 86 or 664 inches torn off. Suppose that all four measured a certain distance. Let us assume that this distance was 1,000 inches. If each began with his tape as it was numbered and took the reading at the farther end on his tape, it is obvious that A's reading would be 1,000 inches since the divisions on his tape were numbered beginning with zero. It would further be obvious that the reading on B's tape would be 1164 inches, since the numbers on his tape began with 164. Likewise C's and D's reading would be 1578 and 1664 inches respectively, because their tapes began with the numbers 578 and 664. Any mean evaluation which these four individuals might make of the distance measured would first require

that the four readings be reduced to a common basis. This could be accomplished by reducing the readings to the level of any one of the four individuals, that is, reduced to A's readings by subtracting 164, 578, and 664 from B's, C's, and D's readings respectively. Or, readings could be reduced to B's reading by adding 164 to A's reading and subtracting 414 and 500 (414 plus 86) from C's and D's readings respectively. In the same way the readings could be reduced to the level of C or of D. Once the readings were reduced to a common level, an average obtained, and account taken of the zero point, then the four readings on the four tapes, each of which began with a different number, would give a measure as reliable as would measurement with a steel tape in which the units began with zero.

In the case of the General Science Scale it was decided to reduce the P.E. values made by each group to the level of the 8th grade girls without General Science. To do so it was necessary to subtract 164, the mean P.E. difference between -8G and +9B, from each of the P.E. values given for -8B in column 7, .578, the sum of the P.E. difference between -8G and -8B or .164 plus the P.E. difference between -8B and +9G or .414, from the P.E. values given for +9G in column 12, and .664, the sum of the P.E. difference between -8G and -8B or .164 plus the P.E. difference between -8B and +9G or .414 plus the P.E. difference between +9G and +9B or .086 from the P.E. values given for +9B in column 17. In this way columns 9, 14, and 19 were secured. They are labelled "P.E. Value'" for

each of the groups. These columns represent the P.E. values on each item reduced to the level of the -8G. Thus, column 4 is both "P.E. Value" and "P.E. Value'", since the -8G were taken as the basis. Column 9 is the result of subtracting .164 from the values given in column 7, column 14 is the result of subtracting .164 plus 414 from the P.E. values given in column 12, and column 19 is the result of subtracting .164 plus .414 plus .086 from the P.E. values given in column 17. Whereas the results in columns 4, 7, 12, and 17 are the P.E. values computed from the four different medians of the four different groups, the results in columns 4, 9, 14, and 19 are the P.E. values made by the four different groups but computed in each case from a common point, namely the median of the 8th grade girls without General Science.

Weighted average P.E. Value'

Having the values in columns 4, 9, 14, and 19 for each item so that they are in comparable form, that is, all computed from the same basis, the next step was to ascertain the average value of these four measures. Thus, for item 78, the "P.E. Values'" are -2.834 P.E., -1.944 P.E., -1.969 P.E., and -1.511 P.E. made by the four different groups. It is evident that a simple arithmetical mean of these four P.E. values might be used. It was thot advisable, however, to weight these values in the order of their reliability. That is, P.E. values are most accurate in the middle fifty percent of a distribution, one P.E. on each side of the median, less accurate 2 P.E. away, still less

accurate 3 P.E. away, and more so when 4 P.E. away from the median. Therefore, in computing the average P.E. value of each item it was decided to use a multiplication factor of 10 for values between 0 and 1 P.E., of 6 for values between 1 and 2 P.E., of 3 for values between 2 and 3 P.E., and of 1 for values between 3 and 4 P.E. In each case the actual P.E. value of the item, not its recomputed value or P.E. Value', was used to find the multiplication factor. To illustrate, for item 78 the final, weighted average P.E. Value' was computed as follows.

-2.834 x 3	(2.834 is between 2 and 3)	equals	- 8.502
-1.944 x 6	(1.780 is between 1 and 2)	equals	-11.664
-1.969 x 6	(1.391 is between 1 and 2)	equals	-11.814
-1.511 x 10	(0.847 is between 0 and 1)	equals	-15.110
Total Wts. 25		Total	-47.090

-47.090 divided by 25 equals -1.884, or the final weighted average value of item 78 computed from the median of the -8G group. In like manner each of the 300 items were weighted and averaged to secure the final weighted average value from the median of the -8G group found in column 20. Where items near the middle of the scale had both positive and negative values, the total in the above computation was the algebraic sum of the plus and minus values.

Location of the value of each item with reference to the arbitrary zero

Thus far a final average P.E. value has been secured for each item. This value, however, is merely a relative value in

uniform units computed from the median of the 8th grade girls without General Science. It is apparent that even the lowest 8th grade girl, who made a score of between 25 and 29, did not represent zero ability in achievement on this test. Were there a hypothetical case of an 8th grade girl who had made a zero score on this test, it would still be doubtful whether or not her achievement or ability in General Science was zero, for, were there an item easier than the easiest item on the test, it is quite conceivable that she might have marked it successfully.

Zero, or better yet, a score of 1 item or one-fifth of one percent on the table of frequencies of a normal surface of distribution would represent a deviation from the median of -49.8% or a P.E. value of -4.275. This, however, is an unknown distance or value above zero. Since the zero is unknown, it was thot advisable arbitrarily to select a zero point sufficiently low to include for all practical purposes every possible achievement or ability in General Science. It was therefore decided to make this arbitrary zero point 8 P.E. below the median achievement of 880 individuals who had taken General Science for one year. Since both boys and girls had taken General Science and the median achievements of the two groups in the 9th grade varied by .086 P.E., this zero point is 8 P.E. below a point which is one-half of .086 P.E. or .043 P.E. above the median achievement of the plus 9 Girls and .043 P.E. below the median achievement of the plus 9 Boys. This zero point is also .043 plus .414 plus .164 or .621 P.E. above the median of the 8th grade girls who were taken as the basis for computing the P.E. value of each item.

It is obvious then that in order to compute the actual value in P.E. of each item above the arbitrary zero point, it would be necessary to bear in mind that the average P.E. value already computed is computed from the -8 Girls' median, and that this median is .621 below the point which is 8 P.E. above the arbitrary zero point. In other words, the -8 Girls' median is 8.000 - .621 P.E. or 7.379 P.E. above the arbitrary zero point. To secure the actual P.E. value of each item above its zero point it was necessary to recompute the average P.E. value, bearing in mind that the -8 Girls' median is the point of reference for the average value and that this point of reference is 7.379 P.E. above the zero point. On this basis column 21 was computed.

In the computation of the column, an item which is below the median, that is, has a minus P.E. value, as does item 78, is an item which was very hard since it was done successfully by less than 50% of the pupils. An item having a negative P.E. value is then above the median in difficulty. Therefore, while item 78 was done successfully by an average number of pupils equivalent to an average P.E. value of -1.884, the difficulty of item 78 was really 1.884 above the -8 Girls' median and its actual P.E. value was 7.379 plus 1.884, or 9.263 P.E. above the zero point. Likewise item 27 which had an average P.E. value of -2.808 from the 8th grade girls' median, had an average difficulty which gives it a value of 7.369 plus 2.808 P.E. or 10.187 P.E. above the zero point. Item 148 at the bottom of the Table was so easy that enough pupils - an average of about 96% - did it successfully to give it an average P.E. value of positive 2.570. This item, there-

fore, was extremely easy. Its difficulty was really 2.570 P.E. below the 8th grade girls' median and its final value was 7.369 - 2.570 P.E. or 4.809 P.E. above the zero point. In like manner all 300 items were given a final P.E. value above the zero point in column 21 by adding the P.E. value in column 20, if negative, to 7.369 and subtracting the P.E. value in column 20, if positive, from 7.369.

Figure I (GRAPHIC REPRESENTATION OF THE P.E. VALUES OF GROUP MEDIANS AND OF TEST ITEMS WITH REFERENCE TO THE ARBITRARY ZERO POINT) is a graphic representation of the relative positions of the grade medians and of the range of difficulty of items in the test. Reference to the two figures (Figure I and Figure IA) may help to simplify any obscurity in the preceding description. It should be borne in mind that figure IA is a magnification of that part on Figure I which lies between A and B.

The range of the items was from about 4.5 P.E. to about 10.2 P.E. above the arbitrary zero point. Naturally some uniform unit of difficulty should exist between items on the scale, just as uniform inches exist on a footrule even if each end of the footrule has a part cut off from it. The unit which was selected as comparable to the inches on the footrule was one tenth of one P.E. (.1 P.E.). Therefore in column 21 the P.E. values above the zero point have been immediately converted into one-tenth P.E. values. Thus item 78, which has a value of 9.263 P.E., is written as having a value of 92.63 points or one-tenth P.E. each above the zero point. Item 27, which has a P.E. value

Fig.I GRAPHIC REPRESENTATION OF THE P.E. VALUES OF GROUP MEDIANS AND OF TEST ITEMS WITH REFERENCE TO THE ARBITRARY ZERO POINT

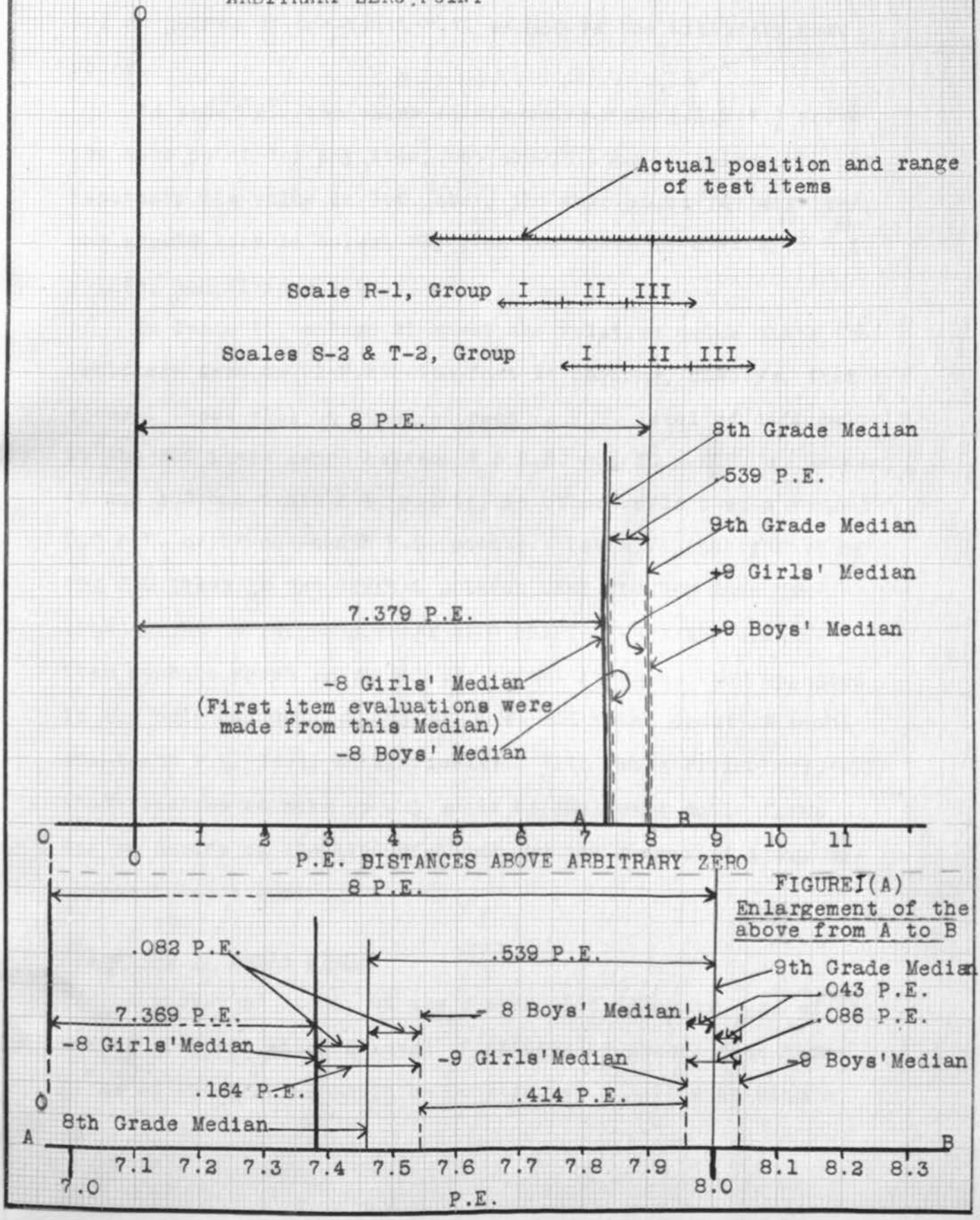


FIGURE I(A)
Enlargement of the above from A to B

of 10.187 above the zero point, is written as having a value of 101.87 points of one-tenth P.E. eachabove the arbitrary zero point.

To ascertain the value in one-tenth P.E. (.1 P.E.) above the zero point for any item, one should look in column 21. To ascertain its value in P.E. above the zero point for any item, one should look in column 21, find the value in one-tenth P.E. points, and divide by ten.

In Table IV, column 21 gives the relative value above the arbitrary zero in .1 P.E. The fact is obvious, however, that several items will be found at each .1 P.E. level of difficulty if the 300 items range between 4.5 P.E. and 10.2 P.E. or between 45 and 102 one-tenth P.E. points, in other words over a range of 5.7 P.E. or 57 one-tenth P.E. points. Table VI (DIFFICULTY OF THE 300 ITEMS IN THE GENERAL SCIENCE TEST FIGURED FROM THE SELECTEDAND DEFINED ARBITRARY ZERO POINT) gives the original item numbers which represent the actual items as they appeared in the original General Science test and which occur at each one-tenth P.E. level of difficulty. With Table VI in hand, all that remained to make up any scale or duplicate scale forms was to decide on the kind of items and the ranges of items to appear in each scale.

Selection of scale items

A survey of items, of the ranges of difficulty, and of the number of items at each level of difficulty showed that three Forms of known value could be constructed. Having in mind a

TABLE VI

DIFFICULTY OF THE 300 ITEMS IN THE GENERAL SCIENCE TEST FIGURED FROM THE SELECTED AND DEFINED ARBITRARY ZERO POINT.

Difficulty No.P.E.s above Zero*	Item Numbers
4.6	24
4.8	148
5.2	131
5.4	3,122,145
5.7	123,254
5.8	62,82,102,133
5.9	79,229
6.0	23,126
6.1	100,103,190
6.2	104,246,292
6.3	185,250
6.4	68,51,107,188
6.5	114,192,230,248
6.6	54,183,198,234
6.7	118,150,168,221,269,296
6.8	1,76,98,111,132,225,257,275
6.9	48,189,202,203,295
7.0	109,120, 161,222,247,262,277
7.1	129,142,169,299
7.2	32,60,156,216,256,297
7.3	55,65,113,211,240,279
7.4	14,59,94,112,172,187,237,255,263,287
7.5	20,40,96,99,115,154,196,232,238,285,286
7.6	80,119,137,141,184,197,200,209,220,245,252,265,274
7.7	2,5,8,71,84,175,195,291
7.8	22,30,42,72,75,147,158,176,215,272
7.9	13,19,25,31,36,49,63,101,153,160,174,186,213,236,264,271,281,29
8.0	77,82,93,95,97,151,166,193,199,233,242
8.1	21,29,41,45,117,152,162,218,280,282,178
8.2	12,33,105,116,181,261,266,268,288
8.3	15,26,61,139,155,167,182,201,239,260,283,289
8.4	17,37,50,52,53,130,157,226,276
8.5	108,136,159,165,177,194,207,223,267,294
8.6	10,11,16,44,81,91,92,106,138,146,170,205,206,231,284
8.7	28,46,47,56,73,85,89,171,191,210,227,243,249,270,273,298
8.8	7,64,86,121,127,163,179,180,204,212,251,253
8.9	4,69,70,164,235,259,300,
9.0	219,241,290
9.1	9,38,43,74,88,90,125,149,208,214,258,278
9.2	18,140,173,224
9.3	78,128,217,244
9.4	34,124
9.5	35,66,67,110,135,143,144
9.6	6,58,134
9.7	39
9.8	57
10.2	27,87,228

*Figured to nearest tenth (.1). In Table IV these values are multiplied by 10 (Column 21), which gives the difficulty in number of one-tenth P.E. (.1 P.E.) above zero.

method of computing scale scores, which will be described later, it was decided to construct a Scale having three Forms, each of which was composed of three groups of twenty items each. The range of difficulty of the items in any one group was to be one P.E. or ten points of one-tenth P.E. each. This meant that in each group there would be ten levels of difficulty with two items at each level. It also meant that the total range of any one scale would be three P.E. or thirty points of one-tenth P.E.

It was found that the easiest scale Form could begin with items at 5.7 P.E. or 57 points and should end at 8.6 P.E. or 86 points in difficulty. This scale Form, designated by "Form R-1", was divided into three groups of items, having two items at each tenth P.E. level of difficulty and ranging from 57 to 66, 67 to 76, and 77 to 86 points of difficulty in each of the three groups respectively. The other two Forms, designated by "Form S-2" and "Form T-2",are also made up of sixty items each over a range of thirty points or 3 P.E., having two items at each level of difficulty and beginning in both forms with item difficulty 67 and ending with item difficulty 96 and divided into three groups of items ranging from 67 to 76, from 77 to 86, and from 87 to 96 points of difficulty for each of the three groups respectively. Reference to Table VII (ITEMS SELECTED TO FORM SCALES R-1, S-2, AND T-2 AND THE DIFFICULTY OR VALUE OF EACH ITEM COMPUTED TO THE NEAREST TENTH (.1) P.E. FROM THE ARBITRARY ZERO POINT) shows the original item numbers which have been used to make up the Scale and the difficulty of each item. With the exception of two items, which occurred alone at one level of difficulty and

TABLE VII

ITEMS SELECTED TO FORM SCALES R-1, S-2, AND T-2 AND THE DIFFICULTY OR VALUE OF EACH ITEM COMPUTED TO THE NEAREST TENTH (.1) P.E. FROM THE ARBITRARY ZERO POINT.

	SCALE -- R-1		SCALE -- S-2		SCALE -- T-2	
	GROUP I (Average value 61.5*)		GROUP I (Average value 71.5*)		GROUP I (Average value 71.5*)	
Scale item numbers	Test item numbers	Value in P.E.	Test item numbers	Value in P.E.	Test item numbers	Value in P.E.
1.	123	5.7	118	6.7	168	6.7
2.	254	5.7	269	6.7	221	6.7
3.	62	5.8	1	6.8	111	6.8
4.	102	5.8	275	6.8	257	6.8
5.	79	5.9	48	6.9	189	6.9
6.	229	5.9	295	6.9	203	6.9
7.	23	6.0	109	7.0	262	7.0
8.	126	6.0	222	7.0	277	7.0
9.	100	6.1	169	7.1	129	7.1
10.	103	6.1	299	7.1	142	7.1
11.	104	6.2	156	7.2	216	7.2
12.	292	6.2	297	7.2	256	7.2
13.	68	6.3	65	7.3	55	7.3
14.	185	6.3	279	7.3	211	7.3
15.	107	6.4	187	7.4	59	7.4
16.	188	6.4	287	7.4	172	7.4
17.	114	6.5	40	7.5	20	7.5
18.	230	6.5	115	7.5	96	7.5
19.	54	6.6	141	7.6	119	7.6
20.	234	6.6	209	7.6	184	7.6

* The unit used in scoring is .1 P.E. Hence the "average value 61.5" Means an average value of 6.15 P.E. above the arbitrary zero point.

TABLE VII CONTINUED

	SCALE -- R-1 GROUP II (Average value 71.5*)		SCALE -- S-2 GROUP II (Average value 81.5*)		SCALE -- T-2 GROUP II (Average value 81.5*)	
Scale item numbers	Test item numbers	Value in P.E.	Test item numbers	Value in P.E.	Test item numbers	Value in P.E.
21	150	6.7	84	7.7	8	7.7
22	296	6.7	175	7.7	71	7.7
23	98	6.8	22	7.8	30	7.8
24	225	6.8	75	7.8	176	7.8
25	202	6.9	213	7.9	31	7.9
26	247	6.9	293	7.9	160	7.9
27	120	7.0	82	8.0	93	8.0
28	161	7.0	166	8.0	199	8.0
29	129	7.1	45	8.1	21	8.1
30	142	7.1	117	8.1	162	8.1
31	32	7.2	12	8.2	266	8.2
32	60	7.2	33	8.2	268	8.2
33	113	7.3	61	8.3	26	8.3
34	240	7.3	239	8.3	167	8.3
35	94	7.4	52	8.4	37	8.4
36	237	7.4	130	8.4	226	8.4
37	99	7.5	108	8.5	136	8.5
38	238	7.5	159	8.5	165	8.5
39	200	7.6	91	8.6	170	8.6
40	220	7.6	92	8.6	284	8.6

* The unit used in scoring is .1 P.E. Hence the "average value 71.5" means an average value of 7.15 P.E. above the arbitrary aero point.

TABLEVII CONTINUED

Scale item numbers	SCALE -- R -1 GROUP III (Average value 81.5*) Test item numbers	Value in P.E.	SCALE -- S-2 GROUP III (Average value 91.5*) Test item numbers	Value in P.E.	SCALE -- T-2 GROUP III (Average value 91.5*) Test item numbers	Value in P.E.
41.	2	7.7	28	8.7	89	8.7
42.	195	7.7	191	8.7	298	8.7
43.	101	7.8	64	8.8	86	8.8
44.	147	7.8	180	8.8	212	8.8
45.	19	7.9	164	8.9	69	8.9
46.	153	7.9	235	8.9	70	8.9
47.	77	8.0	219	9.0	38	9.0
48.	97	8.0	290	9.0	241	9.0
49.	41	8.1	43	9.1	88	9.1
50.	282	8.1	208	9.1	125	9.1
51.	181	8.2	173	9.2	18	9.2
52.	288	8.2	214	9.2	224	9.2
53.	15	8.3	78	9.3	217	9.3
54.	283	8.3	128	9.3	244	9.3
55.	50	8.4	34	9.4	66	9.4
56.	53	8.4	124	9.4	110	9.4
57.	194	8.5	35	9.5	135	9.5
58.	207	8.5	143	9.5	144	9.5
59.	16	8.6	6	9.6	39	9.6
60.	81	8.6	134	9.6	58	9.6

* The unit used in scoring is .1 P.E. Hence the "average value 81.5" means an average value of 8.15 P.E. above the arbitrary zero point.

consequently were put into two Forms, no items found in one Form are to be found in another Form.

Taking Table VII and substituting for the numbers the actual items, we have the final Forms of the Scale. These Forms with directions for giving and with correct responses underlined follow.

Scoring of the Scale

The method of evaluating the achievement of any pupil on the General Science Scale is an adaptation of the method worked out by Doctor M. J. Van Wagenen in the Posey-Van Wagenen Geography Scale.[1] This method is based on a statistical computation of ten points or sub-divisions per P.E. of a normal surface of frequency. Excepting slight revision, due to the fact that in the General Science Scale there are twenty items for each group whereas in the Posey-Van Wagenen Scale there are ten items in each group, the method designed for the General Science Scale is practically the same as that used in the Posey-Van Wagenen Scale. In the use of this method of scoring, each item is assigned a value of ½. Failure on one item is considered ½ an "error". The total of "errors" for any group is the number of items failed divided by 2. According to this scheme, a paper in which all the items were wrong would be credited with 10 "errors" in each group, which adapts the points to a ten point per P.E. computation on a normal surface of frequency.

1. Class Record Sheet for the Posey-Van Wagenen Geography Scales.
Division 2. Information G, L, R, S, T, U, V, or W.
Division 2. Thought R
The Public School Publishing Co. Bloomington, Illinois.

GENERAL SCIENCE SCALE - FORM R-1

Name _____ City _____ School _____

Age: __ Yrs. ___ Mos. Grade _____ Date _____

	ERRORS
Group 1:	
Group 2:	
Group 3:	
SCORE	

INSTRUCTIONS

Below are statements, such as -"A fly is AN ANIMAL, A FISH, AN INSECT, A REPTILE, A BUILDING". YOU can make each of these statements true by underlining the correct one of the five parts printed in large type. For instance, in the statement "A fly is AN ANIMAL, A FISH, AN INSECT, A REPTILE, A BUILDING", it isplain that a fly can not be all of the five things in large type. A fly is an insect, so if you underline "AN INSECT" the statement will read, "A fly is AN ANIMAL, A FISH, AN INSECT, A REPTILE, A BUILDING". By underlining "AN INSECT" you have shown that you know what is correct. In the statement "The heart pumps BLOOD, WATER, OIL, AIR, SAND", "BLOOD" should be underlined.

UNDERLINE THE PART IN EACH OF THE STATEMENTS BELOW WHICH WILL MAKE THE STATEMENT MOST TRUE.

GROUP I. (AVERAGE VALUE 61.5)

1. A bright, blue sky indicates BAD, FAIR, RAINY, GLOOMY, STORMY weather.
2. The house fly is harmful because it DESTROYS CROPS, HAS A POISONOUS BITE, CARRIES BACTERIA, DESTROYS FOOD, IS HARD TO STRIKE.
3. Balloons float in the air because of their LIGHTNESS, SILVERY COLOR, ENGINES, BASKETS, SIZE.
4. The best way to make impure water safe is to LET IT SETTLE, BOIL IT, FREEZE IT, USE CHEMICALS, DO NOTHING.
5. Refrigerators should be cleaned by using KEROSENE, GASOLINE, WARM WATER AND SODA, VINEGAR, SALT.
6. Which can turn somersaults most safely with his machine: the CHAUFFEUR, FLIER, SAILOR, CONDUCTOR, CANNONEER.
7. The source of most healthful light is THE SUN, KEROSENE, GAS, ELECTRICITY, CANDLES.
8. The electric wires are covered because the wire WOULD TURN UP, SET FIRE TO INFLAMMABLE MATERIAL, BREAK, GET HOT, GET COLD.
9. Dressings on a wound should be removed and fresh ones applied ONCE A WEEK, ONCE A DAY, NEVER, WHEN THE WOUND IS WELL, EVERY HOUR.
10. To make milk free from bacteria, milk is PASTEURIZED, FROZEN, INOCULATED, POISONED, SKIMMED.

GENERAL SCIENCE SCALE. GROUP I. FORM R-1 Cont'd.

11. Small pox isprevented by MEDICINE, VACCINATION, ANTI-TOXIN, PASTEURIZATION, STERILIZATION.

12. A thermometer is used to measure TEMPERATURE, PRESSURE, WEIGHT, HEAT, COLD.

13. In the dark the pupil of the cat's eye is LARGER, SMALLER, OF EQUAL SIZE, VERY SMALL, ABSENT.

14. The water pipes burst in the winter time because of CONTRACTION OF LEAD, EXPANSION OF WATER, EXPANSION OF LEAD, CHEMICAL ACTION, BRITTLENESS.

15. Grasshoppers may be distinguished from other insects by LARGE PAIR OF JUMPING LEGS, LARGE WINGS, BRIGHT GREEN COLOR, PRESENCE NEAR FLOWERS, NUMBERS.

16. Windows should be opened at SIDES, TOP AND BOTTOM, TOP AND SIDES, BOTTOM AND SIDES, BOTTOM.

17. Mosquitoes can be eliminated by SWATTING THEM, IMPORTING BIRDS, DESTROYING THEIR BREEDING PLACES, SMUDGES, POISON.

18. The water best fitted to remove dirt is HOT HARD, HOT SOFT, COLD HARD, COLD SOFT, TEPID HARD.

19. Milk is tested for the amount contained of BUTTER FAT, WATER, PROTEINS, BUTTER, BUTTERMILK.

20. When air is heated, it CONTRACTS, EXPANDS, FALLS, LIQUIFIES, SOLIDIFIES.

GROUP II. R -1 (Average value 71.5)

21. A kodak is a MOUTH ORGAN, PICTURE TAKING DEVICE, MUSIC BOX, BROWNIE, FILM.

22. The hard substance of the tooth is called DENTINE, ENAMEL, NECK, ROOT, BONE.

23. To reduce danger of ptomaine poisoning, a can of salmon should be HEATED THOROUGHLY, PROTECTED FROM FLIES, EMPTIED OUT OF CAN PROMPTLY, THOROUGHLY SALTED, EATEN WITH VINEGAR.

24. The food which is most important to be kept in the coldest part of the refrigerator is BREAD, COOKED FOODS, VEGETABLES, MILK, BUTTER.

25. The colored parts of a flower are SEPALS, PISTIL, PETALS, STAMENS, COROLLA.

26. The rainbow is seen DIRECTLY OVERHEAD, IN THE NORTH, IN THE SOUTH, IN THE EAST, IN THE MORNING.

27. All cows in certified dairies are tested for TYPHOID, TUBERCULOSIS, MANGE, DIPHTHERIA, YELLOW FEVER.

28. Concrete is reinforced with IRON, WOOD, STRAW, CLOTH, ROPE.

29. When the child's first permanent teeth appear he is 6 OR 7 YEARS OLD, 12 YEARS OLD, 18 YEARS OLD, 20 YEARS OLD, 30 YEARS OLD.

30. The kidneys DIGEST FOOD, CLEAN BLOOD OF WASTES, BUILD UP NEW BLOOD CELLS, SUPPORT THE BACKBONE, ARE USELESS.

31. The propelling mechanism of an automobile is termed the CHASSIS, PISTON, DIFFERENTIAL, GOVERNOR, MOTOR.

32. The capacity to do work is termed ENERGY, MOMENTUM, EFFICIENCY, MECHANICAL ADVANTAGE, VELOCITY.

33. Adhesive tape may be put over open wounds NEXT TO SKIN, WITH GAUZE BETWEEN TAPE AND SKIN, NOT AT ALL IF FRESHLY CUT, IF THERE IS DIRT PRESENT, IF NO DIRT IS PRESENT.

34. Tea should never be drawn in vessels of ALUMINUM, TIN, GRANITE, SILVER, CHINA.

35. The best lining for refrigerator is TIN, ENAMEL, COPPER, IRON, ZINC.

36. Mosquitoes breed IN FILTH, IN STILL WATER, IN RIVERS, ON THE GROUND, IN OCEANS.

37. The coldest place for food in a refrigerator which is iced at the bottom is the LOWEST SHELF, TOP SHELF, SIDE, CENTER, BACK.

38. Hemorrhages from wounds should be stopped by APPLYING PRESSURE ON SIDE OF BLOOD VESSEL FROM WHICH BLOOD IS COMING, APPLYING ANTI-SEPTICS, KEEPING CLEAN, SHUTTING OUT AIR AND DUST, APPLYING DIRT.

39. Insects have the following number of pairs of wings: ONE, TWO, THREE, FOUR, FIVE.

40. The average pulse rate for an adult man is 100, 45, 72, 60, 50.

GROUP III Form R -1 (Average value 81.5)

41. The process by which animals change their food materials into soluble form is known as ABSORPTION, DIGESTION, PHOTOSYNTHESIS, OSMOSIS, RESPIRATION.

42. The souring of milk is caused by BACTERIA, HEAT, FREEZING, AIR, MOISTURE.

43. Fleas are parasitic on rats and transmit a disease called BERI-BERI, BUBONIC PLAGUE, MALARIA, YELLOW FEVER, MUMPS.

44. The vertebrae are parts of the HEART, MUSCLES, BACKBONE, TEETH, TOES.

45. The eyes are injured most by IMPROPER LIGHT, DARK, DUST, STRAIN, WORK

46. Domestic toasters, curlers and irons are based on the principle of ELECTRICAL REPULSION, ELECTRICAL ATTRACTION, HEATING EFFECT DUE TO RESISTANCE OF A CONDUCTOR, VOLTAGE, ROTATION OF ARMATURE.

47. The best method of sewage disposal is CESS POOL, OPEN SEWER, CLOSED SEWER, SEPTIC TANK, SURFACE DRAIN.

48. The magnetic field in Dynamos is produced by TRANSFORMERS, NATURAL MAGNETS, ELECTRO MAGNETS, CONDENSORS, LEYDEN JARS.

49. Voltaic cells are studied about in BOTANY, BACTERIOLOGY, ZOOLOGY, ELECTRICITY, PSYCHOLOGY.

50. Heating systems are placed in the cellar, because heat causes water and air to EVAPORATE, CONTRACT, EXPAND, RISE, FALL.

51. Large buildings are best heated by A PIPELESS FURNACE, HOT AIR, HOT WATER, STEAM, ELECTRIC HEAT.

52. An example of a leguminous plant is the CLOVER, TOADSTOOL, PANSY, LILAC, MOSS.

53. A dynamo has as one of its parts a RESONATOR, CARBURETOR, ARMATURE, PISTON RINGS, CLUTCH.

54. The device in water or steam pipes for stopping the flow at any point is called a DAMPER, FAUCET, VALVE, SWITCH, STOKER.

55. The weight of moisture or water vapor contained in a cubic foot of air is called the ABSOLUTE HUMIDITY, DEGREE OF SATURATION, RELATIVE HUMIDITY, DENSITY, CONCENTRATION.

56. Escaping illuminating gas mixes with the air of the room by CAPILLARITY, DIFFUSION, COHESION, GRAVITATION, CHEMICAL AFFINITY.

57. An organism that reproduces by means of spores is the MAPLE, AMOEBA, BREAD MOLD, SPONGE, EARTHWORM.

58. The flowers of the elm trees are pollinated by PEOPLE, WIND, ANIMALS, WATER, INSECTS.

59. Current is conducted to and from the commutator by MAGNETIC POLES, BRUSHES, FUSES, INSULATORS, SWITCHES.

60. The handle of a skillet becomes hot as a result of RESISTANCE, CONDUCTION, FRICTION, RADIATION, LATENT HEAT.

GENERAL SCIENCE SCALE - FORM S -2.

Name _____ City _____ School _____

Age: ___ Yrs. ___ Mos. Grade _____ Date _____

	ERRORS
Group 1:	
Group 2:	
Group 3:	
SCORE	

INSTRUCTIONS

Below are statements, such as -"A fly is AN ANIMAL, A FISH, AN INSECT, A REPTILE, A BUILDING". You can make each of these statements true by underlining the correct one of the five parts printed in large type. For instance, in the statement "A fly is AN ANIMAL, A FISH, AN INSECT, A REPTILE, A BUILDING", it is plain that a fly can not be all of the five things in large type. A fly is an insect, so if you underline "AN INSECT" the statement will read, "A fly is AN ANIMAL, A FISH, AN INSECT, A REPTILE, A BUILDING". By underlining "AN INSECT" you have shown that you know what is correct. In the statement "The heart pumps BLOOD, WATER, OIL, AIR, SAND", "BLOOD" should be underlined.

UNDERLINE THE PART IN EACH OF THE STATEMENTS BELOW WHICH WILL MAKE THE STATEMENT MOST TRUE.

GROUP I. (Average value 71.5)

1. Tuberculosis is prevented by MEDICINE, HYGIENIC LIVING, MASSAGE, OSTEOPATHY, CHIROPRACTIC.

2. Soil deposited at the mouth of a river is called a PENINSULA, DELTA, STRAIT, ISLAND, CAPE.

3. The normal temperature of a human being is 100 F., 104 F., 98.6 F., 93 F., 90 F.

4. Volcanoes are most likely to be found in DESERTS, COASTAL PLAINS, MOUNTAINS, DELTAS, ISLANDS.

5. The telephone was invented in 1876 by JAMES WATT, SAMUEL MORSE, ALEXANDER G. BELL, MARCONI, S.F.B.MORSE.

6. An airplane cannot remain in air when AT REST, IN MOTION, UPSIDE DOWN, GLIDING, DESCENDING.

7. The age of a tree is told by BRANCHES, RINGS IN CROSS SECTION OF TRUNK, HEIGHT, SIZE OF TRUNK, COLOR.

8. To treat a cut use LIME WATER, IODINE, LINSEED OIL, SALVE, NOTHING.

9. The passage of the moon between the sun and the earth is called AN ECLIPSE OF THE SUN, FULL MOON, THIRD QUARTER, AN ECLIPSE OF THE MOON, WINTER SOLSTICE.

10. The home gas consumption is measured by a VELOCIPEDE, SPEEDOMETER, METER, GALVANOMETER, AMMETER.

GENERAL SCIENCE SCALE

GROUP I. FORM S -2 Cont'd.

11. The muscles are benefitted most by REST, HARD WORK, SYSTEMATIC DIET, PLAY, SYSTEMATIC EXERCISE.

12. The purpose of the mouthpiece on a telephone is TO CONCENTRATE THE SOUND WAVES, TO PROTECT THE TRANSMITTER, FOR SANITARY PURPOSES, TO KEEP MOISTURE FROM THE WIRES, TO PROTECT THE SPEAKER.

13. Soft coal is also known as ANTHRACITE, ASPHALT, LIGNITE, BITUMINOUS, PEAT.

14. Oil is used in an automobile engine to COOL IT, CLEAR IT, LUBRICATE IT, BURN, SILENCE IT.

15. THe first electric incandescent lamp was made by EDISON, BURROUGHS, WATT, PRIESTLY, WESTINGHOUSE.

16. The process by which a plant is made to grow om the stem of another plant is PRUNING, SLIPPING, GRAFTING, SPRAYING, PLANTING.

17. Alcoholic fermentation is produced by MOLD, YEAST, BACTERIA, GERMS, AIR.

18. A stove radiates more heat when it is all BLACK, RUSTED, NICKEL PLATED, ALUMINUM, SILVERED.

19. Animals which secure food directly from the bodies of other animals are PARASITES, HYDROPHYTES, MESOPHYTES, SAPHROPHYTES, SULPHITES.

20. Trees that have needles are called BIRCH, PINE, OAKS, GUMS, EVERGREEN.

21. Combustion is another name for DRYING, SHRINKING, BOILING, BURNING, MELTING.

22. The light from the moon is DIRECT, REFLECTED, INVISIBLE, ABSTRACTED, REFRACTED.

23. The covering of electric wires is called CONVENTION, RADIATION, ILLUMINATION, INSULATION, ISOLATION.

24. We pay for electricity by the WATT, AMPERE, VOLT, OHM, KILOWATT-HOUR.

25. The simplest independent living structure is the NUCLEUS, PROTOPLASM, CELL, EMBRYO, ATOM.

26. The device for protecting lights and motors from an overcharge of electricity is called a MAGNET, FUSE, SWITCH, BAROMETER? RECTIFIER.

27. The term induction is used most in connection with LEVERS, PUMPS, FALLING BODIES, SOLUTIONS, ELECTRICAL CURRENTS.

28. The act of transfer of pollen from anther to stigma is called POLLINATION, REPRODUCTION, FERTILIZATION, TRANSPIRATION, MITOSIS, FILTRATION.

29. Limewater is used to test for CARBON DIOXIDE, OXYGEN, ALCOHOL, HYDROGEN, CHLORIDES.

30. Tuberculosis is contracted BY CONTACT WITH PATIENT, BY CONTACT WITH CLOTHING, FROM BACILLI OF SPUTUM, BY TAKING COLD, BY BATHING.

31. Humidity relates to DRYNESS, HEAT, COLD, FREEZING, TEMPERATURE.

32. The boiling point on the Centigrade thermometer is 0, 32, 100, 120, 212.

33. The smallest of these things is the MOLECULE, BACTERIUM, PARAMOECIUM, DUST PARTICLES, ATOM.

34. Foods which contain nitrogen as a part of their chemical composition are called PROTEINS, FATS, CARBOHYDRATES, HYDROCARBONS, LIQUIDS.

35. The ovum or egg cell is produced in the KIDNEY, EMBRYO, OVARY, GAMETE, SPORAGIUM.

36. Electrolysis of water liberates hydrogen and CHLORINE, NITROGEN, CARBON-DIOXIDE, AMMONIA, OXYGEN.

37. Poisonsous products secreted by bacteria are called ENZYMES, ANTIBODIES, TOXINS, VACCINES, LEGUMES.

38. The centrifugal force of a cream separator separates milk from cream because the cream is LIGHTER, HEAVIER, THICKER, DENSER, GREASIER.

39. Sewer gas is kept from entering a house from the sewer by a VALVE, TRAP, FAUCET, DAMPER, DRAIN.

40. A mirage is a kind of BODY OF WATER, OPTICAL ILLUSION, VISION, DESERT, WARFARE.

GROUP III. FORM S - 2 (Average value 91.5)

41. Sunlight can be broken up into the spectrum by means of a MIRROR, LENS, PRISM, MICROSCOPE, COLOR-MIXER.

42. A general term for any living thing is PLANT, LARVA, ANIMAL, ORGANISM, MAMMAL.

43. The temperature at which pure water boils is effected by the HEIGHT OF THE FLAME, AMOUNT OF WATER, AIR PRESSURE, DENSITY OF THE WATER, DEPTH OF THE WATER.

44. The process of food manufacture in green plants is called RESPIRATION, MITOSIS, POLLINATION, PHOTOSYNTHESIS, PASTEURIZATION.

45. Fanning the body on a dry day produces a cool sensation because of MOVEMENT OF THE AIR, RAPID EVAPORATION OF MOISTURE INTO THE AIR, AMOUNT OF HEAT TAKEN FROM THE BODY, CREATION OF A DRAUGHT, FRESH AIR.

46. A food rich in carbohydrate is BEEFSTEAK, OLIVE OIL, CUCUMBERS, WATERMELON, HONEY.

47. An example of a fungus plant is the ORCHID, PONDSCUM, BREADMOLD, MOTHER OF VINEGAR, INDIAN PIPE.

48. An anemometer is an instrument used by the weather bureau to measure the AMOUNT OF SUNSHINE, AMOUNT OF RAINFALL, AIR PRESSURE, WIND VELOCITY, ATMOSPHERIC PRESSURE.

49. Potential energy is energy possessed by an object by virtue of its WEIGHT, COMBUSTIBILITY, MOTION, POSITION, DENSITY.

50. The unborn young of an animal is termed the LARVA, EMBRYO, CHRYSALIS, OVUM, SPERM.

51. A star is really a COMET, SATELLITE, PLANET, SUN, LIGHT.

52. The greatest damage is done to trees by BIRDS, WORMS, LARVA OF MOTHS, GRASSHOPPERS, BEES.

53. All space is believed to be filled by AIR, OXYGEN, ETHER, HEAT, MOISTURE.

54. The main purpose of respiration is ENERGY-RELEASE, ELIMINATION OF CO_2, MANUFACTURE OF FOOD, SECRETION OF WATER, PURIFICATION OF AIR.

55. Substances without crystalline structure are termed INERT, DENSE, ELASTIC, OPAQUE, AMORPHOUS.

56. Open wounds should be bathed with a dilute solution of HYDROGEN PEROXIDE, ALCOHOL, SULPHURIC ACID, SODA, TOBACCO JUICE.

57. Heat is measured in DEGREES, CALORIES, CANDLE POWER, KILOWATTS, GRAMS.

58. A ferment is another name for a BACTERIUM, ENZYME, TOXIN, VACCINE, SERUM.

59. One of the excretory organs in the body is the HEART, LIVER, SKIN, DUODENUM, SPLEEN.

60. Water expands when raised above or cooled below OC., 40 C., 32 C., 4 C., 100 F.

GENERAL SCIENCE SCALE - FORM T-2

Name _____ City _____ School _____

Age: __Yrs.__Mos. Grade _____ Date _____

	ERRORS
Group 1:	
Group 2:	
Group 3:	
SCORE	

INSTRUCTIONS

Below are statements, such as -"A fly is AN ANIMAL, A FISH, AN INSECT, A REPTILE, A BUILDING". You can make each of these statements true by underlining the correct one of the five parts printed in large type. For instance, in the statement "A fly is AN ANIMAL, A FISH, AN INSECT, A REPTILE, A BUILDING", it is plain that a fly can not be all of the five things in large type. A fly is an insect, so if you underline "AN INSECT" the statement will read, "A fly is AN ANIMAL, A FISH, AN INSECT, A REPTILE, A BUILDING". By underlining "AN INSECT" you have shown that you know what is correct. In the statement "The heart pumps BLOOD, WATER, OIL, AIR, SAND", "BLOOD" should be underlined.

UNDERLINE THE PART IN EACH OF THE STATEMENTS BELOW WHICH WILL MAKE THE STATEMENT MOST TRUE.

GROUP I. (Average value 71.5)

1. House flies lay their eggs IN WOOD, ON THE WATER, IN ANIMAL AND VEGETABLE WASTE, IN NESTS, IN THE SAND.

2. Distillation is a means of PURIFYING WATER, SECURING AIR PRESSURE, PUMPING WATER, TRANSMITTING WATER, SECURING HEAT.

3. The earth rotates on its axis once in 12 HOURS, 24 HOURS, 7 DAYS, 3 MONTHS, 365¼ DAYS.

4. Wounds should be allowed to bleed A LITTLE, NOT AT ALL, UNTIL THEY STOP NATURALLY, A GREAT DEAL, QUANTITIES.

5. The yellow dust on a flower is CHLOROPHYLL, OVULES, PROTOPLASM, POLLEN, DIRT.

6. All our food comes directly or indirectly from ROCK, ANIMALS, PLANTS, AIR, MINES.

7. A dynamo is a machine for generating HEAT, LIGHT, ELECTRIC CURRENT, SOUND, MUSIC.

8. Ice cracks rock because IT IS COLD, WATER EXPANDS WHEN IT FREEZES, IT MELTS WHEN IT GETS WARM, IT IS HEAVY, IT IS BRITTLE.

9. When the child's first permanent teeth appear he is 6 OR 7 YEARS OLD, 12 YEARS OLD, 18 YEARS OLD, 20 YEARS OLD, 30 YEARS OLD.

10. The kidneys DIGEST FOOD, CLEAN BLOOD OF WASTES, BUILD UP NEW BLOOD CELLS, SUPPORT THE BACKBONE, ARE USELESS.

GENERAL SCIENCE SCALE

GROUP I. FORM T -2 Cont'd.

11. The path of a heavenly body is called its ORBIT, RADIUS, EQUATOR, LATITUDE, DECLINATION.

12. MOSQUITOES lay eggs ON SALT WATER, ON STAGNANT WATER, ON FRESH WATER, ON THE GROUND, IN GARBAGE.

13. The following gas is found in impure air: CALCIUM, GOLD, CARBON-DIOXIDE, CARBON, SODIUM.

14. The purpose of flowers on a plant is to develop ROOTS, SEEDS, LEAVES, PERFUME, BRANCHES.

15. An eclipse of the sun is due to the position of the STARS, PLANETS, MOON, CONSTELLATIONS, MILKY WAY.

16. Black smoke from muffler indicates TOO MUCH AIR, TOO MUCH GAS, TOO LITTLE GAS, ENGINE TOO HOT, BROKEN CLUTCH.

17. Images are formed by the passage of light through a PRISM, HELIX? LENS, DIAPHRAGM, SPECTRUM.

18. The teeth should be examined by the dentist every HALF YEAR, YEAR, TWO YEARS, MONTH, TEN YEARS.

19. The purpose of the roots of plants is to TAKE IN OXYGEN, MANUFACTURE STARCH, GIVE OFF CO, TAKE IN SOIL WATER, GIVE OFF WASTE MATTER.

20. The best temperature for a living room is 60 F., 68 F., 75 F., 78 F., 80 F.

T - 2. GROUP II (Average value 81.5)

21. On a curve, the tracks are HIGHER IN THE INSIDE THAN OUTSIDE, HIGHER OUTSIDE THAN IN, SAME HEIGHT, WIDER, NARROWER.

22. Water freezes at 0 F., 32 F., 42 F., 100 F., 98.6 F.

23. "Shooting stars" are properly called SUNS, ASTEROIDS, MOONS, COMETS, METEORS.

24. An illustration of capillarity is found in the INK BLOTTER, THERMOMETER, BAROMETER, FORCE PUMP, EXCRETION OF UREA.

25. When a liquid contains all the dissolved substance possible, the condition is termed OSMOSIS, PERMEABILITY, FUSION, REDUCATION, SATURATION.

26. The separation of liquids and solids by evaporation and condensation is called SOLUTION, DISTILLATION, DIFFUSION, FUSION, TRANSPIRATIO

27. An example of oxidation is the RUSTING OF IRON, ELECTROLYSIS OF WATER, MELTING OF ICE, ACTION OF ACID ON ZINC, HEATING POTASSIUM CHLORATE.

28. The corolla is made up of the PETALS, PISTILS, SEPALS, STAMENS, OVARIES.

29. The ampere is a measure of AIR PRESSURE, HUMIDITY, RESISTANCE, CURRENT, POTENTIAL

30. Ventilation is best secured with STOVES, HOT AIR FURNACES, STEAM HEATING, HOT WATER HEATING, ELECTRIC HEAT.

31. Rain is water vapor DISTILLED, EVAPORATED, CONDENSED, FILTERED? CONCENTRATED.

32. Isobars are used in TEMPERATURE, AIR PRESSURE, HUMIDITY, WINDS, GRAVITATION.

33. Water cannot be siphoned out of a boat because OF UNEQUAL AIR PRESSURE, OF UNEQUAL AMOUNTS OF WATER, OF ATTRACTION OF WATER PARTICLES FOR EACH OTHER, OF SUCTION, WATER IN BOAT IS TOO LOW.

34. The object to be photographed must be in the sun to ABSORB THE LIGHT, REFLECT THE LIGHT, BE SEEN, CAST A SHADOW, TRANSMIT THE LIGHT.

35. The hottest flame is BLUE, GREEN, WHITE, YELLOW, RED.

36. Cheese is rich in FATS, PROTEINS, OILS, CARBOHYDRATES, WATER.

37. A collection of similar cells is called an ORGANISM, TISSUE, GLAND, MUSCLE, FUNCTION.

38. Heat is carried horizontally through air by CONDUCTION, CONVECTION, RADIATION, EROSION, TRANSMIGRATION.

39. A lifting crane gains power in doing work, by the use of THE WHEEL AND AXLE, THE LEVER, THE PULLEY, THE INCLINED PLANE, AN ENGINE.

40. The largest of the planets is VENUS, SATURN, MARS, JUPITER, EARTH.

41. A chimney on a lamp is FOR ORNAMENTATION, TO MAKE THE LIGHT MORE INTENSE, TO CREATE A DRAFT, TO MAKE THE FLAME BURN, TO SAVE OIL.

42. An example of a lever of the first class is found in the NUT CRACKER, SCISSORS, WHEEL BARROW, INCLINED PLANE, BICEPS MUSCLE.

43. The density of a solid is usually compared with that of AIR, HYDROGEN, WATER, LEAD, WOOD.

44. Pollen is produced in the OVARY, CALYX, STAMEN, STIGMA, PISTIL.

45. The ratio of the number of units of force applied to a machine to the number of units of force delivered by a machine is called EFFICIENCY, OUT-PUT, AVAILABLE ENERGY, MECHANICAL ADVANTAGE, WASTE.

46. An example of a chemical element is WATER, CARBON-DIOXIDE, MERCURY, AMMONIA, NITRIC ACID.

47. The cheapest food on the basis of calorific value is WHEAT FLOUR, BUTTER, MEAT, MILK, CELERY.

48. The foot-pound is a unit of ENERGY, WORK, DISTANCE, WEIGHT, CAPACITY.

49. The resistance a body offers to being set in motion is called MOMENTUM, FRICTION, COHESION, EROSION, INERTIA.

50. The best illumination or light for working or reading is DIRECT, REFLECTED, INDIRECT, WHITE, BLUE.

51. Refraction is studied in connection with SOUND, GRAVITY, FALLING BODIES, LIGHT, ELECTRICITY.

52. Gases enter and leave the leaves of plants through organs called STIPULES, ROOT-HAIRS, STOMATA, MICROPYLES, CHLOROPLASTS.

53. The nucleus isbelieved to play a prominent part in DIGESTION, RESPIRATION, HEREDITY, STORAGE OF FOOD, NERVE-CONDUCTION.

54. The general direction of the wind in front of a low pressure area is EAST, WEST, NORTH, SOUTH, NORTHEAST.

55. Petroleum is A CHEMICAL COMPOUND, A CHEMICAL ELEMENT, A MIXTURE, A PURE SUBSTANCE, AN IMPURE SUBSTANCE.

56. The vaccine used to prevent typhoid fever consists of BACTERIAL CELLS, HORSE BLOOD SERUM, ANTI-TOXIN, A CHEMICAL PREPARATION, ACIDS.

57. The part of the eye that regulates the entrance of light is the PUPIL, IRIS, RETINA, EYE-LID, LENS.

58. The distinguishing features of the mammals is the possession of BACKBONES, HAIR, TWO PAIRS OF LEGS, MILK GLANDS, NERVOUS SYSTEMS.

59. The attraction between molecules of a body is called CAPILLARITY, ADHESION, MAGNETISM, COHESION, CONVECTION.

60. Water rises in a suction pump because it is PULLED UP, PUSHED UP, ATTRACTED, REPELLED, SUCKED UP.

The method in brief consists in taking the number of errors which the pupil makes in the third or hardest group of any Form, dividing this number by 2 to get "errors", and looking up in Key A (inserted at the end of this Chapter) to ascertain the score which corresponds to that number of "errors". This score worked out on the basis of a normal surface of frequency is the P.E. position of the pupil's achievement on this test if he made no "errors" in Group I and Group II and if he had attempted an infinite number of Groups all harder or more difficult than Group III.

Since the pupil usually makes "errors" in Groups I and II the next step consists in subtracting from the first score, called the "Uncorrected Score", the total of "errors" in Groups I and II. The third step consists in subtracting from the second score just ascertained and called "The first corrected score", the equivalent found in Key B (inserted at the end of this Chapter) of the number of "errors" found in Group I. This last amount subtracted is the amount which, determined on the basis of the normal surface of frequency, equals the number of "errors" the pupil would probably have made had he attempted to do an infinite number of Groups easier or less difficult than Group I.

This process of evaluating papers is not laborious. A point which must be borne in mind is that failing to do one item correctly is counted as $\frac{1}{2}$ "error". The explanation for this may be had in a survey of Table VII which shows that in any group there are ten levels of difficulty one-tenth of one P.E. apart and that there are two items at each level. The General Science Forms

could be made up with thirty items each having ten items in a group, in which case failing one item would be counted as one "error" instead of one-half "error". As stated before, all computations were done on the basis of ten points per P.E. on a normal surface of frequency. Failing one item may be considered as failing one-half of one step equivalent to one-tenth of one P.E. It was thot advisable to have sixty items per Form rather than thirty because of the greater breadth of material and the greater reliability which would be possible if two items were used at each level of difficulty.

The following excerpt[1] indicates the meaning of the pupil's score when evaluated by this method.-

"The scores yielded by these tests have no relation to percents. A score of 73 means that the pupil who makes it can answer questions or do problems of difficulty 73 and get one-half of them correct, or its equivalent. It also indicates that the pupil can answer questions or do problems of difficulty 63 and get three-quarters of them right. At the same time, if the pupil were given questions or problems of value 83, he would be most likely to get one-quarter of them correct. Throughout the scale the difference between any two points is equal to a similar distance between any other two points. For instance, the pupil who gets 83 is doing just as much better than the pupil who gets 73 as the pupil who gets 73 is doing better than the pupil who gets 63".

Directions for finding pupil's score.

In Appendix III are to be found the correct responses to each item of the three Scale Forms. From these sheets may be made a cardboard correcting stencil by cutting pieces of cardboard three inches wide and as longas the different pages of the Scale and by writing the correct responses in such position

1. Posey-Van Wagenen Geography Class Record Sheet. Ibid.

that each will be opposite the item for which it is the correct response, when held at either the right or the left of the sheet. The usual transparent stencil will also save much time in the marking of errors.

A.
Combining the errors in groups*

On each pupil's test paper and at the left of each incorrect statement enter "½". Combining the errors in groups for each pupil add the number of "errors" in Group I (items 1-20), bearing in mind that each incorrect item is counted as ½ "error". You have already noted these "errors" at the left of each item on the test paper. Enter this sum on the Class Record Sheet under "No. of Errors, Group I". Similarly, add the number of errors made on items 21-40 (Group II) and enter this sum under "Group II". Likewise, add the number of errors made on items 41-60 (Group III) and enter this sum on the Class Record Sheet under "Group III". For example, a pupil failed on 9 items in Group I, 12 items in Group II and 17 items in Group III. This was counted as 4½ "errors" on the items constituting Group I, 6 "errors" in Group II, and 8½ "errors" in Group III, which are entered on the Class Record Sheet. In like manner enter on the Class Record Sheet the record of the errors of each pupil for each of the three groups.

B.
Uncorrected Score*

For each pupil note the number of errors entered under Group III on the Class Record Sheet. Using Key A, find the

*Adapted from the Posey-Van Wagenen Geography Scale Scoring and Instruction Sheet.

corresponding score. Enter it under "Score, Uncorrected". In the sample the number of errors is 8½ and in Key A the corresponding score is 88½. We may call these the "Uncorrected Scores". They are the scores the pupils would receive if they made no errors on the two easier groups.

C.
First Corrected Score*

But most pupils will make errors in Groups I and II. We therefore subtract them from the Uncorrected Score, thus obtaining the "First Corrected Score". Enter this under "Score, 1st Corrected". In the example 4½ errors were made in Group I and 6 in Group II, or a total of 10½ errors. These are subtracted from 88½, giving 78.

D.
Final Score*

Note the number of errors each pupil made in Group I. Find this number on the first line of Key B. Under this number note the entry in line 2 of Key B. Subtract it from the First Corrected Score; the result is the Final Score. Enter it on the Class Record Sheet under "Score, Final". In the example the pupil made 4½ errors in Group I. The number under "4½" in Key B is 3. Subtracting 3 from 78 gives 75 as the final score. In making this correction account is taken of the fact that a pupil who makes several errors in Group I would probably make additional errors if he had still easier paragraphs to read. Key B gives the most probable number of errors that would be made on all easier paragraphs when the number of errors made in Group I is known.

* Adapted from the Posey-Van Wagenen Geography Scale Scoring and Instruction Sheet

Key A (For use in obtaining the Uncorrected Score)*

When errors in Group III are..	½	1	1½	2	2½	3	3½	4	4½	5 →
Pupil's Uncorrected Score is	116	111	107½	104½	102½	101	99½	98	96½	95

(Key A Continued)

→	5½	6	6½	7	7½	8	8½	9	9½	10
	94	93	92	91	90	89	88½	87½	86½	86

Key B (For use in obtaining the Final Score)*

When errors in Group I are ..	½	1	1½	2	2½	3	3½	4	4½	5 →
Take from First Corrected Score	0	0	½	1	1	1½	2	2½	3	3½

(Key B Continued)

→	5½	6	6½	7	7½	8	8½	9	9½
	4	5	6	7	8½	10	12½	15	20

SAMPLE CLASS RECORD SHEET*

No.	Name	No. Errors in Group			SCORE		
		I	II	III	Uncorrected Score	1st Corr. Score	Final Score
1	John Doe	4½	6	8½	88½	78	75

*Adapted from the Pesey-Van Wagenen Geography Scale Scoring and Instruction Sheet.

CHAPTER VII

RELIABILITY OF THE GENERAL SCIENCE SCALE

A. Composition of the General Science Scale

As has been stated before, the three final Forms of the General Science Scale contain sixty items each. These three Forms of sixty items each were selected from the 300 items which composed the original General Science test. The question might arise why the particular items which compose the three Forms were selected in preference to the items which were discarded. Of the total number of 300 items, 180 items were retained and 120 items were discarded. The 120 items were eliminated and were not even used for the composition of additional Forms of the General Science test for three reasons.

(1) The items of a Scale Form follow a regular sequence of steps or levels of difficulty one-tenth of a P.E. apart. Reference to Table VI shows that there was a large number of items near the middle of the range of difficulty, at about 8.0 P.E., with a dearth of items at either extreme of the range. In order to have Scale Forms each with a range of 3 P.E., it was necessary to start one Form with items at 5.7 P.E. and two Forms with items at 6.7 P.E. This process took six items at each level of difficulty between 6.7 and 8.6 P.E., and as a result all the items at some levels had been exhausted. While 120 items still remained, they were not of such difficulty or value as to form even one sequence of sixty items over a range of 3 P.E. As had

been anticipated during the construction of the original General Science test, all of this original material could not be used. This was not a calamity but was really quite fortunate.

(2) The elimination of certain items permitted a scientific selection of items. As has been stated in a previous Chapter, certain objectives of General Science were to be kept in mind in the construction of the Scale. No item was to be retained in the final Scale, the achievement of which by pupils did not contribute to the objectives of General Science as previously outlined.[1] It would have been deemed advisable to use material from but one specific science if that material contributed most towards the objectives of General Science. In the writer's opinion, the science material which contributes most towards the objectives of General Science is a mass of elementary, fundamental material which several decades ago might well have come under the heading "Natural Philosophy" or which today is classified by a number of research men in various fields of science as material which "commonsense" should make apparent. The frequency with which many of the items in the General Science test were done unsuccessfully by high school pupils indicates the fallacy of the latter characterization, unless one were to assume a paucity of "commonsense".

An analysis of the 180 items selected for the Scale Forms results in a grouping of the following numbers of items under eight specialized sciences.

1. Chapter III

TABLE VIII

DISTRIBUTIONS OF ITEMS OF THREE SCALE FORMS UNDER EIGHT SPECIALIZED SCIENCES.

Sciences.....Forms	Number of Items R-1	S-2	T-2
1. Botany	4	6	7
2. Chemistry.....	4	8	6
3. Domestic science	3	2	2
4. Geography*	3	7	8
5. Hygiene.....	15	5	5
6. Physics	20	21	23
7. Physiology	6	3	4
8. Zoology.....	5	8	5
Total	60	60	60

*Geography is considered in its widest sense -- including even Astronomy, Geology and Physiography.

While another person classifying these same items might make a slightly different classification than the one which is given above, the above classification is an indication of the fairly uniform distribution of the items among the basic sciences. An item like "Flies lay their eggs IN WOOD, ON THE WATER, IN ANIMAL AND VEGETABLE WASTE, IN NESTS, IN THE SAND." might be classed either as Zoology or as Hygiene. Irrespective of the science to which it belongs, knowing it, contributes to "Health" and makes it a good General Science item. In connection with the classification of General Science items, Webb's data* which have been previously cited are a propos.

*See Chapter III, page 8.

(3) It was found that some of the items inserted in the original General Science test were ambiguous or weak or not sufficiently objective. These items, therefore, were discarded because of their structural inefficiency.

Examination of many of the items in the General Science Scale shows that ordinarily some of them would be taught in as many as three or four specialized sciences. "Capillarity", for instance, is legitimate subject matter for Physics, Chemistry, Botany, Agriculture, Physiology and Zoology. Likewise the effect of air pressure (Boyle's Law) is usually legitimate subject matter for Physics, Chemistry, Domestic Science and perhaps Biology. In other words, certain subject matter is fundamental to several, specialized sciences. Usually teachers of these more advanced and specialized sciences can not take for granted the possession of these fundamentals by their students, therefore each teacher duplicates the instruction. This fundamental material in General Science, besides being a prerequisite for more advanced sciences, fulfills the objectives of General Science.

The subject matter of the original General Science test was considered by General Science teachers to be so inclusive that twelve or more of them (in Minnesota) have asked for permission to include the General Science test material in their course of study, subdividing it and using its various items as a skeleton for various parts of the course. Therefore, while it is understood that other material might have been included in the Scale, it is believed that the material actually included, if it satisfies

other requirements, is sufficiently varied and sufficiently inclusive.

B. Correlation with original General Science test.

In a previous chapter evidence has been presented which showed that the original 300 item test had considerable reliability, evidenced by its correlation with certain criteria. The original test would therefore serve as one criterion for ascertaining the reliability of the final Scale. With that purpose in mind a number of the original 300 item papers, selected at random by taking the first 100 in each grade for the five grades of - Boys (8th, 9th, 10th, 11th and 12th grades), were rescored on the basis of Form S-2. That is, the original 300 item papers contained the 60 items which now comprise the Form S-2. By counting up the errors on those 60 particular items, taking recognition of the group in which they belong (Group I, II, or III), the paper was given an S-2 Scale score, which indicated the pupil's achievement on the 60 items. The 300 item test scores were correlated with the S-2 Scale scores by the product-moment method. The coefficients of correlation ranged from .81 to .93 for the five grade groups.

For	49	-8th	grade	boys'	test	and	Scale	scores	r equals	.87	-P.E. .02
"	100	-9th	"	"	"	"	"	"	"	.93	" .01
"	100	-10th	"	"	"	"	"	"	"	.90	" .01
"	100	-11th	"	"	"	"	"	"	"	.905	" .01
"	100	-12th	"	"	"	"	"	"	"	.81	" .02
							Mean	"	"	.882	" .015*

* P.E. of r when r equals .882, not a mean.

From these coefficients of correlation it is evident that if the original test had fair reliability, the abbreviated Form of the original test (Form S-2), having exceptionally high agreement with the original test, must, therefore, approximate the original test in its reliability. Evidence will be presented later that the Scale Form S-2 actually was more reliable than the original test. That these coefficients are not higher, is largely due to the errors of the test.

C. Correlation and agreement of test and Scale medians

Additional data obtained in the study of correlation between test and Scale are also significant. In Chapter VI it was indicated that when the rank order of difficulty for any item had been secured from as many as 215 papers, adding 215 papers did not materially change its relative position, as evidenced by a rank order correlation coefficient of .98 between a rank order on 215 and a rank order on 430 papers. In this part of the study it was found that by taking 100 papers in each grade group, the medians for the five groups of 100 papers each did not differ from the medians on as many as 500 papers by as much as an average of one-sixth P.E. of the distribution. The P.E.s of the medians of distributions having 500 cases with a P.E. of distribution of 22 were one point. The P.E.s of medians of the distributions having 100 cases with P.E.s of distribution of 22 were two plus.

On the following page is a tabulation of test and Scale medians.

MEDIANS

	300 ITEM TEST				SCALE S-2	
	On original group		On 100 cases		On 100 cases	
	A	Sigma	B	Sigma	C	Sigma
+8 Boys	155	31.5	154	26.7	80	5.5
+9 "	162	33	165	34	81.5	7.1
+10 "	168	33	173	34	84	6.5
+11 "	188	28.5	190	28	89	6.1
+12 "	190	22.5	194	25.4	89.5	5.5

The coefficients of correlation between the medians of columns A and C and of columns B and C are .993 and .986 respectively. Further evidence of the marked agreement between the test and Scale scores is given in Figure II. It is clear from this figure that it would be possible to make up a table of scale values and their corresponding test values which would enable one immediately to translate a scale score into a test score and vice versa. In Figure II three systems of varying lengths of ordinates have been arranged in such manner that the extremes of all curves coincide. Lack of agreement among the three sets of medians must therefore appear in divergence of the central parts of the curves. Reference to these data will again be made in Chapter VIII.

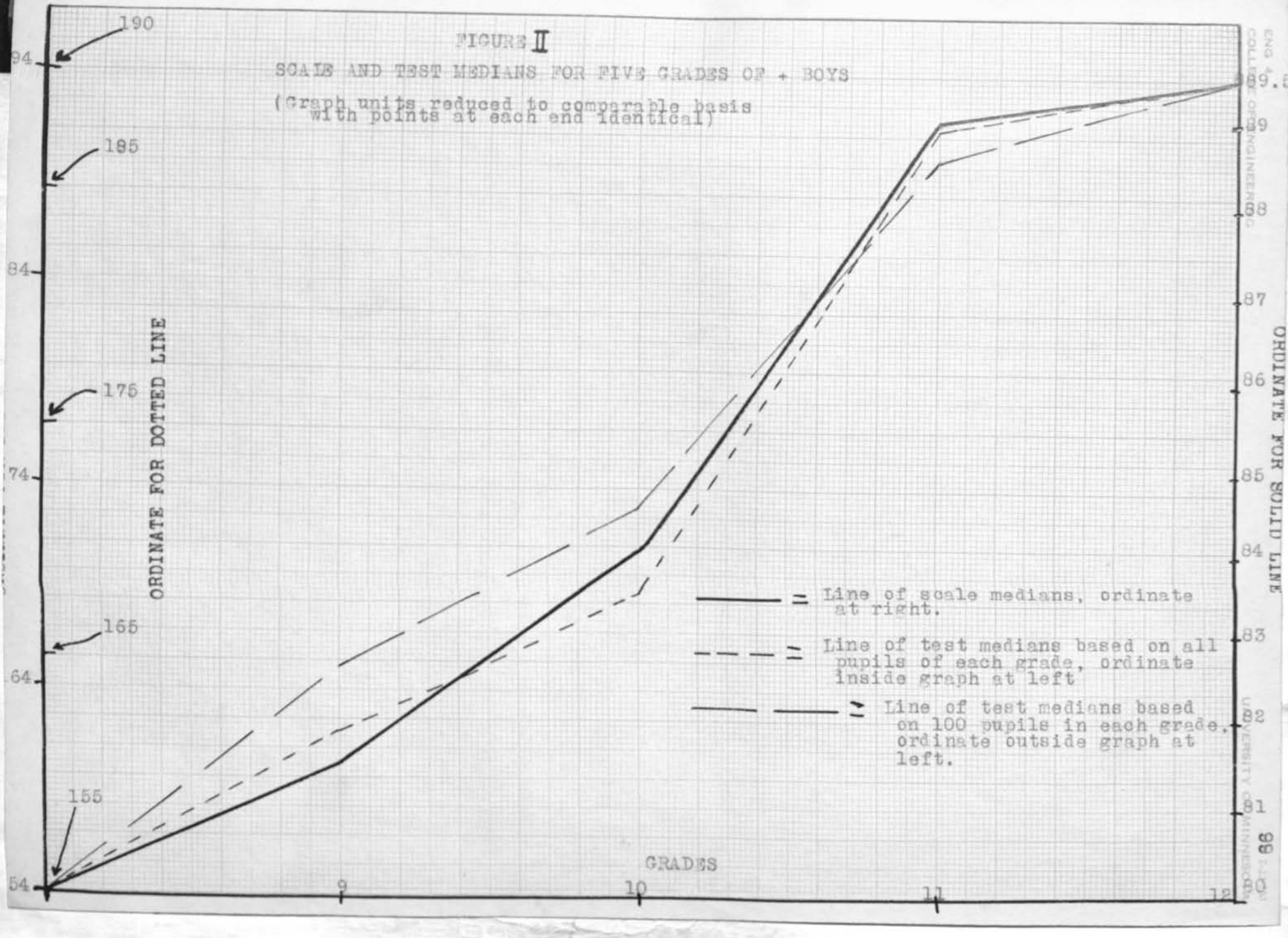
D. Self Correlation

Since Scale S-2 and Scale T-2 were constructed to be of identical difficulty, both these Forms were given to a number of pupils to ascertain the agreement between them. School A (Stillwater, Minnesota) gave the two Scale Forms to 140 pupils who were taking General Science and had completed thirty weeks of the course. Results

FIGURE II

SCALE AND TEST MEDIANS FOR FIVE GRADES OF + BOYS

(Graph units reduced to comparable basis with points at each end identical)



follow.

SCHOOL A

	S-2	T-2
Number cases	140	140
Median	92	86
Sigma	6.1	4.1
P.E. of estimate*	2.8	1.9
P.E. of median** ..	.6	.4

r ..... .70 ..... P.E. of r .. .03

Had four Forms of the Scale been given, or four repetitions of the same Form, r would have equalled .903***

The same Scale Forms were given to School B (University High School) pupils all of whom had been taking General Science for the first time for thirty weeks. Their results were:-

SCHOOL B

Group I	S-2	T-2
Number cases	24	24
Median	87	87
Sigma	5.8	4.7
P.E. of estimate .	2.4	2
P.E. of median ...	1.4	1.2

r ..... .77 ..... P.E. of r ... .05

Had four Forms of the Scale been given, or four repetitions of the same Form, r would have equalled .93

* P.E. of estimate equals .6745 Sigma $\sqrt{1-r^2}$

** P.E. of median equals .6745 $\frac{1\frac{1}{4}\text{ S.D. Distribution}}{\sqrt{\text{No. cases}}}$

*** Brown's formula. r_1 equals $\frac{Nr}{1+(N-1)r}$ where N equals number of repetitions, and r_1 equals desired coefficient of reliability.

SCHOOL B

Group II	S-2	T-2
Number cases	34	34
Median	84	82
Sigma	5.8	4.0
P.E.of estimate ..	2.6	1.9
P.E. of median ...	1.2	.8

r ..... .71 ..... P.E. of r ... .05

Had four repetitions been given r would have equalled .915

These data show that as a device for measuring the pupils' achievement in General Science, the Scale Forms have fair reliability, as is shown by an average self correlation coefficient of .73 and an average P.E. of estimate of 2.2. As a device for measuring class achievement in General Science, the Scale Forms are really very reliable, as is indicated by an average P.E. of medians of .9 and with close agreement of medians. Explanation of the difference of the medians on S-2 and T-2 is found in the case of School A to be due to the fact that this school offers an exceptionally fine course in Biology which is elected by most pupils and therefore omits from its General Science course as much biological material as possible. Because the items on Biology are not equally distributed in the Groups I, II, and III, failure on the Biology items in Group III where they are of most value had a tendency to lower the scores in Scale Form T-2 for this group of pupils.

E. Correlation with intelligence test scores

Correlation of General Science achievement scores on Scale

Forms S-2 and T-2 with the intelligence test scores was computed for two groups of pupils. In both groups the correlation coefficient between intelligence test scores and General Science Scale scores was high. For 90 cases from Central High School, all of whom had taken General Science one year previous, the correlation between General Science Scale scores and mental age in months from mental test scores (Haggerty Delta 2*) was .741, P.E. of .03. For 81 cases a similar coefficient was .727, P.E. of .035. For the University High School group of 50 cases the coefficient of correlation between mental test scores (Miller Mental Ability Test** Form A) and the scores on the General Science Scale Form S-2 was .603, P.E. of .06. For the same mental test scores and the General Science Scale Form T-2, r was .745, P.E. of .05. For the same mental test scores and the average of the General Science Scale scores for Forms S-2 and T-2, r was .633, P.E. of .057.

F. Correlation between General Science marks and Scale scores

To compute the relationship between General Science Scale scores and the marks that the pupils received in General Science, data were used from three schools. For School A, the Central High School in Minneapolis, data were available giving marks received in General Science a year ago by 90 pupils and also Scale scores in Form S-2 made April 6th, 1923***. These data gave a correlation of .50 (.496), P.E. of .05. Computed for 79 cases these data gave a coefficient of correlation of .47, P.E. of .06. School B, Stillwater High School, gave the Scales S-2 and T-2 April 18th, 1923 to pupils who had taken General Science for about 30 weeks. By using an average of the monthly marks given

* M. E. Haggerty, University of Minnesota. World Book Company.
** W. S. Miller, University of Minnesota. World Book Company.
*** Data furnished by J. E. Bohan (Unpublished thesis).

by teachers for achievement in General Science, the following results were obtained.

	S-2	T-2	Average S-2 & T-2	Marks*
Number cases	140	140	140	140
Median ..	92	86	88	85
Sigma	6.1	4.1	4.5	5.7

r equals .72 P.E. .03, between S-2 and Marks
" " .70 " " " T-2 " "
" " .74 " " " Average of S-2 and T-2 and Marks.

School C, the University High School, had 58 pupils in two groups, all of whom had taken General Science from September until April 20th. Final marks were available for two complete quarters and were evaluated on the basis "A" equals 6, "B" equals 5, "C-" equals 4, "C" equals 3, "C-" equals 2, "D" equals 1, and "F" equals 0. Results follow.

Group I	S-2	T-2	Average S-2 & T-2	Marks
Number cases	24	24	24	24
Median	87	87	87	8
Sigma	5.8	4.7	5.0	2.7

r equals .73 P.E. .06 for S-2 and Marks
" " .64 " .08 " T-2 " "
" " .75 " .06 " Average of S-2 and T-2 and Marks

Group II	S-2	T-2	Average S-2 & T-2	Marks
Number cases	34	34	34	34
Median	84	82	82.5	6.0
Sigma	5.8	4.0	4.6	2.8

r equals .71 P.E. .06 for S-2 and Marks
" " .67 " .07 " T-2 " "
" " .82 " .04 " Average of S-2 and T-2 and Marks.

* These marks were in percents, not letters.

In view of the above data it is believed that the General Science Scale Forms R-1, S-2, and T-2 are even more reliable than was the original 300 item General Science test. Besides being more reliable, a Form of the Scale can be done by pupils of average capacity in 13 minutes, whereas the original test took one hour. The time required for scoring has been reduced to a minimum. The probable error of a measurement or estimation* has been reduced from 10 points on the original test to 2 points on the 60 item Scale Forms by the elimination of unreliable items from the Scale. Finally, each unit of a Scale Form is exactly the equal of every other unit of the same Scale Form or of the other two Scale Forms.

Scale Forms S-2 and T-2 are of equal difficulty and are so constructed that a score of 60 is the median achievement for 9th grade pupils who have taken General Science one year. This was established on the basis of the achievements of 1760 pupils. Scale Form R-1 is one P.E. or 10 points easier than S-2 or T-2. Therefore the median achievement for 9th grade pupils who have taken General Science one year is 90. Because of the known difficulty of each Form, the three may be used interchangeably to check up class progress in General Science from term to term, or they may be combined to secure still more accurate measurements of class or pupil achievements.in General Science.

*Computed by either the formula of (1) P.E. of estimate equals .6745Sigma x square root of $(1-r^2)$, or (2) P.E. of estimate equals square root of $\frac{1}{2}$ times the median deviation.

CHAPTER VIII

COMPARATIVE STUDY OF ACHIEVEMENT IN GENERAL SCIENCE

In Chapter VII, under "B", data were presented which showed that based on approximately 500 papers in five groups of 100 each, in which the original 300 item tests were rescored on the basis of one of the Scale Forms, the coefficient of correlation between distributions of test and Scale scores ranged from .81 to .93 with a mean of .882. This would indicate that where distributions were used, distributions of either test or Scale scores would give approximately the same results, and that any statement made on the basis of test comparisons would have approximately the same justification on the basis of Scale comparison, as indicated by the coefficient of correlation of .882. In "C", however, when grade medians on test and grade medians on Scale Form S-2 were correlated, they gave a correlation coefficient of over .99. These correlations mean that any comparison made on the basis of the test would, with reference to an individual case, receive only as much justification by the Scale, or vice versa, as is indicated by a mean positive coefficient of correlation of .882. Any group comparison, however, made on the basis of a median of test scores, would receive practically identical justification on the basis of a median of Scale scores, or vice versa, as is indicated by a coefficient of correlation of .99 plus. In as much as rescoring approximately 9,000 300 item tests on the basis of the Scale would be a laborious, time consuming process, and in as much as comparisons between the General Science test and other criteria were only

slightly inferior to those of the Scale and the same criteria, it was decided to base the study of achievement on the scores which had been made available for the 300 item test. In other words, the development of the Scale Forms was necessary in order to prove that the original test was sufficiently accurate for measuring group achievement. The Scale Forms are a good check on the test medians. Since, however, for group comparisons the test medians give the same results and since, having been necessary for the Scale development, the test results were at hand, the Scale results need not for economy's sake be used for this part of the study.

The following paragraphs are discussions of some of the comparative studies which have been made of the achievement in General Science as indicated by the 300 item test.

A. Comparison of group achievement in individual schools

To facilitate the treat ment and to increase the accuracy of data, results on each group were kept separately for each school. That is, all the data for the -8G were not only kept separately but were also subdivided according to schools from which they came. Thus it was possible to locate the results for -8G for school A, B, or K at will. Furthermore, since each of the administrators of the twenty-two schools co-operating in this study desired to have data on the achievement for his school compared with the rest, it was a matter of compilation of individual group results to formulate TABLE IX (RESULTS BY SCHOOLS ON THE FIRST 221 ITEMS OF THE GENERAL SCIENCE TEST).

These data were on the first 221 items which enabled the inclusion of practically 9,000 cases. To have compared achievement

TABLE IX RESULTS BY SCHOOLS ON THE FIRST 221 ITEMS OF THE GENERAL SCIENCE TEST

	SCHOOLS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	NORM*
-8 GIRLS	No.Cases	14	15	39	52	12	57	18	17	38	33	26	42	46	13	2	15	41	14	3	28	65	18	608
	Min.Score	55	70	65	60	65	20	65	45	50	50	60	65	50	70	60	65	45	55	60	35	40	70	20
	1st Q. "	72	76	80	78	77	65	79	77	80	68	85	77	76	92	..**	92	61	83	..**	76	74	85	74
	Median "	79	84	86	88	84	73	90	87	87	75	94	85	85	96	75	98	75	87	77	87	81	89	84
	3rd Q. "	90	89	95	94	100	81	99	93	95	84	104	100	93	100	..	106	83	92	..	107	88	96	94
	Max.Score	119	99	114	124	114	109	124	114	119	99	129	134	109	119	89	119	104	119	94	134	114	109	134
-8 BOYS	No.Cases	33	10	38	42	11	50	6	18	40	29	8	21	45	6	8	18	23	14	6	33	41	20	520
	Min.Score	65	65	55	40	65	35	95	60	40	45	75	60	60	75	60	55	50	60	45	35	50	75	35
	1st Q. "	86	77	87	88	84	62	..	86	85	71	86	84	78	..	65	75	79	71	..	93	80	91	79
	Median "	95	84	96	98	100	75	102	93	98	85	92	97	89	92	82	92	92	82	87	102	93	100	92
	3rd Q. "	108	91	106	108	104	86	..	102	115	95	100	110	99	..	87	107	100	93	..	117	102	107	104
	Max.Score	129	109	129	124	109	114	114	114	139	109	104	124	159	129	109	134	124	114	119	159	129	124	179
+8 GIRLS	No.Cases	..	..	1	1	..	1	..	..	..	1	42	..	..	..	..	..	..	1	..	..	..	2	49
	Min.Score	..	..	87	87	..	37	..	..	..	87	60	..	..	..	..	..	..	87	..	..	..	80	35
	1st Q. "	..	..	..	..	..	..	..	..	..	..	87	..	..	..	..	..	..	..	..	..	..	..	86
	Median "	..	..	87	87	..	37	..	..	..	87	100	..	..	..	..	..	..	87	..	..	..	87	95
	3rd Q. "	..	..	..	..	..	..	..	..	..	..	112	..	..	..	..	..	..	..	..	..	..	..	111
+	Max.Score	..	..	87	87	..	37	..	..	..	87	134	..	..	..	..	..	..	87	..	..	..	94	134
+8 BOYS	No.Cases	..	..	..	2	..	1	1	..	..	..	38	..	..	..	1	..	..	..	..	..	..	8	51
	Min.Score	..	..	..	95	..	62	112	..	..	..	70	..	..	..	87	..	..	..	..	..	..	100	60
	1st Q. "	..	..	..	..	..	..	..	..	..	..	98	..	..	..	..	..	..	..	..	..	..	114	98
	Median "	..	..	..	110	..	62	112	..	..	..	110	..	..	..	87	..	..	..	..	..	..	125	111
	3rd.Q. "	..	..	..	..	..	..	..	..	..	..	122	..	..	..	..	..	..	..	..	..	..	132	125
	Max.Score	..	..	..	124	..	62	112	..	..	..	144	..	..	..	87	..	..	..	..	..	..	154	154
-9 GIRLS	No.Cases	8	11	50	115	..	63	4	2	42	10	46	196	11	18	3	1	173	8	11	..	37	6	815
	Min.Score	75	65	65	55	..	55	95	55	50	45	75	55	75	60	60	77	45	75	60	..	35	85	35
	1st Q. "	85	79	87	82	..	79	..	..	77	59	93	79	87	84	..	..	77	90	69	..	82	..	80
	Median "	92	87	95	92	..	94	102	70	90	77	104	88	90	89	75	77	88	109	89	..	92	92	90
	3rd Q. "	100	97	109	100	..	105	..	..	99	97	117	99	105	97	..	..	94	117	105	..	104	..	100
	Max.Score	119	119	134	129	..	154	109	119	134	114	139	144	129	119	89	77	124	129	129	..	124	109	154
-9 BOYS	No.Cases	6	..	23	96	..	39	..	..	3	..	21	83	5	4	1	1	122	2	5	..	14	8	433
	Min.Score	55	..	60	70	..	45	..	..	80	..	65	65	85	60	47	102	55	110	55	..	75	70	45
	1st Q. "	..	..	92	93	..	71	..	..	..	..	87	84	..	..	..	..	83	..	..	..	88	89	85
	Median "	107	..	108	104	..	85	..	..	102	..	109	98	97	77	47	102	93	115	92	..	100	113	98
	3rd Q. "	..	..	118	122	..	106	..	..	..	..	116	108	..	..	..	..	103	..	..	..	111	120	111
-	Max.Score	144	..	139	174	...	154	..	..	124	..	144	149	114	119	47	102	144	119	109	..	134	154	174
+9 GIRLS	No.Cases	56	9	6	4	19	7	25	15	22	26	30	82	45	..	7	41	..	6	2	28	77	25	532
	Min.Score	65	110	95	80	60	85	90	65	65	80	70	75	80	..	55	70	..	80	100	75	70	95	55
	1st Q. "	100	120	..	..	94	..	108	99	94	92	94	93	105	..	..	100	..	..	..	107	99	110	97
	Median "	112	129	115	115	99	117	116	115	105	99	101	104	114	..	99	120	..	110	107	125	109	123	111
	3rd Q. "	125	132	..	..	130	..	120	120	116	112	110	114	122	..	..	129	..	..	..	145	117	132	122
+	Max.Score	154	159	134	119	144	124	139	159	139	149	124	149	154	..	144	164	..	119	114	169	164	144	169

*In each case "Norm" is the composite of all pupils from all schools coming under a single heading, as "-8 Girls".

**Where number of cases, indicated by "No.Cases", is less than 8, 1st Q. and 3rd Q. are omitted as inaccurate.

TABLE IX RESULTS BY SCHOOLS ON THE FIRST 321 ITEMS OF THE GENERAL SCIENCE TEST CONT'D.

	SCHOOLS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	NORM
+9 BOYS	No.Cases	29	13	14	9	13	..	9	7	47	33	41	153	38	..	3	34	1	10	..	27	62	25	568
	Min.Score	85	110	70	55	80	..	100	70	65	45	70	55	90	..	85	65	82	75	..	65	75	90	45
	1st Q. "	117	121	102	80	115	..	115	..	94	89	93	95	107	..	..	105	..	101	..	130	102	109	101
	Median"	136	127	121	92	127	..	125	122	110	110	107	111	117	..	127	125	82	115	..	141	115	116	116
	3rd Q."	143	146	127	109	140	..	129	..	124	122	120	127	132	..	..	137	..	133	..	155	135	130	132
	Max.Score	164	164	174	139	194	..	179	149	159	164	154	164	159	..	144	164	82	149	..	169	159	144	194
-10 GIRLS	No.Cases	44	9	38	227	1	26	7	12	35	4	38	157	31	9	2	2	102	5	5	..	8	1	763
	Min.Score	45	65	70	45	87	65	85	80	50	65	65	55	85	40	75	110	40	90	50	..	90	132	40
	1st Q. "	90	99	93	82	..	87	..	100	74	..	93	85	98	60	..	..	85	..	..	..	110	..	85
	Median "	98	105	103	92	87	102	100	107	90	95	105	94	108	67	90	130	96	105	92	..	115	132	96
	3rd Q. "	108	115	115	104	..	110	..	115	98	..	115	104	115	75	..	..	108	..	..	..	120	..	108
	Max.Score	144	124	129	149	87	139	134	124	124	119	129	129	134	94	104	149	159	114	104	...	129	132	179
-10 BOYS	No.Cases	26	2	18	120	1	18	..	1	11	3	33	70	29	3	3	1	70	2	1	..	3	1	416
	Min.Score	70	100	90	60	142	75	..	107	70	80	90	65	55	55	75	122	60	80	102	..	105	77	55
	1st Q. "	90	..	112	93	..	90	..	..	80	..	105	89	95	..	..	..	93	..	..	..	..	..	93
	Median "	102	115	120	110	142	100	..	107	95	100	117	100	107	77	97	122	105	97	102	..	110	77	106
	3rd Q. "	110	..	127	122	..	115	..	..	100	..	132	114	120	..	..	..	117	..	..	..	..	..	119
	Max.Score	134	129	144	159	142	149	..	107	114	119	169	149	154	99	114	122	164	114	102	..	139	77	169
+10 GIRLS	No.Cases	4	3	11	21	13	14	11	11	9	12	60	93	8	..	3	29	4	13	5	27	64	20	435
	Min.Score	95	105	85	70	100	80	100	95	65	75	70	75	100	..	80	95	80	80	105	90	75	100	65
	1st Q. "	..	..	102	104	122	107	115	99	92	90	101	98	110	..	..	112	..	112	..	111	100	110	101
	Median "	120	127	110	110	135	115	122	111	97	97	110	106	122	..	102	118	90	125	120	122	112	122	112
	3rd Q. "	..	..	112	128	140	120	130	115	102	115	120	116	142	..	..	130	..	130	..	128	122	129	123
	Max.Score	144	149	119	159	154	134	144	149	114	124	149	144	154	..	119	169	109	139	149	149	144	149	169
+10 BOYS	No.Cases	2	4	9	59	7	8	4	10	36	8	44	135	11	..	2	19	2	9	1	28	30	13	441
	Min.Score	115	125	75	60	115	85	110	95	70	50	60	65	95	..	85	110	110	85	97	95	80	110	50
	1st Q. "	..	..	91	102	..	107	..	106	102	87	100	104	117	..	..	127	..	122	..	119	113	125	107
	Median "	140	152	117	119	151	122	140	130	113	100	111	119	130	..	112	137	137	127	97	148	120	140	122
	3rd Q. "	..	..	122	133	..	129	..	136	131	117	130	135	137	..	..	147	..	132	..	160	133	145	137
	Max.Score	164	184	159	169	184	134	164	174	179	129	174	174	154	..	139	169	164	159	97	194	174	169	194
-11 GIRLS	No.Cases	44	14	25	175	3	17	12	7	22	11	39	99	39	7	1	3	59	7	4	..	9	5	600
	Min.Score	65	100	75	50	95	70	95	65	40	75	45	50	70	65	122	105	70	90	85	..	75	105	40
	1st Q."	97	110	97	92	..	110	107	..	77	105	101	86	100	..	..	..	92	..	..	..	94	..	93
	Median"	107	115	104	107	110	122	117	94	90	107	112	97	115	87	122	117	102	117	112	..	112	105	105
	3rd Q."	122	122	117	124	..	134	135	..	100	112	123	108	126	..	..	..	115	..	..	..	117	..	120
	Max.Score	159	134	169	159	119	164	159	144	134	124	169	169	149	154	122	129	154	144	139	..	129	114	169
-11 BOYS	No.Cases	18	6	16	89	4	10	6	6	12	9	26	56	26	3	..	2	61	2	1	..	13	..	366
	Min.Score	55	110	120	45	85	90	100	95	90	105	95	80	90	70	..	100	65	115	132	..	75	..	45
	1st Q. "	107	..	130	115	..	115	..	..	94	112	119	105	112	..	..	..	104	..	..	..	122	..	109
	Median "	121	120	145	125	122	127	132	142	109	117	130	122	130	92	..	120	115	130	132	..	137	..	124
	3rd.Q. "	138	..	160	141	..	132	..	..	115	125	138	139	142	..	..	..	127	..	..	..	146	..	138
	Max.Score	169	139	174	174	149	159	154	159	134	169	159	169	164	114	..	139	154	144	132	..	159	..	174
+11 GIRLS	No.Cases	6	6	9	15	2	24	1	5	10	4	30	90	1	..	4	19	7	16	1	23	57	21	351
	Min.Score	100	120	85	80	125	90	82	85	70	105	85	55	112	..	65	90	85	90	147	75	35	80	35
	1st Q. "	..	..	105	100	..	105	..	..	92	..	107	98	..	..	..	..	107	..	112	..	102	104	107	102
	Median "	125	130	112	118	135	113	82	107	102	110	122	108	112	..	117	120	99	127	147	112	115	117	114
	3rd Q. "	..	..	114	125	..	124	..	..	115	..	134	121	..	..	..	..	..	140	..	132	130	130	128
	Max.Score	174	134	134	169	144	179	82	114	129	144	164	154	112	..	124	149	124	154	147	169	154	164	179

TABLE IX RESULTS BY SCHOOLS ON THE FIRST 221 ITEMS OF THE GENERAL SCIENCE TEST CONT'D

	SCHOOLS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	NORM
+11 BOYS	No.Cases	8	..	3	40	2	11	4	3	20	4	31	81	1	..	2	18	1	4	..	16	46	14	309
	Min.Score	115	..	120	45	120	110	120	105	85	90	60	80	137	..	120	125	82	115	..	115	95	95	45
	1st Q. "	137	..	..	118	..	122	..	..	109	..	115	114	..	..	..	139	..	..	..	122	127	114	119
	Median "	142	..	145	128	127	142	137	135	124	118	140	135	137	..	140	147	82	135	..	149	138	142	135
	3rd Q. "	165	..	..	138	..	162	..	..	152	..	150	146	..	..	..	155	..	..	..	158	151	155	150
	Max.Score	179	..	169	164	134	169	149	164	169	154	184	204	137	..	159	189	82	159	..	179	184	189	204
-12 GIRLS	No.Cases	32	4	23	105	5	18	7	10	27	17	34	57	28	6	1	3	55	5	4	..	35	3	479
	Min.Score	70	110	95	65	90	95	110	80	50	90	90	75	85	70	137	110	40	110	120	..	80	120	40
	1st Q. "	110	..	110	101	..	110	..	97	71	102	112	98	100	..	..	..	97	..	..	..	99	..	100
	Median "	121	125	120	116	132	132	139	112	78	112	120	108	112	85	137	115	110	117	147	..	107	132	114
	3rd Q. "	137	..	135	129	..	140	..	120	89	125	131	119	145	..	..	..	121	..	..	..	116	..	129
	Max.Score	154	149	154	184	149	159	159	164	159	149	149	179	159	139	137	129	149	154	154	..	149	149	184
-12 BOYS	No.Cases	18	3	11	69	9	13	2	4	5	10	39	62	12	5	..	..	25	2	..	..	11	..	300
	Min.Score	105	135	95	70	100	115	155	130	100	65	90	85	105	95	..	..	90	155	..	..	95	..	65
	1st Q. "	117	..	145	122	122	130	..	..	..	109	130	115	122	..	..	..	113	..	..	..	132	..	119
	Median "	132	145	152	136	134	145	162	145	127	125	143	125	145	117	..	..	132	170	..	..	147	..	137
	3rd Q. "	145	..	167	149	155	157	..	..	..	140	157	144	155	..	..	..	149	..	..	..	155	..	150
	Max.Score	164	154	184	184	179	179	169	159	159	159	179	184	159	134	..	..	174	184	..	..	159	..	184
+12 GIRLS	No.Cases	10	1	12	40	2	19	1	4	2	..	40	97	3	..	..	18	6	12	2	28	6	20	323
	Min.Score	110	102	110	75	140	80	152	80	120	..	65	75	100	..	..	110	90	105	135	60	115	90	60
	1st Q. "	120	..	120	100	..	100	..	..	..	..	110	102	..	..	..	122	..	117	..	117	..	125	107
	Median "	124	102	127	119	147	132	152	102	122	..	132	111	117	..	..	128	112	132	140	130	125	137	124
	3rd Q. "	130	..	137	135	..	150	..	..	..	..	144	127	..	..	..	137	..	140	..	142	..	148	137
	Max.Score	144	102	149	184	154	164	152	179	124	..	154	164	134	..	..	164	124	149	144	174	154	184	184
+12 BOYS	No.Cases	7	1	5	27	..	9	..	5	19	1	18	50	5	..	3	11	2	11	1	23	14	14	226
	Min.Score	110	147	135	100	..	90	..	115	110	122	105	90	125	..	105	120	130	130	137	130	115	115	90
	1st Q. "	..	..	..	129	..	100	..	..	127	..	129	128	..	..	..	139	..	145	..	140	137	127	130
	Median "	145	147	147	140	..	127	..	137	134	122	137	145	140	..	135	142	137	160	137	150	152	132	142
	3rd Q. "	..	..	..	155	..	145	..	..	162	..	160	160	..	..	..	160	..	167	..	160	165	140	158
	Max.Score	169	147	159	179	..	154	..	184	184	122	179	179	169	..	139	184	144	184	137	189	189	164	189

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UNIVERSITY		
	No.Cases	347
	Min.Score	105
	1st Q. "	153
	Median "	165
	3rd Q. "	176
	Max.Score	204

on 300 items would have allowed the use of about two-thirds of the data or about 6,000 cases. Data in Chapter V show that 300 item results on the General Science test and 221 item results on the same test agree to the extent of giving for a large number of the cases a product-moment correlation of .98. Therefore the comparative results by schools are as accurate for the 221 item test as they would have been had 300 items been used. They are in fact more accurate in the case of these data because of the additional 3,000 cases, the use of which was made possible by including the first 221 items of the test only.

These 9,000 cases included about 90% of all papers submitted. The 10% which had been eliminated were not used because (a) the pupils did not do as much as three pages in the original test, presumably because insufficient time was allowed for the test, (b) pupils had omitted necessary information such as their name, grade in school, and sciences taken, and (c) pupils (a small number) had misunderstood directions and had written out correct responses instead of underling them, or had in some way failed to follow directions. These last mentioned papers could have been used but the scoring of them would have required individual reading of each paper rather than the use of the correcting stencil.

With reference to the first reason given for elimination, in an examination of time taken for the test and the score obtained, the writer found that there was no relationship between time and success in the test. Four hundred forty cases, over as wide a range of test scores as possible, were studied. The wide range of scores selected gave excellent conditions for securing a high co-

efficient of correlation. These data, however, gave a product-moment coefficient of correlation of .09 with P.E. of .03 between time in minutes and score achieved. This result is easily explained by the fact that the directions for giving the test (See Appendix II) stated that no time limit was to be used. Directions of this kind would naturally cause pupils to work at comfortable rates rather than at maximum speed.

In Table IX each of the 22 schools, represented by a letter, has its results on the test in a column of its own. The last column labelled "Norm" is the composite of the 22 columns preceding, this composite being in the form of a single distribution rather than a median or mean of the results in the 22 columns. At the left are indicated the grades and subdivisions of the grades using nomenclature which has been used thruout this study, namely, sex, grade, and whether or not the pupil had taken General Science indicated by "-8 Girls" for 8th grade girls who had not taken General Science and"+9 Boys" for 9th grade boys who had taken General Science. Number of cases, minimum and maximum score, and first and third quartile and median score for each group are self explanatory.

Examination of the Table shows that schools differ quite markedly in their achievements on this General Science test. Also the fact that a course in General Science was taken gives the obvious results in all cases, namely, a higher score for pupils of any grade who have taken General Science than for pupils of the same grade in the same school who have not taken General Science. With regard to the latter result, some data will be presented later regarding the selective influence of General Science where the

subject is elective. With regard to school achievements, the difference is in part at least due to differences in native ability and in part to the kinds of courses which are offered in the different schools. If the latter statement is really true, one of the valuable results of this study is to make available a device for measuring achievement in General Science, the use of which would be one of the first requisites in a study of the achievements in various courses in General Science.

B. Overlapping

In securing the "norms" presented in the previous paragraphs, distributions of scores on the 221 item General Science test were made. These distributions are presented in TABLE X (DISTRIBUTION OF SCORES OF 8970 CASES ON FIRST 221 ITEMS OF THE GENERAL SCIENCE TEST) and are plotted in FIGURE III (A-E) -DISTRIBUTIONS OF GENERAL SCIENCE SCORES (FOR 221 ITEMS) FOR VARIOUS GRADE GROUPS TOTALING 8970 CASES. Survey of TABLE X shows a gradual shifting of the distributions toward the higher scores from the 8th to the 12th grade. The medians and percentiles for these same 8970 cases are given in TABLE XI (PERCENTILE SCORES ON FIRST 221 ITEMS MADE BY 8970 CASES). It is obvious that there is not only a gradual shifting of distributions and medians toward higher scores in the upper grades giving great differences, but that there are also sex differences and differences due to having had or not having had the subject. In like manner Table II (See page 47), FIGURE IV (A-C) -DISTRIBUTION OF GENERAL SCIENCE SCORES (FOR 300 ITEMS) FOR VARIOUS GRADE GROUPS TOTALING 6053 CASES -, which gives the data

TABLE X

DISTRIBUTION OF SCORES OF 8970 CASES ON FIRST 221 ITEMS OF THE GENERAL SCIENCE TEST.

Score	-8G	-8B	+8G	+8B	-9G	-9B	+9G	+9B	-10G	-10B	+10G	+10B	-11G	-11B	+11G	+11B	-12G	-12B	+12G	+12B	UNIVERSITY I	UNIVERSITY II	UNIVERSITY III	UNIVERSITY IV	J.C.	T.C.
20- 24	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25- 29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30- 34	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35- 39	2	2	1	.	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
40- 44	1	4	.	.	.	.	.	.	2	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.
45- 49	6	5	.	.	2	2	.	1	2	.	.	.	1	1	.	1	.	.	.	.	.	.	.	.	.	.
50- 54	8	5	.	.	2	.	.	.	3	.	.	1	2	.	.	.	2	.	.	.	.	.	.	.	.	.
55- 59	13	11	.	.	12	7	1	3	8	2	.	.	6	1	2	.	.	.	.	.	.	.	.	.	.	.
60- 64	24	17	1	1	13	4	1	1	6	3	.	2	2	.	.	1	3	.	1	.	.	.	.	.	.	.
65- 69	44	28	1	.	36	10	4	5	17	3	1	1	8	1	2	.	2	1	1	.	.	.	.	.	.	.
70- 74	52	25	1	1	43	13	6	10	34	11	2	3	14	2	5	.	10	1	.	.	.	.	.	.	.	.
75- 79	73	35	1	1	85	28	10	10	46	16	5	5	20	2	1	.	10	1	4	.	.	.	.	.	1	.
80- 84	84	40	5	3	87	38	20	17	66	25	13	8	26	10	9	4	12	.	8	.	.	.	.	.	.	.
85- 89	85	58	9	2	117	42	18	18	78	24	16	12	32	9	15	2	15	2	6	.	.	.	.	.	.	2
90- 94	74	56	6	1	100	44	44	35	94	36	20	16	58	13	17	3	29	4	11	2	.	.	.	.	.	.
95- 99	44	63	2	5	99	37	61	27	92	26	32	30	57	14	21	5	34	8	13	2	.	.	.	.	.	3
100-104	40	42	5	7	57	50	35	49	78	45	53	22	62	17	21	8	40	10	21	3	.	.	.	.	.	2
105-109	25	46	3	2	60	42	58	36	72	45	42	27	59	25	46	12	41	10	27	3	.	1	.	.	.	4
110-114	14	23	6	7	33	32	59	57	57	37	62	36	48	37	37	21	43	17	26	5	.	.	.	.	.	4
115-119	8	28	5	4	28	22	66	52	32	43	56	40	48	23	34	23	53	25	22	8	1	2	.	.	2	4
120-124	5	14	2	4	16	18	45	35	36	29	36	39	44	36	39	22	36	23	25	9	1	3	1	.	1	4
125-129	2	7	.	4	13	15	24	43	20	21	37	40	38	24	25	19	33	16	35	20	.	5	.	.	.	.
130-134	2	2	1	3	5	11	34	37	10	7	20	32	24	35	26	27	31	18	31	25	1	2	1	.	.	7
135-139	.	3	.	3	4	5	13	42	5	12	10	30	23	34	18	24	24	24	23	24	2	9	2	.	1	.
140-144	.	.	.	2	1	6	13	35	1	9	15	20	9	23	10	31	16	31	19	26	4	15	2	.	.	.
145-149	.	2	.	.	.	2	7	16	2	8	8	18	6	19	6	27	20	30	17	18	1	11	1	1	1	2
150-154	.	1	.	1	1	3	7	17	.	7	3	19	4	16	7	20	12	25	17	11	2	23	3	2	.	2.
155-159	.	2	.	.	.	.	2	11	1	5	2	13	4	11	1	16	5	26	6	17	1	22	4	.	.	2
160-164	.	.	.	.	.	.	3	7	.	1	1	11	1	8	4	15	2	7	4	19	3	32	10	4	.	.
165-169	..	.	.	.	.	1	1	1	.	1	1	5	3	4	2	15	.	9	.	15	4	34	4	1	.	.
170-174	.	.	.	.	.	1	.	1	.	.	.	6	.	2	1	2	2	3	2	6	4	23	6	2	.	.
175-179	.	1	.	.	.	.	.	1	1	.	.	2	.	.	1	6	2	5	2	5	5	29	7	4	.	.
180-184	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	3	1	4	.	6	3	17	2	2	.	.
185-189	.	;	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	2	.	12	3	1	.	.
190-194	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	6	.	3	.	.
195-199	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.
200-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Total Number	608	520	49	51	815	433	532	568	763	416	435	441	600	366	351	309	479	300	323	226	32	248	46	21	6	32

FIG.III DISTRIBUTIONS OF GENERAL SCIENCE SCORES (for 221 items) FOR VARIOUS GRADE GROUPS TOTALING 8970 CASES

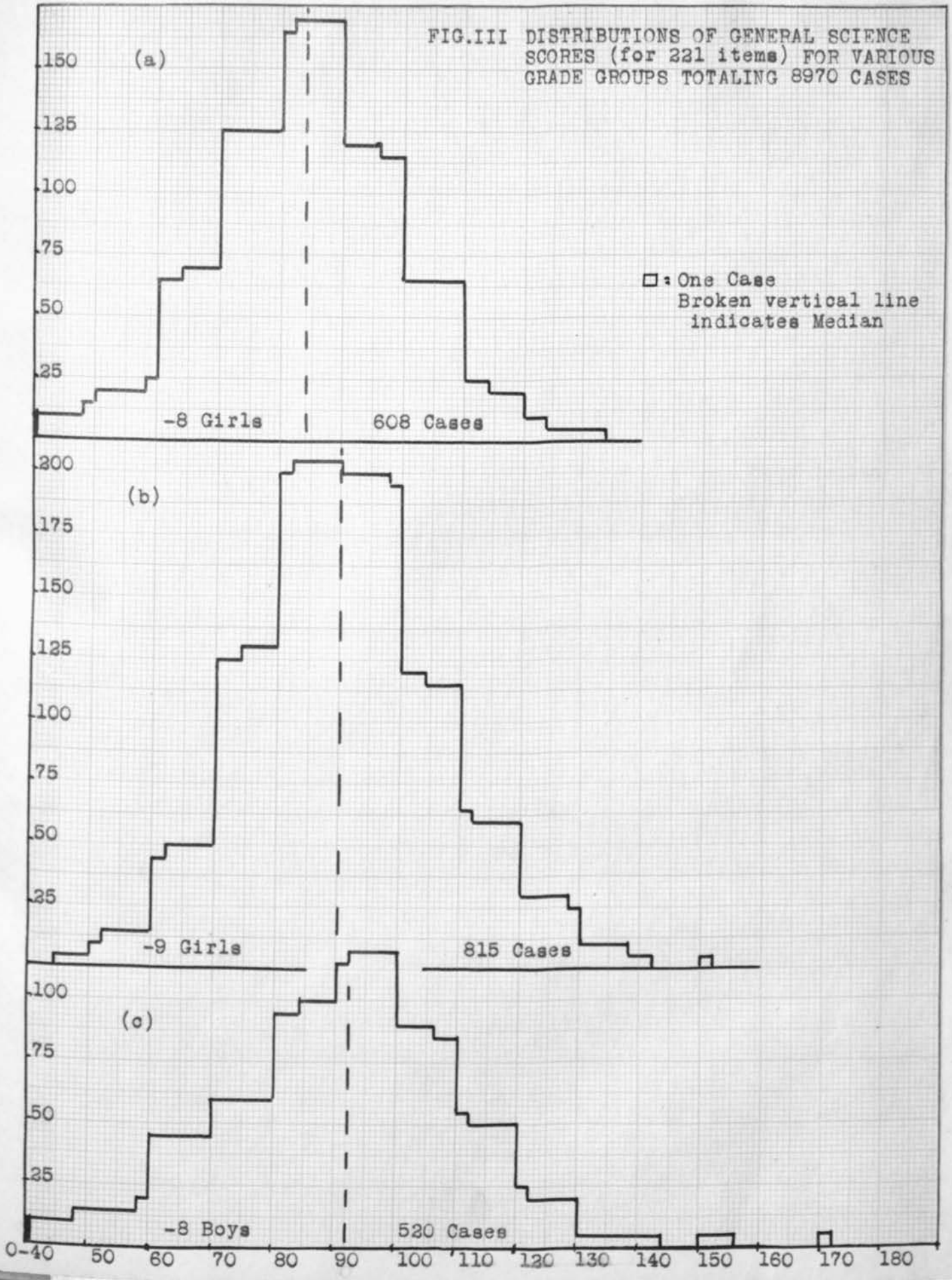


FIG. III (Continued)

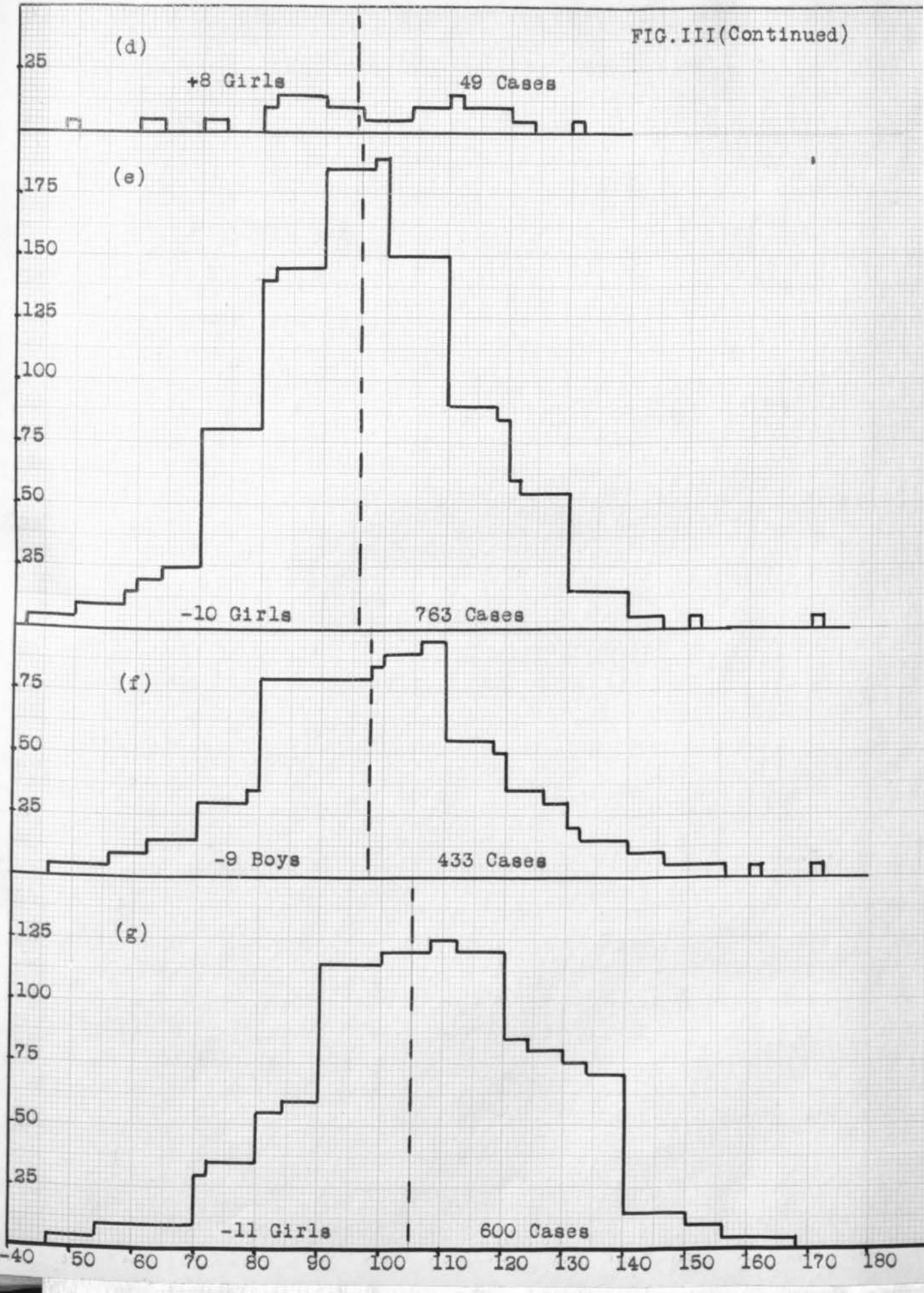


Fig.III (Continued)

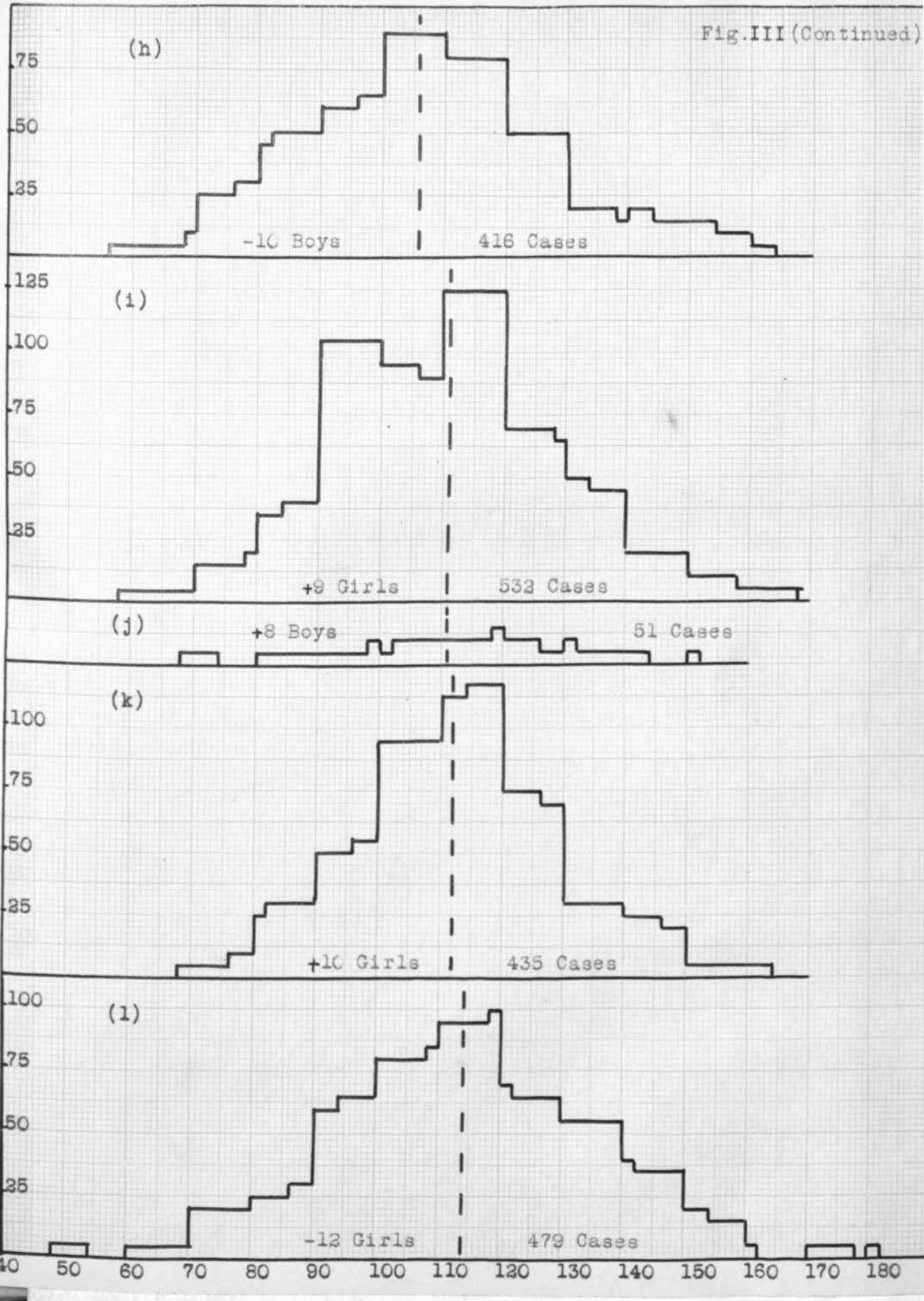


FIG.III (Continued)

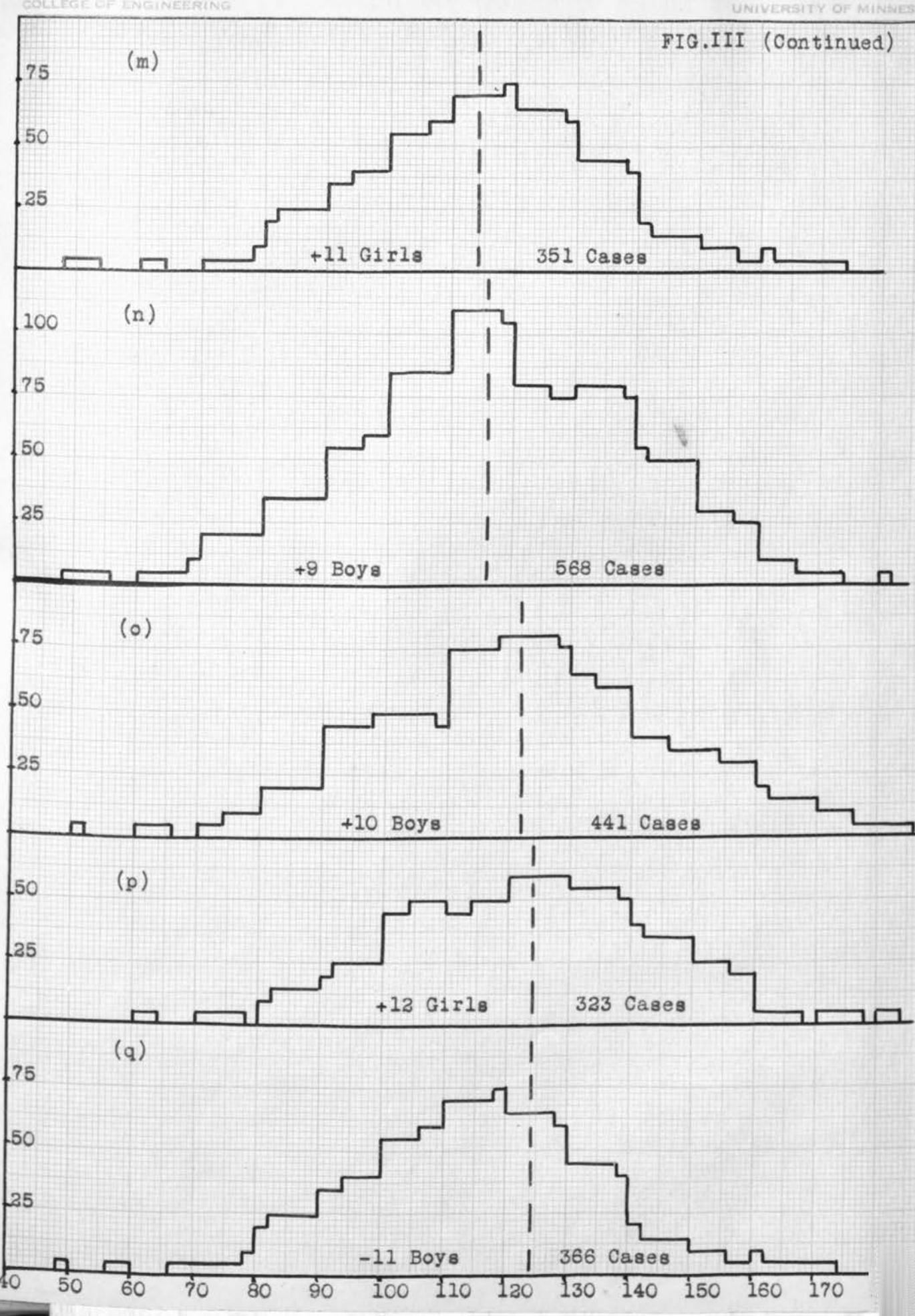


Fig.III (Continued)

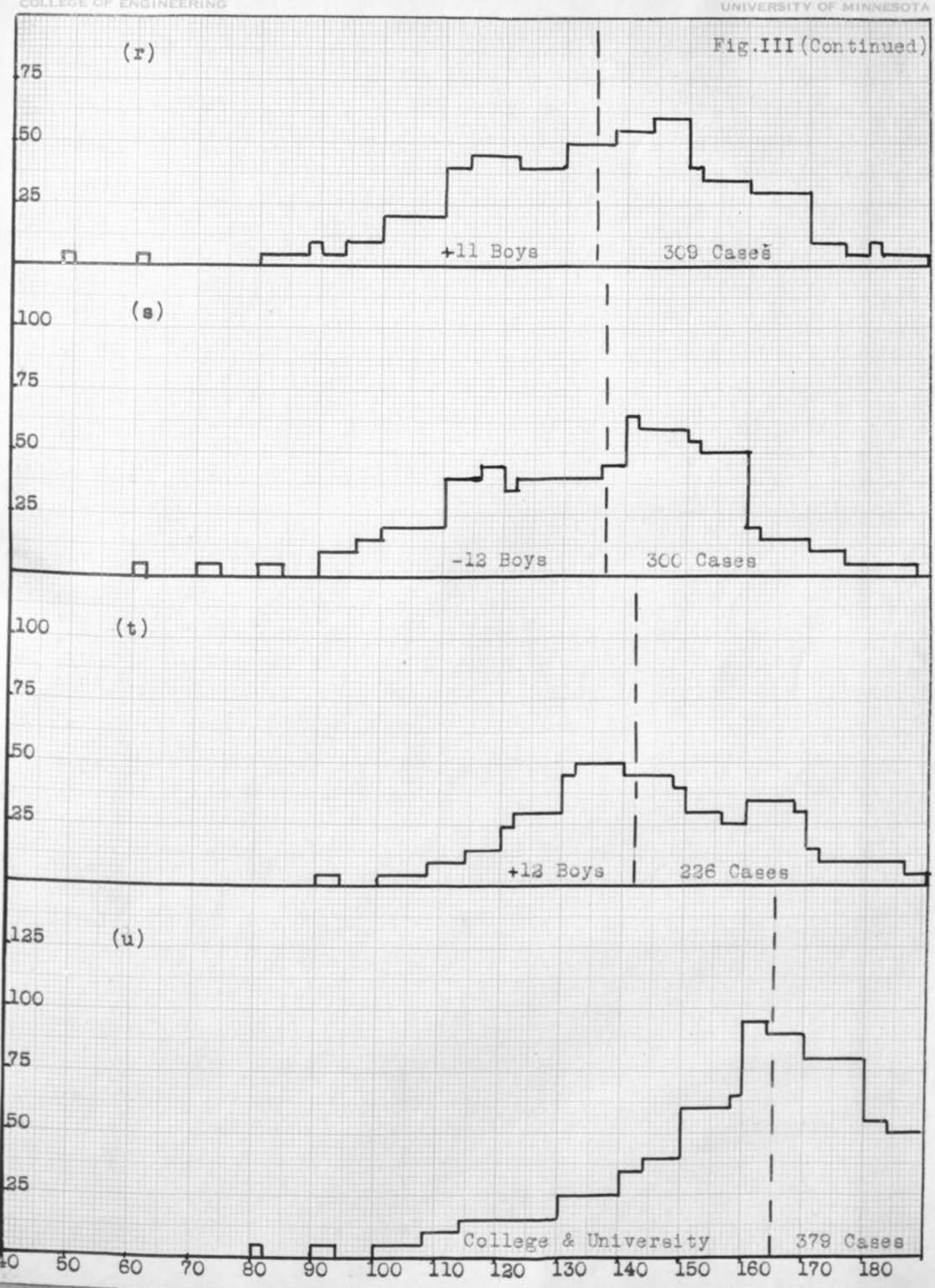


TABLE XI

PERCENTILE SCORES ON FIRST 221 ITEMS MADE BY 8970 CASES

		SCORES														
PERCENTILE		0	1	10	20	25	30	40	50	60	70	75	80	90	99	100
GROUP	NUMBER															
-8 Girls	608	20	47	65	71	74	77	81	84	88	92	94	97	104	123	134
-9 "	815	35	56	72	77	80	83	86	90	94	98	100	104	112	132	154
-10 "	763	40	55	75	82	85	87	92	96	100	105	108	111	119	137	179
-11 "	600	40	56	81	90	93	95	101	105	111	117	120	124	152	157	169
-12 "	479	40	63	87	96	100	103	109	114	119	125	129	133	143	165	184
+8 Girls	49	35		79	84	86	87	91	95	102	107	111	113	118		134
+9 "	532	55	69	88	95	97	99	106	111	115	119	122	124	133	155	169
+10 "	435	65	76	91	99	101	103	108	112	116	120	123	126	134	154	169
+11 "	351	35	67	90	99	102	106	110	114	119	124	128	130	138	165	179
+12 "	323	60	77	95	104	107	110	117	124	129	134	137	141	150	175	184
-8 Boys	520	35	43	66	75	79	82	88	92	96	101	104	107	116	145	179
-9 "	433	45	56	76	82	85	88	93	98	103	108	111	114	125	150	174
-10 "	416	55	64	81	89	93	95	102	106	111	117	119	122	135	157	169
-11 "	366	45	72	94	105	109	112	118	124	130	135	138	141	151	167	174
-12 "	300	65	84	106	116	119	122	130	137	143	148	150	153	159	181	184
+8 Boys	51	60		82	96	98	100	104	111	116	122	125	128	136		154
+9 "	568	45	65	87	97	101	104	111	116	121	128	132	135	144	168	194
+10 "	441	50	70	92	102	107	110	116	122	127	134	137	141	153	175	194
+11 "	309	45	82	107	116	119	123	130	135	140	147	150	154	163	183	204
+12 "	226	90	97	119	128	130	134	137	142	147	155	158	161	168	184	189
Jr.College	6	80				115			119			139				149
Univ. 1	32	115		135	142	143	147	157	162	168	172	174	176	179		184
" 2	248	105	119	140	150	153	155	161	164	169	173	175	177	183	194	204
" 3	46	120		142	154	157	159	162	164	169	173	175	176	180		189
" 4	21	145		154	162	163	164	171	175	177	180	182	185	191		199
Teachers College	32	90		103	108	110	113	117	120	130	132	133	134	150		159
Total No.	8970															

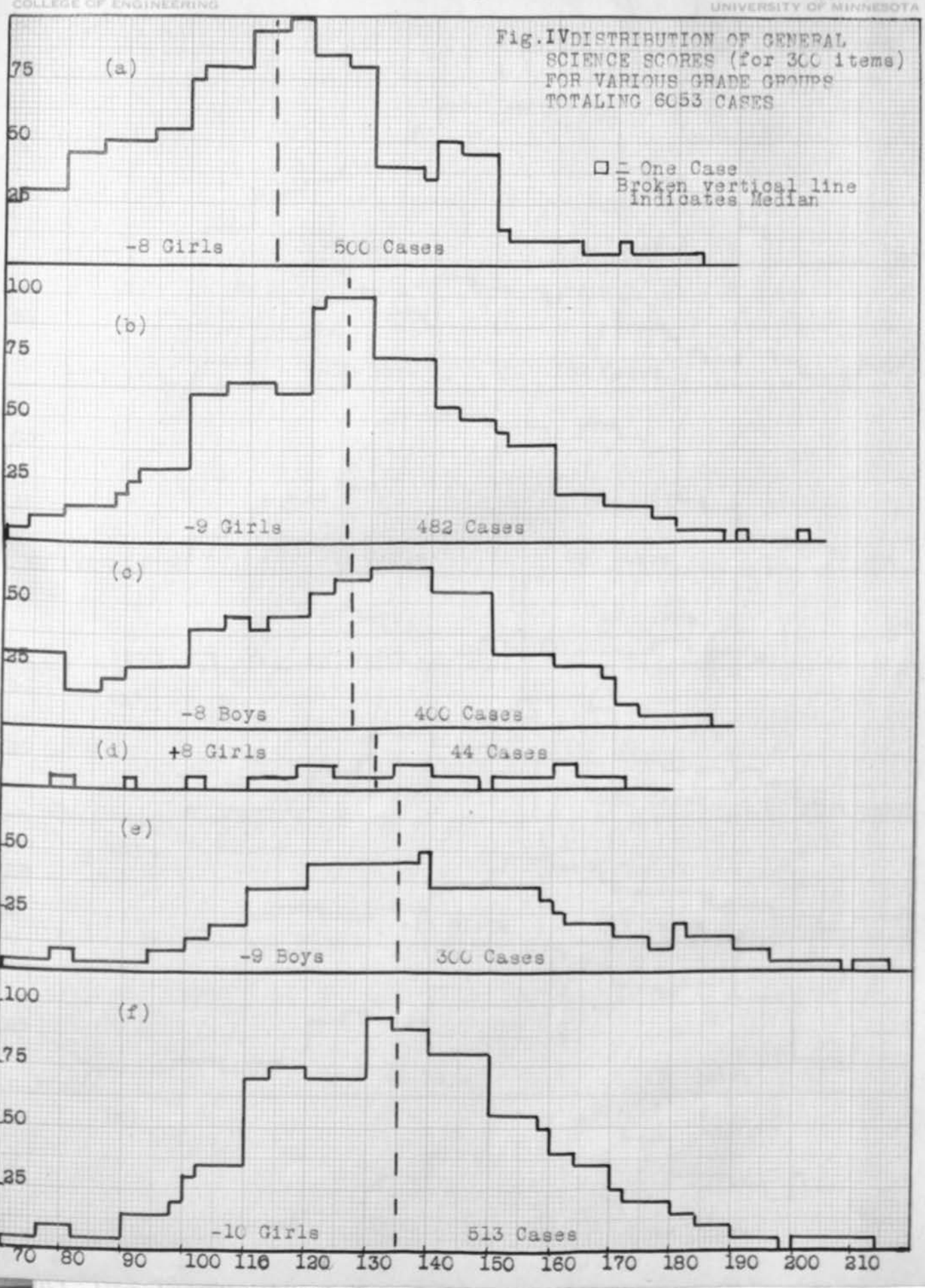


Fig. IV DISTRIBUTION OF GENERAL SCIENCE SCORES (for 300 items) FOR VARIOUS GRADE GROUPS TOTALING 6053 CASES
□ = One Case
Broken vertical line indicates Median
(a)
75
50
25
-8 Girls
500 Cases
(b)
100
75
50
25
-9 Girls
482 Cases
(c)
50
25
-8 Boys
400 Cases
(d)
+8 Girls
44 Cases
(e)
50
25
-9 Boys
300 Cases
(f)
100
75
50
25
-10 Girls
513 Cases
70 80 90 100 110 120 130 140 150 160 170 180 190 200 210

Fig.IV (Continued)

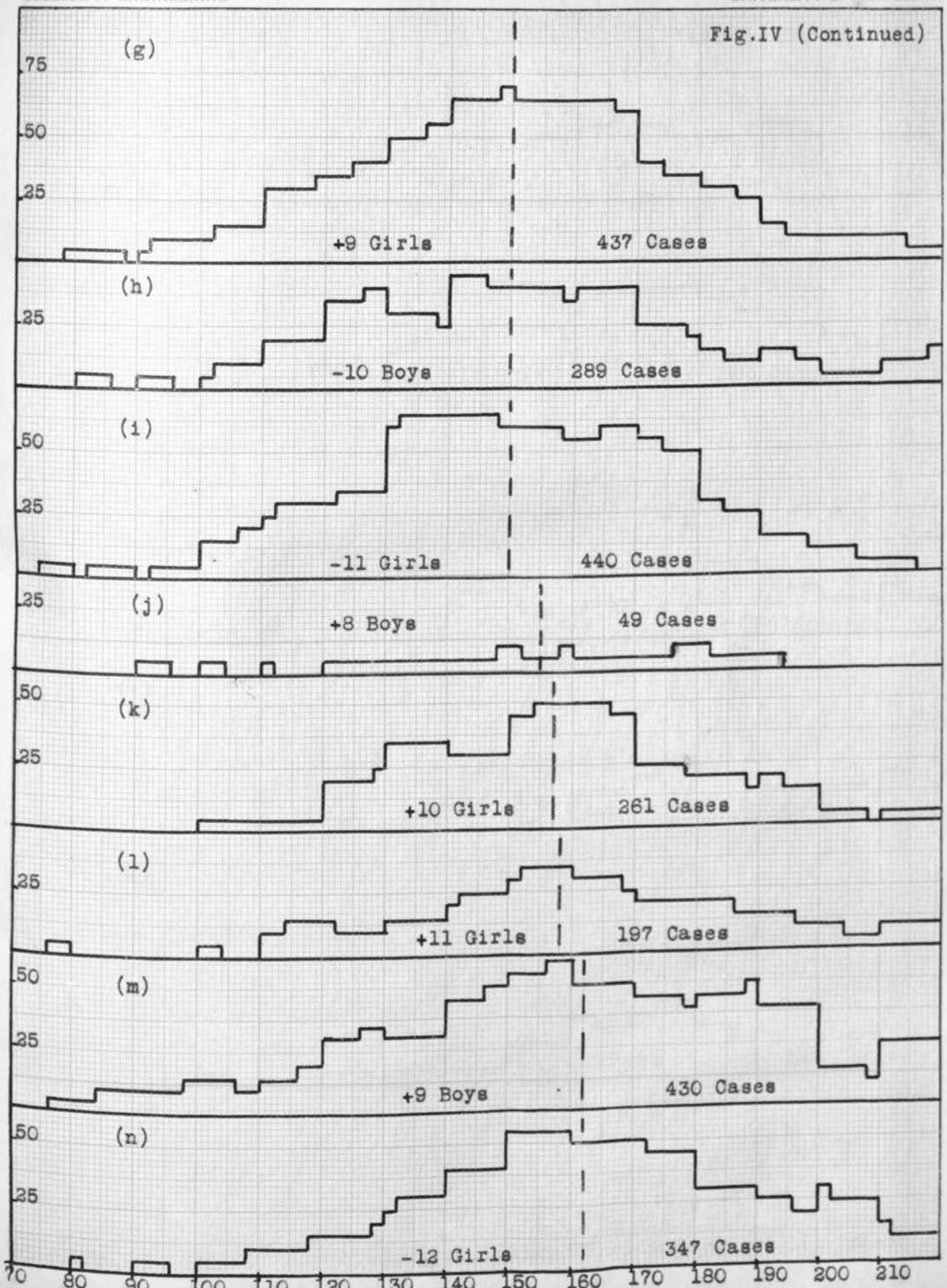
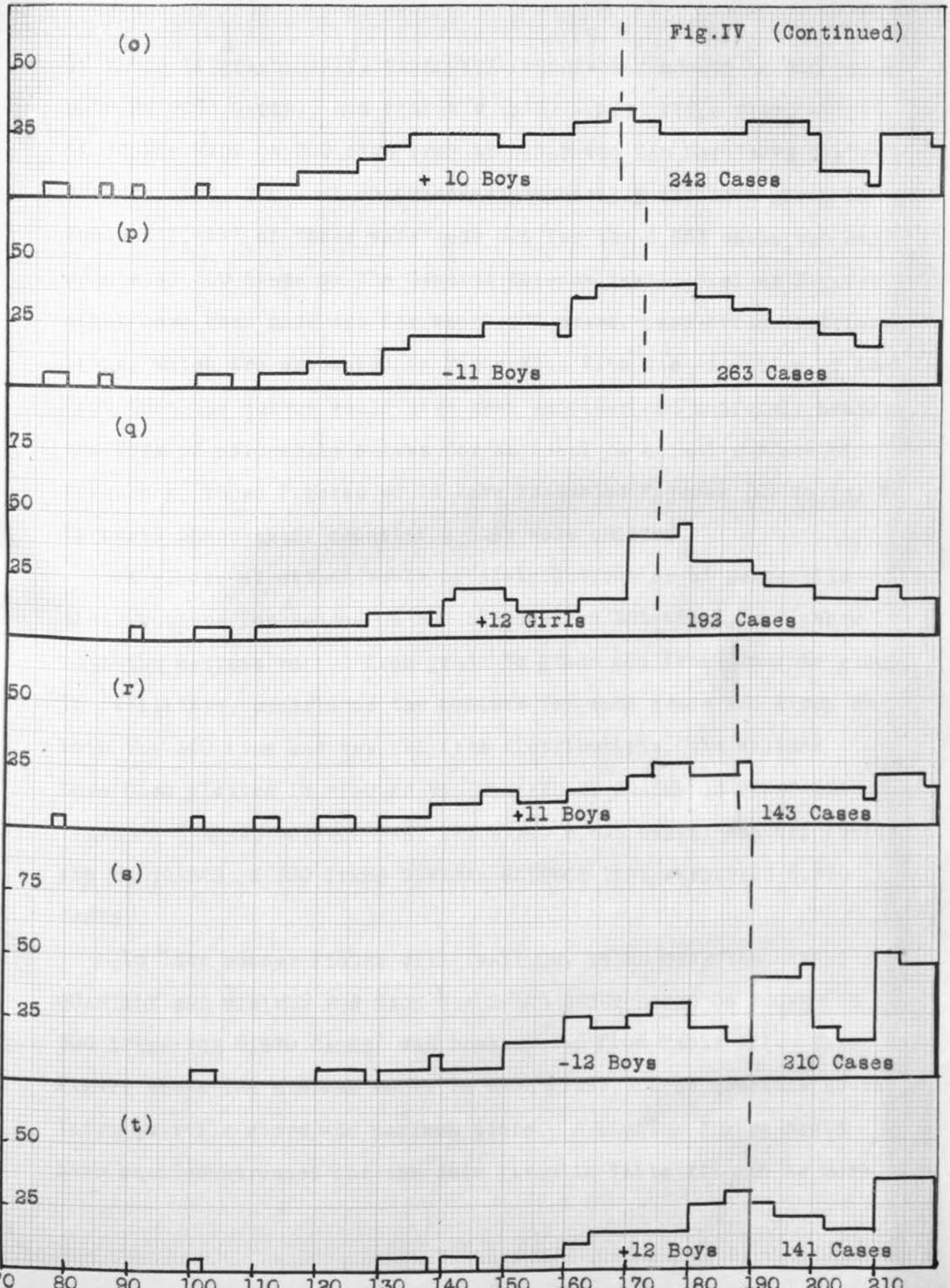


Fig.IV (Continued)



of Table II graphically, TABLE XII (PERCENTILE SCORES ON 300 ITEMS MADE BY 6053 CASES), and FIGURE V (A-H) - PERCENTILE DISTRIBUTION OF SCORES MADE ON 300 ITEM TEST BY GIRLS WHO HAD NOT TAKEN GENERAL SCIENCE, ETC, ETC - which presents graphically the data given in Table XII, all of these were made out for the 6,053 cases who had completed 300 items on the General Science test. Similar Figures might have been made out for the 9,000 cases, percentile distributions, which are presented in Table XI. With the exception of the fact that the curves would have been smoother and uniformly nearer the form of percentile curves for an ideal or normal surface of frequency, those Figures would have resembled Figures (a) to (h) V. To avoid unnecessary repetition they were omitted.

A glance at either table of distributions or of percentile distributions for scores on 300 items or on 221 items, will show that the medians varied from grade to grade and from group to group. To facilitate comparisons the medians for each grade and group on both the 300 item and the 221 item distributions, the medians have been plotted in FIGURES VI (MEDIANS BY GRADES ON FIRST 221 ITEMS OF GENERAL SCIENCE TEST INVOLVING 8,591 CASES) and VII (MEDIANS BY GRADES ON 300 ITEMS GENERAL SCIENCE TEST INVOLVING 5,970 CASES).

In like manner FIGURE VIII (MAXIMUM, THIRD QUARTILE, FIRST QUARTILE AND MINIMUM FOR EACH GRADE AND GROUP BASED ON SCORES ON 300 ITEMS FOR 5,970 CASES) was constructed from Table XII. This Figure shows the minimum score in each grade, first quartile score, third quartile score and maximum score. A similar figure could have been constructed for the data given in Table XI. In as much

TABLE XII

PERCENTILE SCORES ON 300 ITEMS MADE BY 6053 CASES.

PERCENTILE		SCORES														
		0	1	10	20	25	30	40	50	60	70	75	80	90	99	100
GROUP	NUMBER															
-8 Girls	500	29	54	84	94	98	103	109	114	119	125	128	132	144	174	184
-9 "	482	23	67	98	107	110	115	121	126	131	137	142	146	155	184	202
-10 "	513	60	72	107	116	119	122	129	135	140	148	150	155	167	203	222
-11 "	440	45	84	115	129	133	136	143	150	157	164	168	172	183	207	217
-12 "	347	84	99	129	139	145	148	156	162	169	177	181	186	200	224	239
+8 Girls	44	54	69	104	117	119	122	128	131	139	148	157	159	163	175	179
+9 "	437	50	89	113	128	132	137	144	150	157	163	166	171	184	214	236
+10 "	261	102	106	127	138	139	144	151	157	163	168	172	178	189	219	228
+11 "	197	63	104	123	138	143	147	151	158	165	174	178	183	197	224	231
+12 "	192	99	104	134	147	152	159	171	175	183	189	192	197	206	239	249
-8 Boys	400	50	59	87	101	107	111	120	127	133	139	145	147	157	178	184
-9 "	300	58	74	105	116	121	124	130	135	144	152	156	161	180	209	235
-10 "	289	84	89	116	126	130	136	143	150	157	165	167	173	190	219	233
-11 "	283	69	104	134	147	154	158	165	172	178	187	191	197	210	237	230
-12 "	210	104	120	152	165	168	173	181	190	196	203	207	212	220	246	262
+8 Boys	49	95	95	108	124	133	138	147	155	162	170	174	176	183	195	195
+9 "	430	75	78	117	131	138	142	152	162	169	179	183	187	198	225	244
+10 "	242	67	89	128	140	146	150	159	168	176	184	190	194	213	234	257
+11 "	143	54	110	151	166	170	172	183	188	194	203	207	213	224	247	251
+12 "	141	103	130	160	171	179	180	184	190	196	204	209	213	228	244	255
Jr.College	6	122				164			172			186				207
University																
1....	9	190		190	199	201	208	219	228	235	236	237	238	242		246
2....	134	125	175	198	210	214	217	224	228	232	239	241	244	249	264	274
3....	18	189		205	214	215	216	219	229	238	241	242	244	247		262
4....	6	206				212			236			259				264

FIGURE V (a)

PERCENTILE DISTRIBUTION OF SCORES MADE ON 300 ITEM TEST BY GIRLS WHO HAD NOT TAKEN GENERAL SCIENCE.

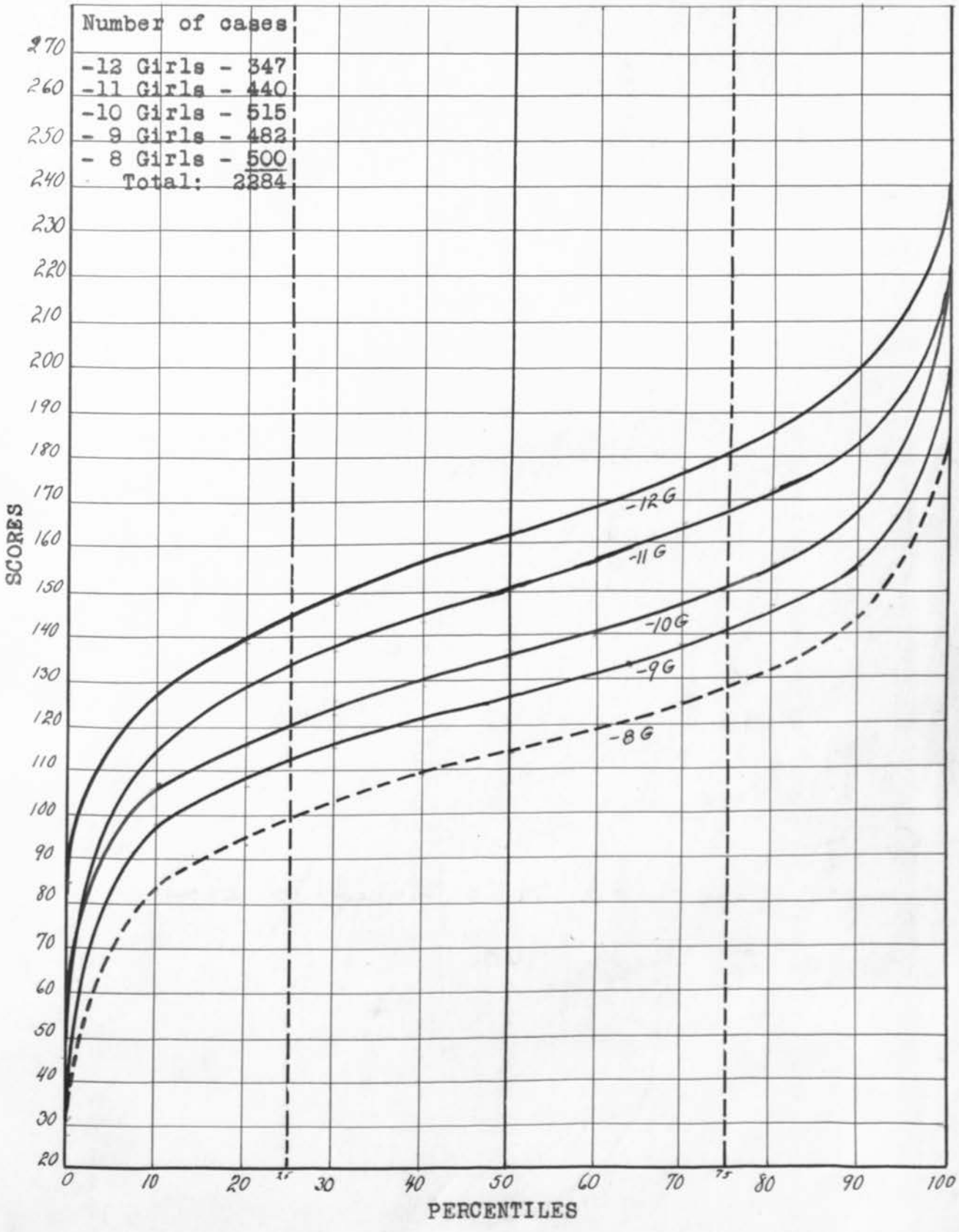


FIGURE V (b)

PERCENTILE DISTRIBUTION OF SCORES MADE ON 300 ITEMS BY GIRLS WHO HAD TAKEN GENERAL SCIENCE.

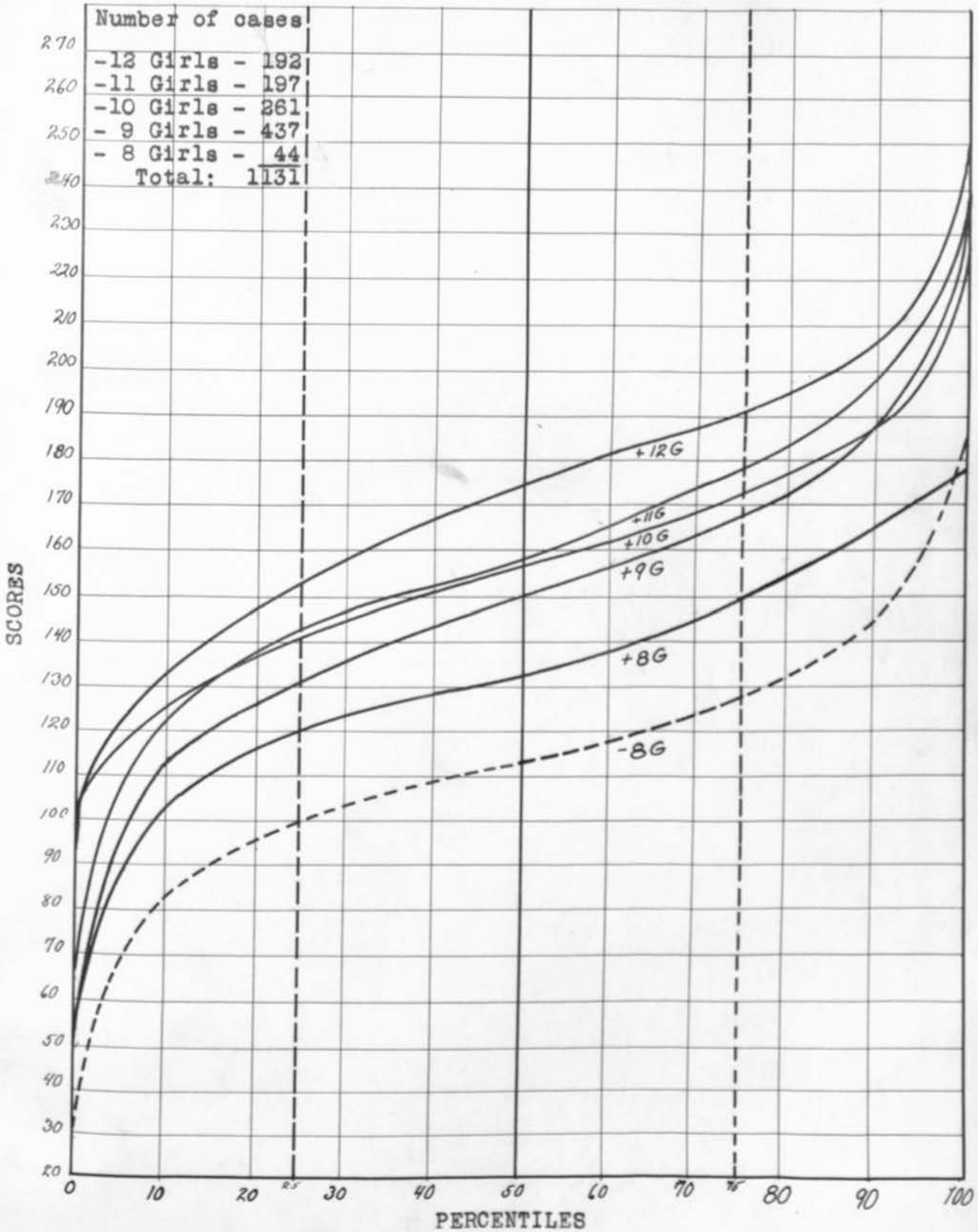


FIGURE V (c)

PERCENTILE DISTRIBUTION OF SCORES MADE BY BOYS WHO HAD NOT STUDIED GENERAL SCIENCE, ON 300 ITEM TEST.

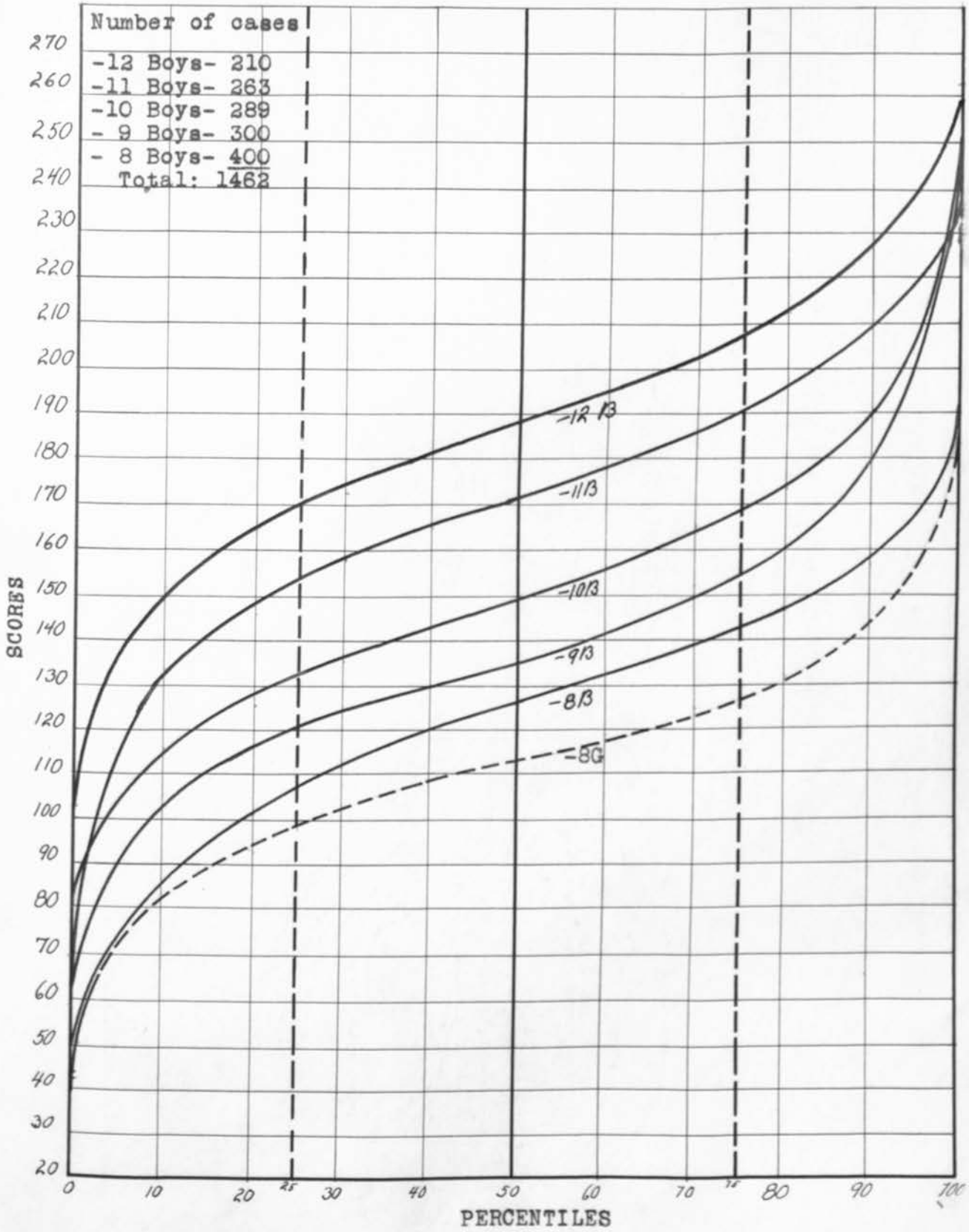


FIGURE V (d)

PERCENTILE DISTRIBUTION OF SCORES MADE ON 300 ITEMS BY BOYS WHO HAD TAKEN GENERAL SCIENCE.

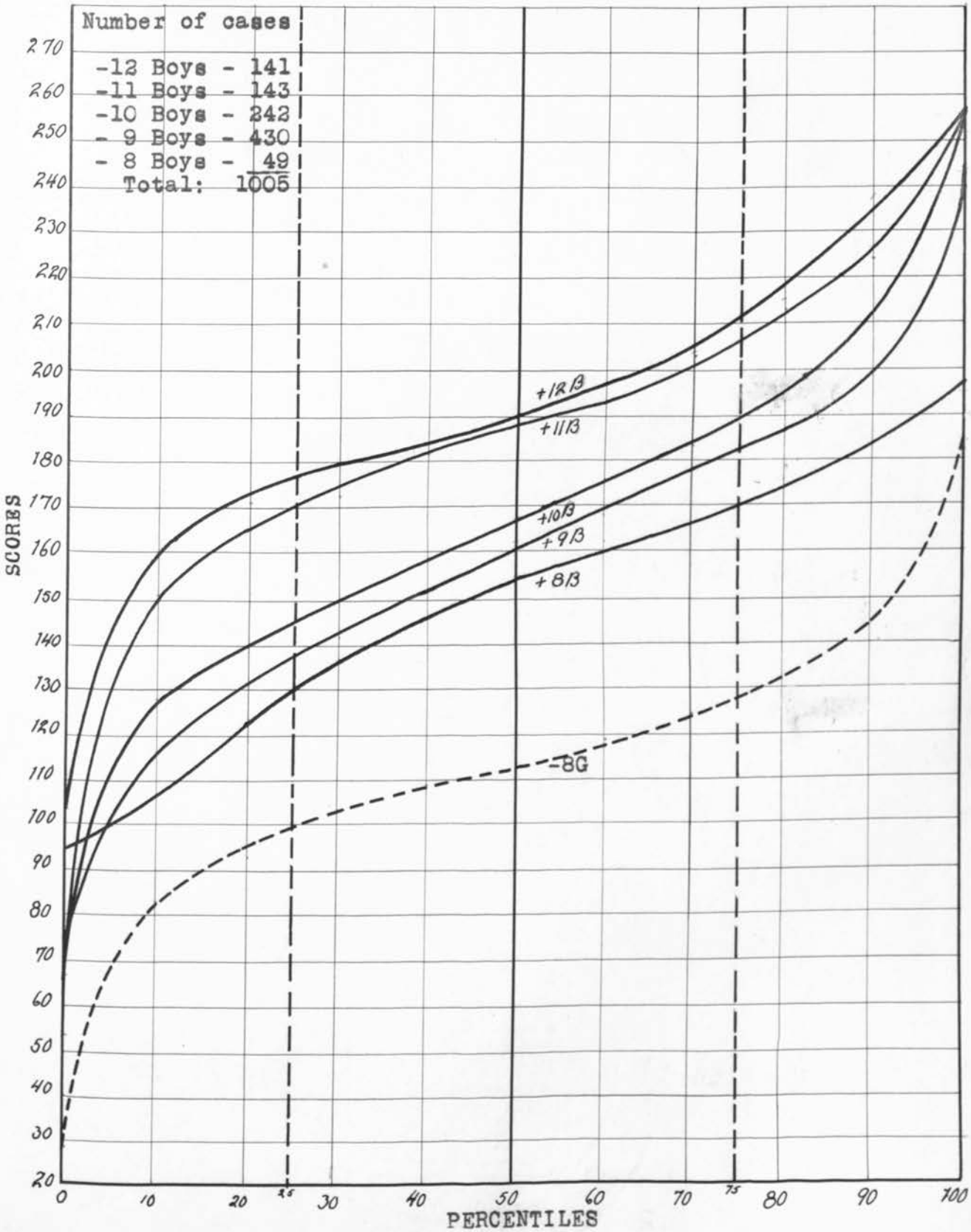


FIGURE V (e)

DISTRIBUTION OF SCORES MADE ON 300 ITEM TEST BY EIGHTH AND TWELFTH GRADE PUPILS.

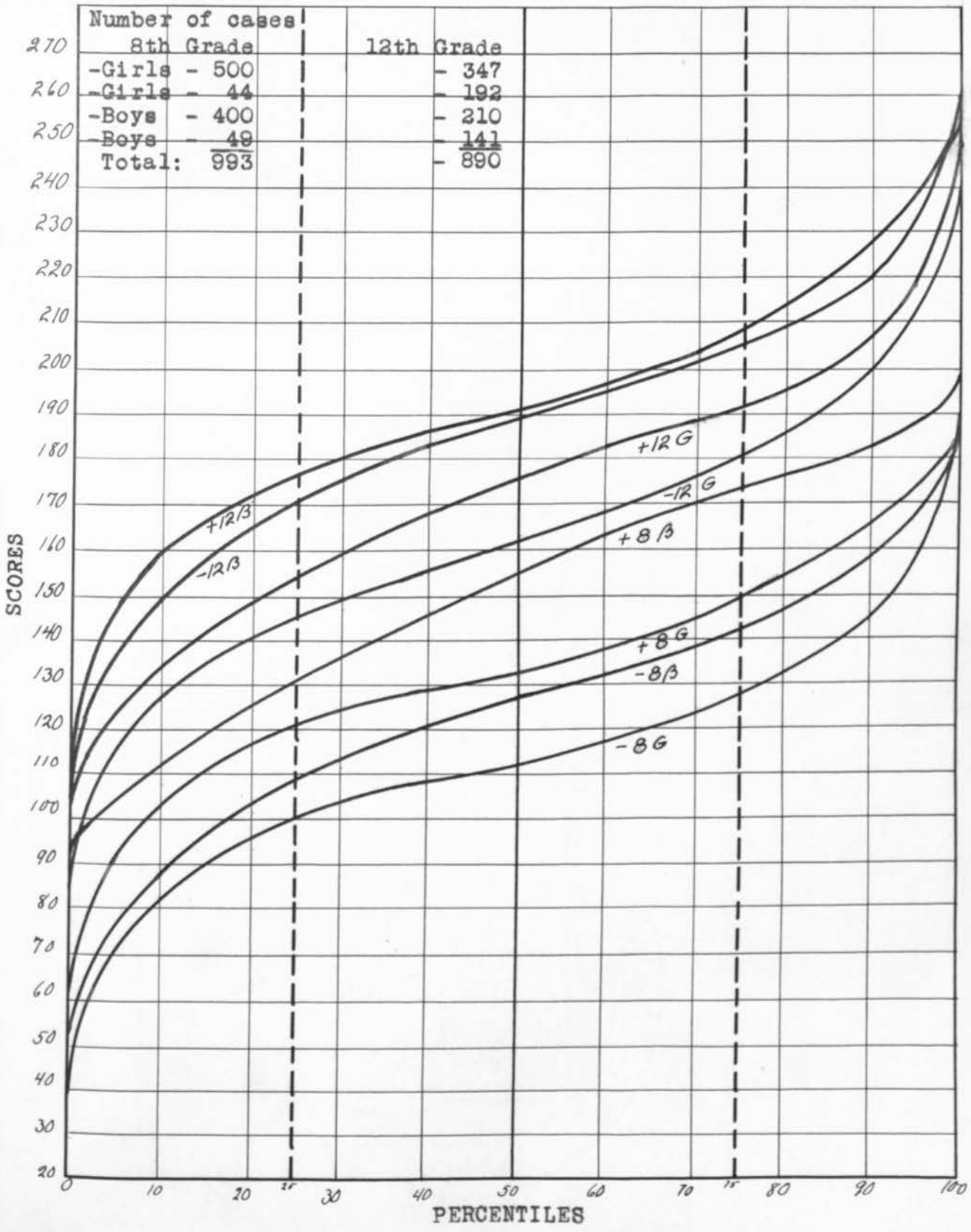


FIGURE V (f)

DISTRIBUTION OF SCORES MADE ON 300 ITEMS BY NINTH GRADE PUPILS.

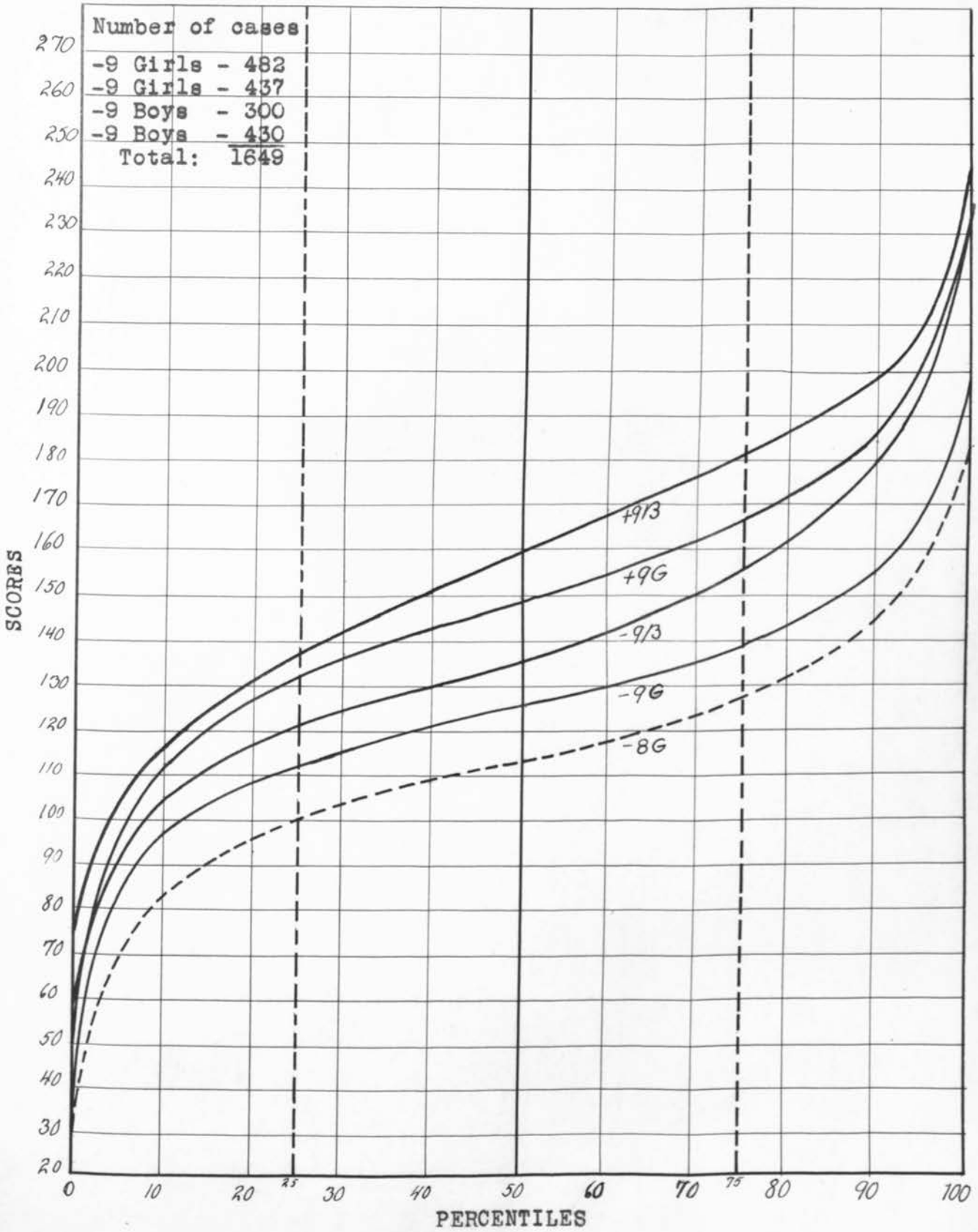


FIGURE V (g)

PERCENTILE DISTRIBUTION OF SCORES MADE ON 300 ITEM TEST BY TENTH GRADE PUPILS.

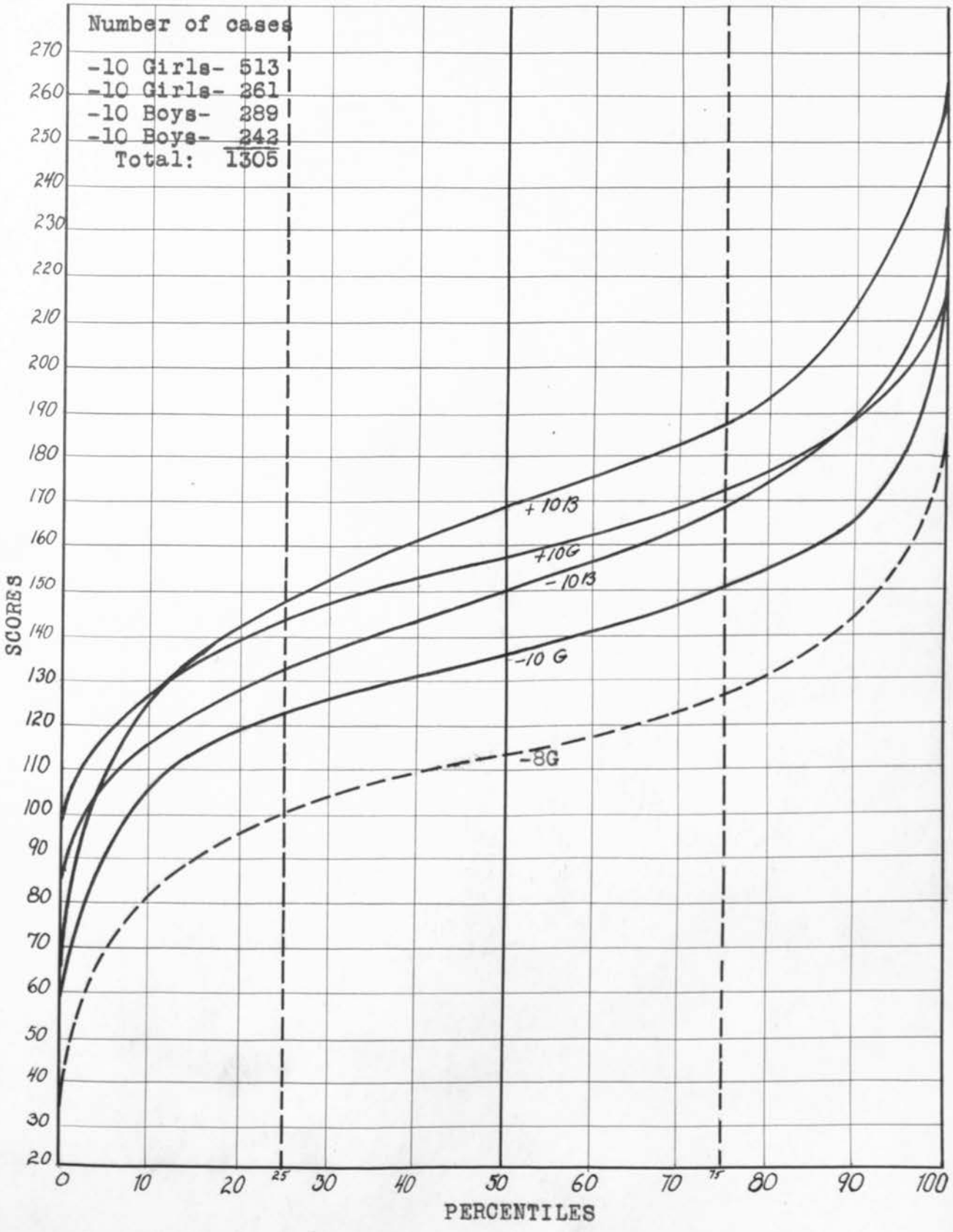


FIGURE V (h)

PERCENTILE DISTRIBUTION OF SCORES MADE ON 300 ITEM TEST BY ELEVENTH GRADE PUPILS.

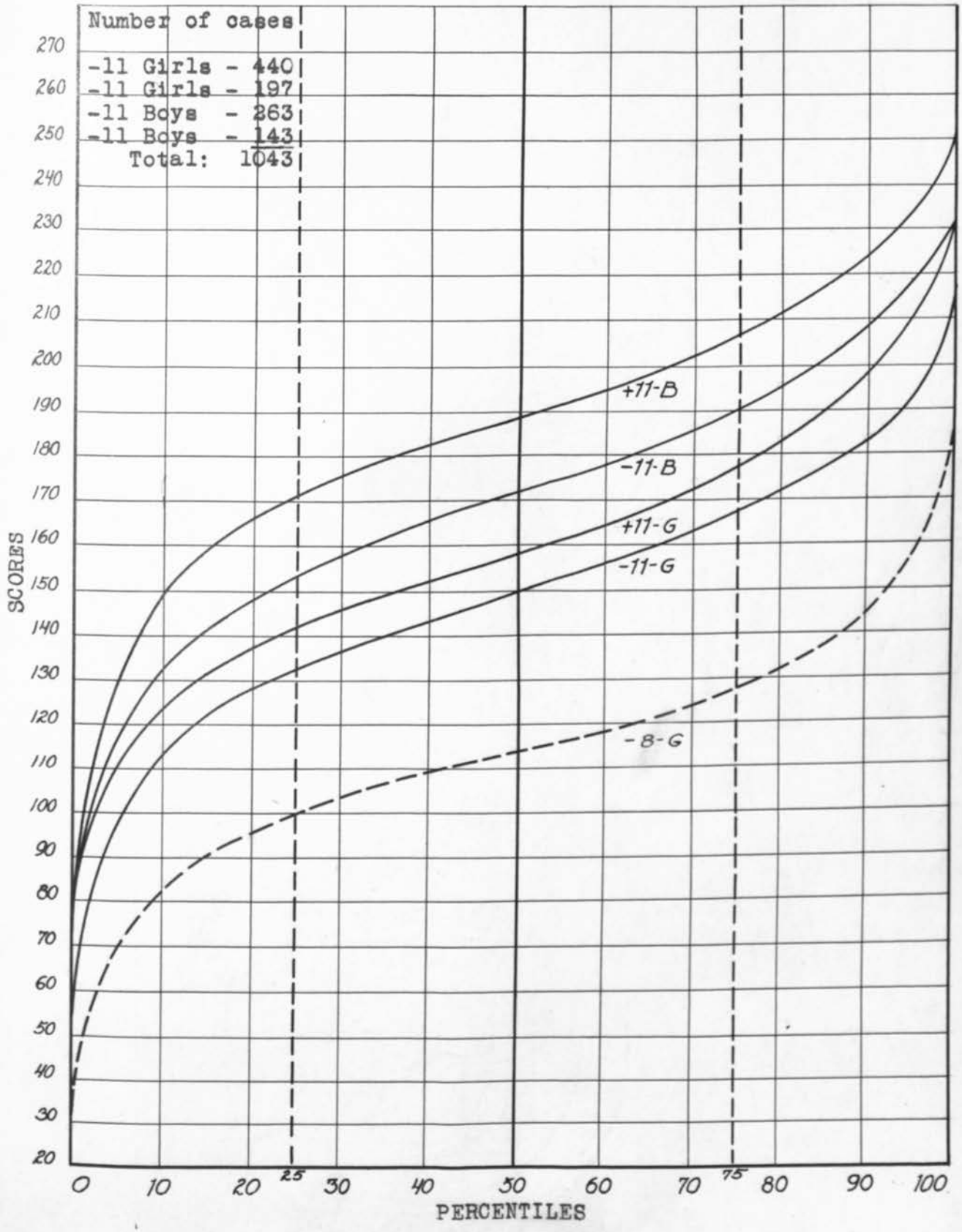


FIGURE VI

MEDIANS BY GRADES ON FIRST 221 ITEMS OF GENERAL SCIENCE TEST INVOLVING 8,591 CASES

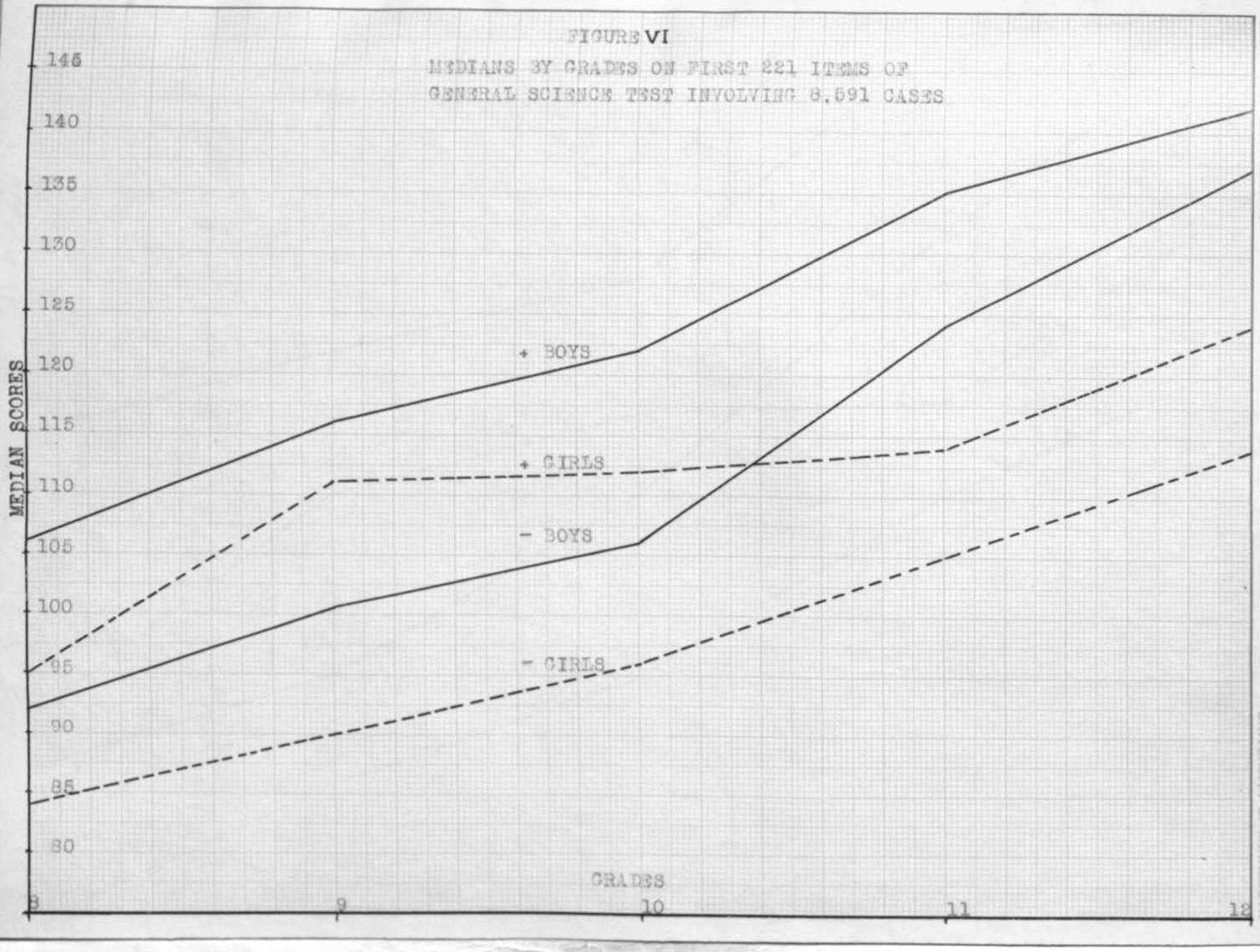


FIGURE VII

MEDIANS BY GRADES ON 300 ITEMS GENERAL SCIENCE TEST INVOLVING 5,970 CASES

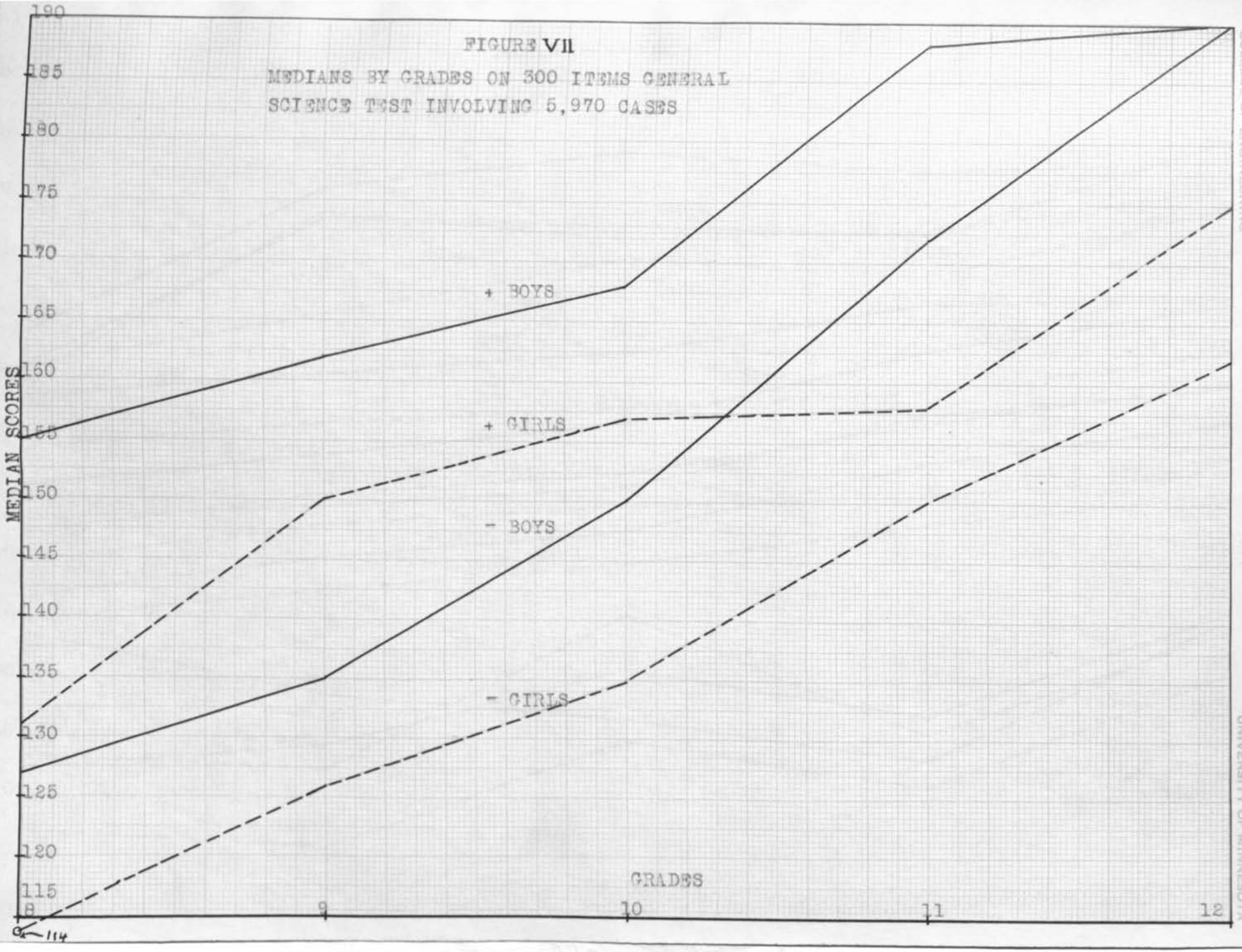
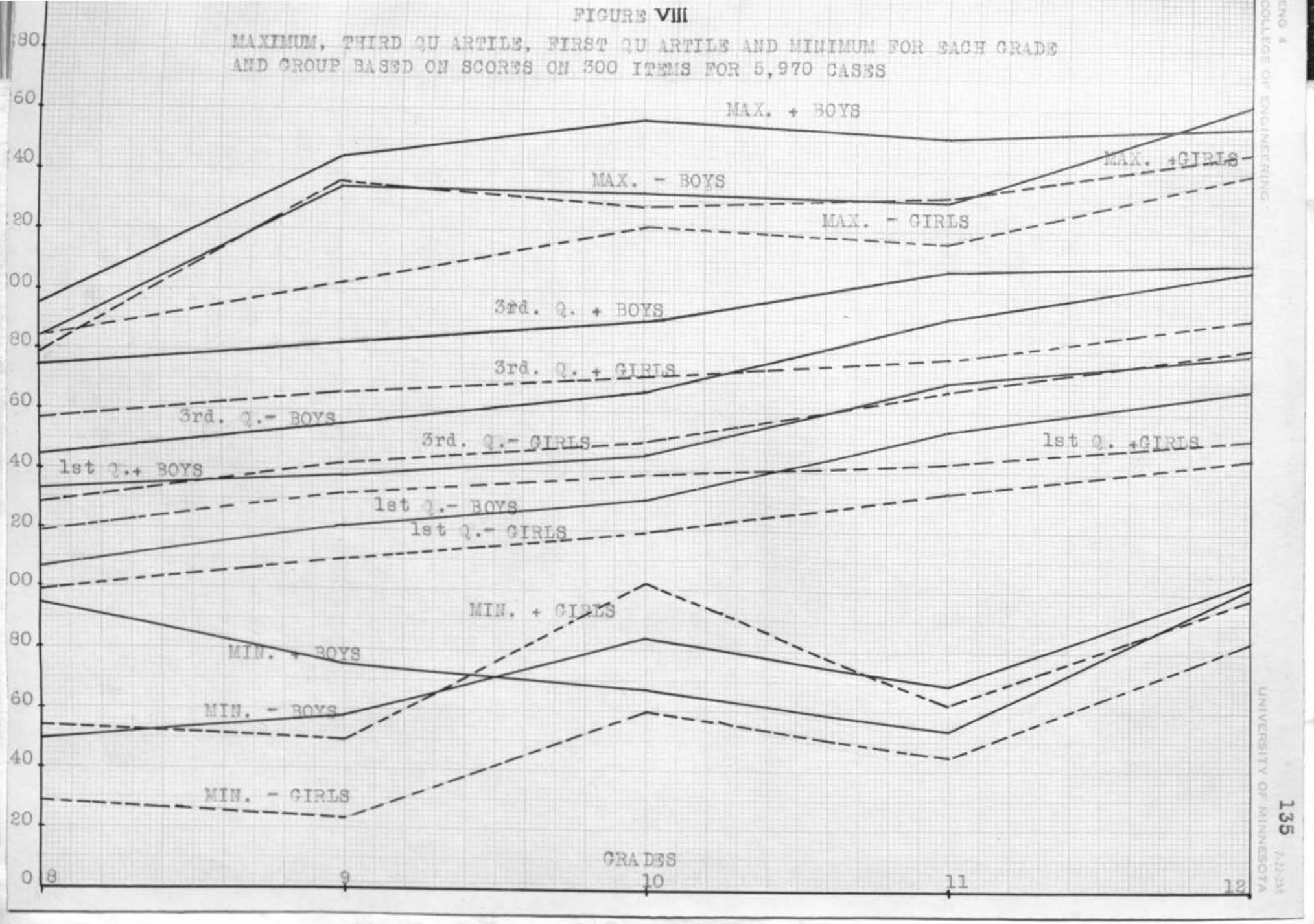


FIGURE VIII

MAXIMUM, THIRD QU ARTILE, FIRST QU ARTILE AND MINIMUM FOR EACH GRADE AND GROUP BASED ON SCORES ON 300 ITEMS FOR 5,970 CASES



as this would have resembled Figure VIII, except in score locations, it was omitted.

Naturally at least three questions might be asked relative to the data and figures presented, namely,-

1. How reliable are the medians presented?
2. Are the groups of equal variability?
3. Are the differences noted between the medians of the different groups real differences?

The computations of the answers to these questions are too extended to be presented in detail, therefore a summary of each will be presented. To find any particular detail will entail small effort on the part of the reader.

1. The medians for both the 221 and the 300 item distributions are reliable. For the 300 item distribution the P.E.s of the medians range from .8 to 1.8 points*. For the 221 item distribution the P.E.s of the medians range from .4 to 1.0. In other words, were these distributions extended infinitely, the chances are even that even in the least reliable group the median would not vary by more than 1.8 points from that given in Table XII and 1.0 points from that given in Table XI. The quartile deviations for the twenty groups are likewise very constant, varying from $14\frac{1}{2}$ to $22\frac{1}{2}$ in Table XII and from 10 to $15\frac{1}{2}$ in Table XI.

* P.E. of median equals $\frac{1\frac{1}{4}\ \text{P.E. of Distribution}}{\sqrt{N}}$

2. The variability of the groups decreases in the upper years. Seniors are less variable in their achievement on the General Science test, especially if they have taken General Science, than are 8th grade pupils who have not taken General Science. A course in General Science tends to cut down the variability in the test. Using the formula Variability of coefficient equals $\frac{100 \text{ Quartile Dev.}}{\text{Median}}$ the coefficient of Variability varies in the 300 item distributions from 12.7 for -8G, the most variable, to 8.0 for +12B, the least variable. In the 221 item distributions, the variability coefficient varies from 12.0 for the -8G to 10.0 for the +12B.

3. The differences between median achievements of the grades of any one group, as -Girls or +Boys, are all significant and real differences. Likewise the sex differences are real differences. In most cases the differences are from two to four times as large as they had to be in order to be significant and real differences. McCall gives some formulae for finding the reliability of a Difference.[1] Namely,

$$\text{Sigma of Difference equals } \sqrt{\text{Sigma } 1^2 \text{ \& Sigma } 2^2}$$

$$\text{and Experimental Coefficient } = \frac{\text{Difference}}{2.78 \times \text{Sigma of Difference}}.$$

When, by the use of these formulae, the experimental coefficient equals 1, McCall states that the difference is real, that is, it cannot be the result of chance.

Since the computation and presentation of all the differences would be lengthy, the writer proposes to use these formulae to

1. McCall, W. A. "How to measure in Education". The Macmillan Co. New York. 1922. Pp. 398-407.

compute a difference that will just give an experimental coefficient of 1. Then all differences which exceed the amount necessary just to produce an experimental coefficient of 1, are large enough to be beyond doubt real differences and not the products of chance distributions.

In the answer to question (1) is found data which indicate that for the medians on 300 item distributions, the P.E.s of the medians ranged from .8 to 1.8 and for the medians of the 221 distributions the P.E.s ranged from .4 to 1. By taking the extreme cases in each of the distributions, we find that the sigma differences for the 300 item distributions range from 1.8 to 3.8 and for the 221 item distributions range from .8 to 2.2. Using McCall's second formula so as to have the experimental coefficient equal 1 - for the minimum sigma difference of the 300 item distribution - this 1 equals $\frac{\text{Difference}}{2.78 \times 1.8}$, then Difference equals 5.2. That is, for the distribution having the lowest P.E. of the median, namely .8 and a sigma difference of 1.8, a Difference of 5.2 gives an experimental coefficient of 1. This coefficient indicates with practical certainty that the difference is not a result of chance distributions in two series. Repeating the above process for Sigma Differences 3.8, .8, and 2.2, it is found that to secure an experimental coefficient of 1 for all the 300 item distribution differences of medians, the difference must range from 5.2 to 10.5. For the 221 item distribution differences of medians, the difference must range between 2.2 and 6.1.

Examination of the actual differences of medians shows, as stated before, that the differences are real differences and not

due to chance even in the case of the four groups in the same grade. When the differences found between medians of the same group, two or more grades removed, are considered, the experimental coefficient becomes as much as 6 times as large as it need be to eliminate all chance errors of accidental distributions.

From the above examination it is evident that tho the differences between grades are not due to chance they are small, and that in each grade there is a certain appreciable percent of pupils who fall below the median of the grade just below, and also an appreciable percent of pupils who fall above the median of the grade next higher. Perhaps the most striking illustration of overlapping is to be found in Figure V (2) -8th and 12th grade pupils. This Figure shows that from 4% to 40% of the 8th grade pupils' scores were above the median for the -12 Girls, 2 to 20% of the 8th grade pupils' scores were above the median for the +12 Girls, while 3% of the +8 Boys were above the median for the -12 Boys. In fact it was impossible to find any grade group which does not overlap considerably with each of the other grade groups. This illustration is of the extreme case, for it involved the 8th and 12th grades, the widest range of grades. For two adjacent grades the overlapping is even greater.

C. Numbers of sciences

Since there are significant differences among the achievements of the different grade groups, all of which are in favor of the higher grades and also in favor of the pupils who had studied

General Science, the question arose as to the probable causes of greater achievement, other than the fact that the pupil had taken General Science. This was an important question in as much as the Figures and data show a constant growth of achievement whether pupils take General Science or not, the only difference being in the relative amounts of the growth.

It is important to note that the median of the +12 Girls is only 13 points or a little less than 1 P.E. of the distribution above the median of the -12 Girls. (See Table II, XII, and Figures V(a-h), VII, VIII) Likewise note may be made that the median of the + 12 Boys was identical with the median of the -12 Boys. The latter, however, was due largely to chance, as it was not in the 221 distributions and was the only case of its kind. In the Tables and Figures of the 221 item distribution, the median of the +12 Girls is 10 points or slightly less than 1 P.E. of distribution above the median of the -12 Girls, and the median of the +12 Boys is only 5 points or ½ P.E. of distribution above the median of the -12 Boys. Further, the amount of increase of achievement as noted by medians is 30 points between -8 Girls and -12 Girls, and 40 points between -8 Girls and +12 Girls, For the boys the difference between median of -8 Boys and -12 Boys is 45 points, and between -8 Boys and +12 Boys 50 points, when based on the distribution Table XI. Similar data for 300 item distribution Table XII show that the difference between the medians of -8 Girls and -12 Girls is 48 points, between -8 Girls and +12 Girls is 61 points, between -8 Boys and -12 Boys is 63 points, and between -8 Boys and +12 Boys is 63 points.

The decided differences of achievement, on the part of pupils who had not taken General Science and have reached the 12th grade, over the respective medians of their 8th grades has at least two explanations.

(1) Sciences other than General Science taken by the pupil have accounted for this growth.

(2) Elimination of the less capable pupils might account for an apparent growth. The latter explanation, however, is subject to two criticisms - (a) The correlation between scores and time of doing the test, which usually has a positive correlation with intelligence test scores, was practically zero, and (b) likewise the correlation between chronological age and scores was near zero. Both these correlations show that the less capable pupils were in the group taking the test, at least in some numbers.

In order to ascertain to what extent other sciences contributed towards the achievement of pupils who had not had General Science, the number of sciences which the pupils had taken were counted for 5,970 cases. Table XIII (NUMBER OF SCIENCES PER STUDENT FOR 5742 CASES) gives the distribution of the pupils in the twenty grade groups and the number of the sciences, which these pupils had listed on the first page of the original test in General Science, completed by each pupil. At the right of the Table in the column headed "TOTAL" is the actual number of sciences, each taken for one year, or "science years", which were taken by the group listed at the left. Thus 582 is the sum of 49 times zero plus 206 times 1 plus 176 times 2 plus 8 times 3, or the total number of times any sciences were taken by all of the 439

TABLE XIII

NUMBER OF SCIENCES PER STUDENT FOR 5742 CASES

Student Groups	No. Students	NUMBER OF SCIENCES PER STUDENT: Number of students having the above number of sciences										TOTAL sciences
		0	1	2	3	4	5	6	7	8	9	
-8Girls	439	49	206	176	8	.	.	.	.	.	.	582
-8Boys	372	163	186	22	1	.	.	.	.	.	.	233
+8Girls	44	.	8	10	25	1	..	.	.	.	.	107
+8Boys	49	.	9	36	4	.	.	.	.	.	.	93
TOTAL	904	212	410	243	38	1	.	.	.	.	.	1015
-9Girls	482	89	220	138	22	6	6	1	.	.	.	622
-9Boys	300	188	71	32	3	5	1	.	.	.	.	169
+9Girls	351	.	57	131	145	10	3	5	.	.	.	839
+9Boys	294	.	150	127	16	1	.	.	.	.	.	456
TOTAL	1427	277	498	428	186	22	10	6	.	.	.	2086
-10Girls	513	116	181	147	42	13	12	2	.	.	.	725
-10Boys	289	100	105	58	14	7	5	.	.	.	.	316
+10Girls	261	.	23	103	93	33	9	6	4	.	.	709
+10Boys	242	.	80	86	54	13	5	8	.	.	.	509
TOTAL	1305	216	389	394	203	56	31	16	4	.	.	2259
-11Girls	440	32	91	127	114	50	16	9	1	.	.	1028
-11Boys	263	38	69	88	46	15	6	1	.	.	.	479
+11Girls	197	.	23	33	61	44	23	11	2	.	.	643
+11Boys	143	.	16	47	49	18	5	5	3	.	.	405
TOTAL	1043	70	199	295	270	127	50	26	6	.	.	2555
-12Girls	347	17	46	76	104	53	25	14	11	1	.	1016
-12Boys	210	5	25	61	68	30	13	5	2	1	.	588
+12Girls	192	.	3	21	44	59	33	13	14	2	3	797
+12Boys	141	.	3	16	43	45	17	9	6	2	.	541
TOTAL	890	22	77	174	259	187	88	41	33	6	3	2942
Jr.Coll.	6	.	.	.	4	2	.	.	.	.	.	20
Univ.I	9	.	1	1	4	2	.	1	.	.	.	39
" II	134	.	.	17	43	38	23	9	3	1	.	513
" III	18	.	.	2	7	1	4	2	1	1	.	76
" IV	6	.	.	.	.	1	5	.	.	.	.	29
TOTAL	173	.	1	20	58	44	32	12	4	2	.	667

girls. Likewise, 233 is the sum of 163 times 0 plus 186 times 1 plus 22 times 2 plus 1 times 3, or the total number of times any sciences were taken by all of the 372 -8 Boys. On the basis of Table XIII, Table XIV was constructed. It gives the mean number of sciences per pupil in each of the different grade groups.

TABLE XIV

GROUP	GRADES 8th	9th	10th	11th	12th
- Girls	1.32	1.29	1.41	2.34	2.92
+ Girls	2.43	2.38	2.72	3.27	4.16
- Boys	.63	.56	1.10	1.82	2.8
+ Boys	1.90	1.55	2.10	2.83	3.84

University .....(I)3.22 .(II) 3.82.(III) 4.22.(IV) 4.83

TABLE XIV - MEAN NUMBER SCIENCES PER PUPIL IN THE VARIOUS GRADES AND PER UNIVERSITY STUDENT IN FOUR GROUPS.

Thus 582 divided by 439 equals 1.32 or the mean number of sciences per pupil in the -8 Girls' group. Likewise, 233 divided by 372 gives .63 or the mean number of sciences per pupil in the -8 Boys' group.

FIGURE IX (MEAN NUMBER SCIENCES PER PUPIL IN EACH GRADE BASED ON 5,970 CASES) is a graphic representation of Table XIV. It is worth while to notice that girls uniformly are credited with a higher mean number of sciences than are the boys of similar classification. That is, girls without General Science have a higher mean number of sciences per pupil than boys without General Science in the same grade, and girls with General Science have a higher mean number of sciences per pupil than boys with General

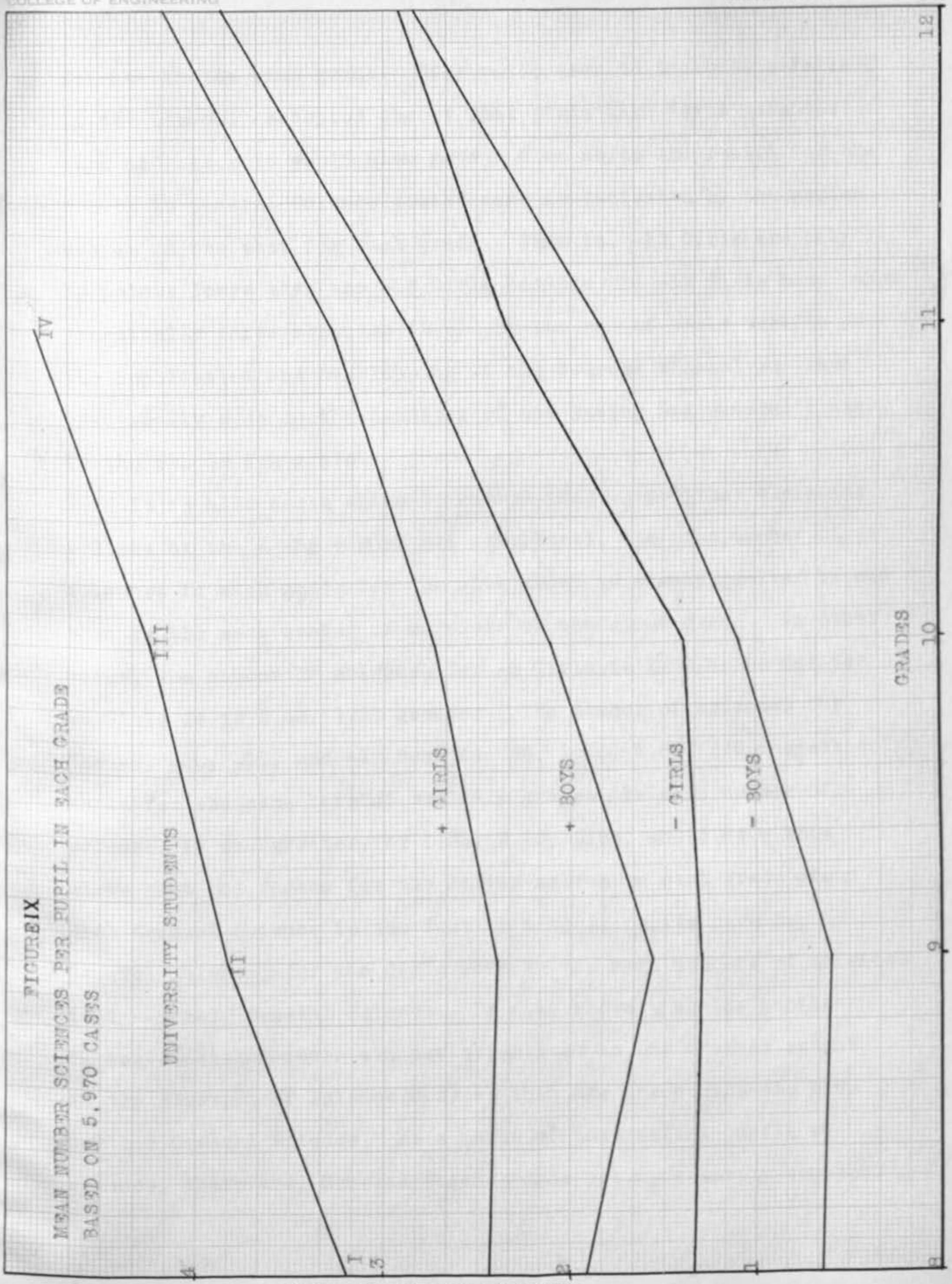


FIGURE IX
MEAN NUMBER SCIENCES PER PUPIL IN EACH GRADE
BASED ON 5,970 CASES

Science in the same grade. This would seem to indicate a fallacy in the commonly accepted theory that girls take fewer sciences than do boys. It would also give a clue as to the reason for the growth in General Science achievement as indicated by the median scores on the test for each grade. That is, -12 Girls are only 12 points lower than the +12 Girls because the -12 Girls have taken practically three sciences (2.92) by the end of their twelfth year. The duplication and overlapping of the courses themselves have practically made up the handicap of not having had General Science in the 8th or 9th grade.

It is also worth while to notice that when either the - and + Girls or the - and + Boys are considered, the mean number of sciences in each grade for the plus group is simply greater by one than is the mean number of sciences of the minus group. In other words, the number of sciences for -8 Girls is 1.32 while for the +8 Girls it is 2.43, 1.11 greater. The number of sciences for the -9, -10, -11, and -12 Boys is .56, 1.10, 1.82, 2.8 respectively, while for the plus boys of the same grades the mean number of sciences is one greater, or 1.55, 2.10, 2.83, and 3.84. This shows that one reason for the larger scores in each grade group with General Science is the fact that <u>those pupils have had General Science</u>, for the difference in the mean numbers of sciences is 1 --namely General Science. It also shows that the pupils taking General Science are not stimulated to any greater extent in the election of science courses than are the pupils who have not had General Science. As a means of interesting pupils in science, therefore, General Science does not necessarily succeed.

The numbers of pupils taking 0 and 1 science in each grade is an indication of the current apathy for science courses on the part of a high school population.

It might, however, be worth while to notice a possible fallacy in the above statement may lie in the matter of "required" sciences and in the current science offerings in the 22 schools studied. That is, many schools require one or more sciences unless the pupil satisfies some other conditions which relieve him from taking science courses. If one or two sciences were required, of which one might be General Science, then the mean number of sciences per pupil, being larger for pupils having taken General Science, would indicate that General Science did have some drawing power for further science courses, in as much as the pupil need not have taken extra science courses after having satisfied the science requirements - but which many proceed to do as indicated by the means. Furthermore, few schools offer more than three science courses; many only offer two. Glancing at Table XIII, it is evident that with the exception of the 8th and 9th grades, where pupils have not had time to take more than three sciences, the columns of 2 and 3 sciences maintain the largest percentage of pupils.

A brief study of the achievement of 150 seniors, all of whom had had five or more sciences, showed that in achievement on the General Science test they ranked as follows (given on next page)

SCORES	No. CASES
150-159	4
160-169	14
170-179	22
180-189	24
190-199	25
200-209	22
210-219	17
220-229	16
230-239	7
240-249	5
250-	4
Total:	150

It is to be remembered that score 175 is in the 50 percentile for the achievement of +12 Girls. One hundred twenty-one or 80% of these seniors with five sciences were in the upper half of the distribution of +12 Girls.

Reference to the relatively larger number of sciences per pupil on the part of the girls and their relatively lower achievement on the test as compared with boys, prompted an analysis of the actual sciences taken by different groups of pupils. TABLE XV (FREQUENCIES WITH WHICH DIFFERENT SCIENCES WERE TAKEN BY 5742 STUDENTS) which shows the frequencies with which different sciences were taken by 5,742 pupils in the five grades, leads one to conclude that the higher mean number of sciences per pupil, for instance of the +9 Girls over the +9 Boys, is due to the fact that relatively larger numbers of girls take Physiology than do boys, and that a high percentage of girls take Domestic Science, which is seldom taken by boys. In as much as the difference in the mean number of sciences per pupil at any grade is comparatively small (about ½ a science per pupil in favor of the girls), when either -Girls and -Boys or +Girls and +Boys are considered, this latter explanation seems quite feasible. There

TABLE XV

FREQUENCIES WITH WHICH DIFFERENT SCIENCES WERE TAKEN BY 5742 STUDENTS.

Student Groups	No. Cases	Gen. Sci.	Chem-istry	Phy-sics	Physi-ology	Bot-any	Zool-ogy	Physio-graphy	Bio-logy	Astro-nomy	Dom. Sci.	Total Frequ'cy
-8Girls	439	.	.	.	251	1	.	3	8	1	319	582
-8Boys	372	.	.	.	211	.	.	2	.	.	20	233
+8Girls	44	44	.	.	35	1	.	.	.	.	27	107
+8Boys	49	49	.	.	36	.	.	1	4	1	3	93
TOTAL	904	93	.	.	533	2	.	5	12	2	369	1015
-9Girls	482	.	.	.	192	13	12	11	69	3	322	622
-9Boys	300	.	.	.	84	13	8	17	43	1	3	169
+9Girls	351	351	.	.	193	12	6	4	12	4	257	839
+9Boys	294	294	.	.	124	.	3	5	13	3	15	456
TOTAL	1427	645	.	.	593	38	29	37	137	10	597	2086
-10Girls	513	.	.	2	239	40	25	30	109	3	277	725
-10Boys	289	.	2	1	146	25	15	40	71	1	15	316
+10Girls	261	261	2	.	120	18	16	35	59	1	197	709
+10Boys	242	242	6	1	96	19	13	51	56	.	25	509
TOTAL	1305	503	10	4	601	102	69	156	295	5	514	2259
-11Girls	440	.	88	70	260	86	53	64	130	2	275	1028
-11Boys	263	.	65	93	127	39	19	44	82	2	8	479
+11Girls	197	197	31	36	83	42	23	34	56	4	137	643
+11Boys	143	143	22	66	65	25	18	26	35	.	5	405
TOTAL	1043	340	206	265	535	192	113	168	303	8	425	2555
-12Girls	347	.	135	134	207	80	49	70	96	2	243	1016
-12Boys	210	.	121	160	130	28	19	59	62	1	8	588
+12Girls	192	192	75	88	114	55	30	47	57	1	148	797
+12Boys	141	141	71	93	89	35	19	44	33	1	15	541
TOTAL	890	333	402	475	540	198	107	220	248	5	414	2942
Jr.Coll.	6	3	.	4	5	1	.	2	.	.	5	20
Univ.I	9	5	6	8	3	2	3	2	.	.	.	29
" II	134	31	131	133	101	31	21	29	21	11	4	513
" III	18	3	18	18	13	4	9	3	6	2	.	76
" IV	6	1	6	6	6	4	2	2	1	.	1	39
TOTAL	173	43	161	169	128	42	35	38	28	13	10	667

is a relatively small number of items in the test which would be answered by Domestic Science training.

D. Differences in Achievement due to initial possession

In ordinary practice the teacher of General Science, like the teacher of many other secondary school subjects, frequently meets his or her class for the first time on the opening day of school. The teacher's assignment is to take that class in the following nine months, and to teach it as much General Science as he or she is capable of teaching the class or as the class is capable of being taught. At the end of every month and at the end of each quarter, semester, or year, this teacher has to assign ratings to each pupil which are to indicate the amount of accumulated information and knowledge which the pupil has achieved in General Science, in the teacher's opinion. Frequently the teacher knows nothing of the abilities of the various members of the class. The class may be composed of individuals with various levels of so-called "native ability" or "intelligence", which is known to have an important function in the speed and amount of learning of which the pupil is capable. Irrespective of this, at the end of the year or at the end of each quarter or semester, the rating assigned by the teacher on General Science is supposed to be indicative of the amount the pupil has profited by instruction, regardless of his ability to learn.

In a more modernly organized school the class to which the teacher is assigned may have been selected on the basis of mental tests and may therefore have comparative homogeneity of ability. Modern technique has triumphed and the teacher sets forth to do

the best he can with the class. Results have shown that a homogeneous class selected on the basis of intelligence tests is capable of more efficient progress on the part of all its members than a heterogeneous class. Few administrators have gone beyond this new step in modern educational administration. A few of the more daring investigators have attempted to secure ratings on the achievement tests for pupils before they have begun their study of the subject. Similar ratings at the close of a year's study of the subject have shown that not all of the pupils' usual rating in a subject at the end of a quarter, semester or year is due to his study of the subject. In other words, it has been suggested that the pupil's final achievement in a subject may be conditioned by his starting point. Pupils entering on their study of General Science enter the class, not only with differences in mental abilities but also with various amounts of the subject matter of General Science already in their possession. What teacher of General Science has not been amazed at the apparent ease with which many 8th and 9th grade boys are, during the present radio craze, talking of "tuning coils", "condensers", "'B' batteries", "wave lengths", "peanut tubes", "variometers" and so forth,-- subject matter and vocabulary which ten years ago was common only to the advanced student of Physics. It is easy to imagine the disdain with which these boys would listen to a dissertation by a not overly expert teacher on a simple subject such as "a fuse" or "a magnetic coil" or a "knife switch" -- subject matter and vocabulary which to certain other members of the class seem most complex because of their lack of previous information.

A study of the 8th grade scores made on the General Science test by boys and girls who had not had General Science and of the scores of 11th and 12th grade pupils many of whom had had several specialized sciences, shows considerable overlapping. Reference to Figure V(a) shows that 25% of the -8 Boys do as well as 3 to 50% of the 12th grade boys who have had a mean number of 3.84 sciences per pupil, including General Science. Twenty-five per-cent of the -8 Girls do as well as 8 to 50% of the 12th grade girls who have had a mean of 4.16 sciences per pupil, including General Science. The fact is also apparent that only 50% of the 12th grade pupils in either group exceed the scores made by the best 8th grade pupils who have not had General Science. Likewise only about 25% of the 8th grade pupils who have not had General Science do poorer work on the General Science test than the poorest 12th grade pupil. It is easy to understand some of the class problems if in that class are to be found several boys or girls who belong to the upper level of the 8th grade group just described. It is also possible to realize how little some of the better pupils are really able to achieve in a class of this kind when the subject matter of that course is already largely in their possession.

In accordance with the findings of this study, it is the writer's purpose to suggest that pupils be divided for the purpose of class instruction on the basis of the amount of the subject matter of General Science already in their possession rather than on sheer mental ability. Of course the ideal condition -- the most commendable class room situation in a school

large enough to permit it -- would be that pupils for the sake of homogeneity in teaching be divided on the basis of initial amount of subject matter already in their possession and also on their ability further to acquire subject matter. This suggestion is further strengthened by reference to Figure V (b), which shows that 50% of the -8 Girls exceed 17% of the +8 Girls and 9% of the +9 Girls in achievement. Likewise 10% of the -8 Girls exceed 67% of the +8 Girls and 40% of the +9 Girls in achievement. It must be borne in mind that whatever the amount of percent of -8 Girls that exceed or even equal achievements of + 8 or +9 Girls, this amount or percent tends to represent the amount of effort wasted in their teaching.

It may also be added that the General Science test given before pupils have begun the study of a subject, gave a correlation of .62 between test scores and school marks for the first two quarters. This would seem to indicate that the amount that pupils know of a subject before studying it is an important factor in conditioning the school mark which they will receive in that subject when they study it.

Reference to Figure VII shows that whereas the median for -8 Boys was 127 and the median for -8 Girls was 114 or 13 points less, the median for +9 Boys was 162 and for the +9 Girls was 150 or 12 points less. That is, initially the boys exceeded the girls by 13 points and one year later (basis of the 9th grade scores) the boys still exceeded the girls by 12 points or practically the same amount by which they had exceeded the girls before instruction. In the 10th year the medians were 157 for the plus

girls and 168 for the plus boys, or 11 points better. In the 11th year the median score for plus girls was 158 and for plus boys 188, or 30 points better. Reference to the mean number of sciences per pupil shows that between the 10th and the 11th year the increase in the mean number of sciences per pupil is greater by about one-fifth science for the boys. Reference to Table XV shows that 88 of the plus 11 boys or 61% had taken Physics or Chemistry, while only 67 or 34% of the girls had added these so-called "harder" sciences to their possession. In the 12th year, when each group had added practically a whole science to its mean, the median for the +12 Girls was 175 while for the +12 Boys the median was 190, a difference of 15 points. Thruout this comparison it is evident that differences in grade medians, after the subject was studied, are dependent to a large extent on differences of grade medians before the study of the subjedt was begun.

E. Comparison of 8th and 9th grade achievement

It is possible to compare the achievement on the 221 item and on the 300 item test for 100 pupils (50 boys and 50 girls) who took General Science in the 8th grade of the Junior High School. These data may be significant.

221 item test

Median Scores of —	-8 Group	+8 Group	+9 Group	-9 Group
Girls	84	95	111	90
Boys	92	111	116	98

300 item test

Median Scores of ...	-8 Group	+8 Group	+9 Group	-9 Group
Girls	114	131	150	126
Boys	127	155	162	135

It is significant to note that +8 Girls do better in the test than either the -8 Girls or -9 Girls but not so well as the +9 Girls, and that the +8 Boys do better than the -8 Boys and the -9 Boys but not so well as the +9 Boys. When, however, the difference between the -8 and the -9 grade groups (the amount due to growth without General Science) is added to the +8 grade medians for the boys the total is almost identical with the +9 Boys' median, while for the girls it is slightly less than the -9 Girls' median. In as much as +9 pupils owe their score to the sum of their progress without study of General Science plus their progress with study of General Science, it would seem that the 8th grade pupils profited equally as much by instruction in General Science as did the 9th grade pupils. Knowledge of this is especially of value in the construction of a course of study for a Junior High School.

F. Sex differences

In the tabular and graphic data presented so far it has been evident that a more or less uniform difference exists between the achievement in General Science of boys and girls for the plus and minus groups. This difference in test medians between boys and girls was in favor of the boys, as indicated in the following tabular statement.

THE AMOUNTS BY WHICH BOYS' MEDIANS EXCEED GIRLS' MEDIANS ON 300 ITEM DISTRIBUTIONS.

	GRADE				
	8th	9th	10th	11th	12th
Plus Group	24	12	11	30	15
Minus Group	13	11	15	22	28

It has previously been demonstrated that the maximum difference of medians on the 300 item distributions, which is necessary just to eliminate all chance errors of its not being a difference, is 10.5 It is evident that the above differences all exceed 10.5 and are therefore actual differences. Similarly examination of Table XI will show that medians for the boys' groups exceed medians for the girls' group by an amount greater than 6.1 which is just necessary to eliminate all chance errors of its not being a difference.

G. Annual growth in achievement

The optimistic teacher will probably be astounded by the statement that the amount of achievement, as measured by a Scale, due to a year's work or study in a subject results in relatively smaller gains than even the more conservative teacher would estimate. When the amount of annual growth is computed on the basis of median scores on the General Science test, we find that the differences between -8 Girls and +9 Girls and between -8 Boys and +9 Boys (the only two places in this study where a comparison of this kind would be safe) are 36 points and 28 points respectively when quartile deviations are 14.5 and 17 for the 8th and 9th grade girls and 19 and 22½ for the 8th and 9th grade boys.

When the difference between - 8th grade pupils and + 9th grade pupils is computed on the basis of Scale points or P.E. values based on item difficulty, the difference due to instruction is considerably less. Reference to Figure I shows that the 8th grade median, which is the average of the medians for the -8 Girls and the -8 Boys, is 7.451 P.E. above the arbitrary zero. The 9th grade median, based on the average of the medians of the +9 Girls and the +9 Boys, was 8 P.E. above the arbitrary zero. The difference due to one year's growth and teaching was found to be .539 P.E. or about 5.4 Scale points. This difference corresponds fairly closely with differences found by Doctor Van Wagenen in his studies of History, Geography and English Composition* He reports that about .6 P.E. or 6 Scale points is the median amount of growth to be expected from one year's teaching.

This may be at least partly explained by assuming that there are hierarchies of ideas or conceptions deveoped in the learning of any subject material other than mere routine memory work. That is, it is impossible to teach or to understand a complex, difficult idea or conception apart from the basic facts, ideas or conceptions which underlie it. Thus it is impossible really to understand the working principles of a suction pump without first understanding the principle of air pressure. Nor is it possible to teach or to understand respiration without first teaching or understanding oxidation. The understanding of heredity requires some understanding of reproduction and of cell structure. It is apparent that if one measured the progress made in any course by the number of really complex ideas or conceptions acquired,

* Unpublished data.

the progress would necessarily be smaller than if one measured it by the number of illustrations or of the sub-ideas of these complex conceptions. If a scale of complex ideas or conceptions is constructed in such a way that the unit of measurement is an idea or conception which is possessed by 50% of pupils who have studied the subject for one year, the amount of growth will necessarily be small.

It must be borne in mind when comparing Scale and test scores and Scale and test medians that, as is seen in Table VI, if pupils are able to do tasks of the difficulty of those found 8 P.E. above the arbitrary zero because of the large number of items in the Scale which are in the range of approximately 1 P.E. above and 1 P.E. below this median of 8 P.E., the pupils' scores have a tendency to show erratically large amounts of growth, as is indicated by the medians in the former paragraph. That is, because as many as 18 items were found to be of the same difficulty, namely 7.9 P.E., it is logical to assume that if a pupil who could do only items of the difficulty of 7.8 P.E. were in some way to acquire ability to do items one-tenth of 1 P.E. more difficult, namely 7.9 P.E., this achievement would be indicated on the original test by an increase of not 1 point but 18 points, whereas on the Scale this added achievement would be indicated by an increase of 1 point. Therefore an increase of .539 P.E. or of 5.4 tasks on the Scale really means the acquisition of a rather large number of conceptions subordinate to these 5.4 tasks.

A word of warning should, however, be given with regard to the comparison of the test medians to measure the amount of growth

which is due to instruction in the upper grades. In the study of overlapping data were cited which showed that certain numbers of even 8th grade pupils without General Science exceeded the achievement of various percents of 9th grade pupils who had studied General Science. It does not require much statistical comprehension to imagine what would happen to a median if one had a thousand 8th grade pupils with a median of 100 with a range of 50 to 150 and then were to eliminate the lower 50%. The median would immediately rise to the position previously occupied by the 75th percentile. Whereas such an elimination did not take place from the 8th to the 9th grade, for the whole school systems were given the General Science test and no such decrease of pupils was found from the 8th to the 9th grade, nor did the correlations between scores and time used in doing the test, nor the correlations between scores and chronological age verify the assumption of any such elimination, some elimination however does take place.

H. Relative difficulty of the different items for boys and girls

In Chapter VI under the introduction to the "Derivation of the Scale" were presented data which answer the question, "Do boys and girls differ in the kind of material each is capable of learning and does learn?" The rank orders of the 300 items were made on the basis of the number of correct responses made by 500 -8 Girls and by 430 +9 Girls. The rank order correlation of these rankings gave a coefficient of .87 with a P.E. of .007. The same was done for 400 -8 Boys and 430 +9 Boys, which gave a coefficient of correlation of .916 with a P.E. of .005. The

mean of these two coefficients is .893. When the same was done for -8 Girls and -8 Boys, the coefficient was .95 with a P.E. of .003, while for +9 Girls and +9 Boys it was .91 with a P.E. of .005. The mean of the two coefficients is .93

In other words, the rank orders of the items for the untaught girls and untaught boys were more alike than were the rank orders of the items for girls before and after taking General Science. Likewise the rank orders of the items were more alike for taught 9th grade girls and boys than were the rank orders of the items for the boys before and after taking General Science. The medians of the boys' groups were of course higher than were the medians of the girls' groups, but except for a few items highly specialized for each group, the relative order of difficulty of the items remain practically the same. This would mean that not parts of General Science were more difficult for girls than for boys but that relatively all of General Science was as much more difficult for girls than for the boys as is indicated by the difference in the medians. The study of annual growths showed that girls actually make as large gains by instruction as do boys. The difference in the achievements on the General Science test began for the two sexes back in the elementary school and in the elementary training outside of the school, for the difference in medians which is found between girls and boys in the 8th grade is the difference which continues thruout the grades of the secondary school when measured by the General Science test.

CHAPTER IX

SUMMARY

A summary of the conclusions reached in this study of subject matter and achievement in General Science is given in the following brief statements.

1. General Science originated out of a desire for a course of science which would serve, not necessarily as intensive training for a specialized field, but for immediate use in everyday life.
2. The development of General Science has been paralleled by the formulation of General Science objectives in harmony with the Cardinal Principles of Education.
3. Achievement in General Science can be measured objectively, as is shown by the development of a reliable scale in General Science.
4. A Scale Form of 60 properly evaluated and selected items gives as accurate results in the measurement of General Science achievement as does a 300 item test.
5. Before taking a General Science course, many pupils are already familiar with much of the material of the course. This fact makes it desirable if not imperative to classify pupils for instruction in General Science on the basis of their previous knowledge of the subject. Furthermore, it emphasizes the need for General Science texts adapted to pupils of different mental levels.

6. The annual increase in achievement in General Science due to teaching, as measured by the General Science Scale, is small, namely, .539 P.E. or 5.39 Scale points.
7. Real sex differences in amount of General Science information exist even prior to instruction in General Science. These sex differences, in favor of the boys, persist thruout the high school course.
8. The relative order of difficulty for the items of the General Science test are practically similar for the two sexes.
9. There is a wide variation of achievement in General Science among different schools.
10. The difference in test points between the median scores of 8th grade pupils who have and who have not had General Science, is equal to the difference between the median scores of 9th grade pupils who have and who have not had General Science. This indicates that 8th grade pupils profit approximately as much by instruction in General Science as do 9th grade pupils.
11. Pupils who have not had a course in General Science, acquire considerable General Science information in courses in specialized sciences. Differences in central tendencies continue, however, in favor of those pupils who have had General Science.
12. Achievement on the General Science test shows uniformly higher scores for pupils who have had a course in General Science.
13. Performance on the General Science Scale shows for each sex a definite, direct relationship to the number of science courses the pupil has taken.

14. Any two of the five grades studied show considerable overlapping of achievement, even in the case of 8th and 12th grade pupils.

APPENDIX

GENERAL SCIENCE INFORMATION

Arranged by August Dvorak, University of Minnesota.

PART I.

(1) Name ..... (2) City ..... (3) Age: Yrs. ..... Mos. .....
(4) Underline year in school: 8th grade; Freshman, Sophomore; Junior; Senior.
(5) How many years have you been in school in all? .....
(6) Have you taken General Science? ..... How long? ..... How many years ago? .....
(7) Have you taken Chemistry? ..... How long? ..... How many years ago? .....
(8) Have you taken Physics? ..... How long? ..... How many years ago? .....
(9) Have you taken Physiology—Hygiene? ..... How long? ..... How many years ago? .....
(10) Have you taken Botany? ..... How long? ..... How many years ago? .....
(11) Have you taken Zoology? ..... How long? ..... How many years ago? .....
(12) Have you taken Physiography? ..... How long? ..... How many years ago? .....
(13) Have you taken Biology? ..... How long? ..... How many years ago? .....
(14) Have you taken Astronomy? ..... How long? ..... How many years ago? .....
(15) Have you taken Domestic Science? ..... How long? ..... How many years ago? .....
(16) Do you like the study of sciences? .....

PART II.

Below are statements of scientific facts which are stated thus: "A fly is an **Animal, a Fish, an Insect, a Reptile, a Building.**" Of course a fly can not be all the things which are printed in extra-black type. A fly is an insect, so if you underline "**an insect**" that will show that you know which is correct. In the statement "The heart pumps **Blood, Water, Oil, Air, Sand,**" "**Blood**" should be underlined. Underline the correct word in the statements below so that each statement is true. If you don't know, guess.

1. The normal temperature of a human being is **100 F., 104 F., 98.6 F., 93 F., 90 F.** 1
2. The souring of milk is caused by **Bacteria, Heat, Freezing, Air, Moisture** 2
3. Ventilation is for the purpose of securing **Sunlight, Warmth, Pure Air, Comfort, Germs** 3
4. The length of a meter in inches is about **12, 19, 27, 39, 144** 4
5. Water boils at **100 F., 18 F., 212 F., 222 F., 98.6 F.** 5
6. Water expands when raised above or cooled below **0 C., 40 C., 32 C., 4 C., 100 F.** 6
7. Water pressure in city mains is ordinarily about **25, 60, 100, 150, 200** pounds per square inch 7
8. Water freezes at **0 F., 32 F., 42 F., 100 F., 98.6 F.** 8
9. The mercurial barometer reads at sea level about **10 In., 18 In., 30 Cm., 30 In., 100 In.** 9
10. A calorie is the amount of heat neecssary to raise the temperature of one gram of water **1 C., 2.4 C., 32 F., 100 C., 212 F.** 10
11. The greatest vertical height to which water can be siphoned is about **30 In., 10 Ft., 30 Ft., 40 Ft., 100 Yds.** 11
12. The boiling point on the Centigrade thermometer is **0, 32, 100, 120, 212** 12
13. An oboe is a **Wood Wind Instrument, a String Instrument, a Drum, a Brass Horn, a Percussion Instrument** 13
14. A trombone is a **Wood Wind Instrument, a Percussion Instrument, a Stringed Instrument, a Brass Instrument, a Drum** 14
15. A dynamo has as one of its parts a **Resonator, Carburetor, Armature, Piston Rings, Clutch** 15
16. Current is conducted to and from the commutator by **Magnetic Poles, Brushes, Fuses, Insulators, Switches** 16
17. The unit for measuring gas flow is the **Gallon, Watt, Cubic Centimeter, Cubic Foot, Cubic Yard** 17
18. Refraction is studied in connection with **Sound, Gravity, Falling Bodies, Light, Electricity** 18
19. *Domestic toasters, curlers and irons are based on the principle of* **Electrical Repulsion, Electrical Attraction, Heating Effect Due to Resistance of a Conductor, Voltage, Rotation of Armature.** 19
20. Images are formed by the passage of light through a **Prism, Helix, Lens, Diaphragm, Spectrum** 20
21. The ampere is a measure of **Air Pressure, Humidity, Resistance, Current, Potential** 21
22. The covering of electric wires is called **Convention, Radiation, Illumination, Insulation, Isolation** 22
23. The electric wires are covered because **the Wire Would Turn Up, Set Fire to Inflammable Material, Break, Get Hot, Get Cold** 23
24. The automobile engine is in **Front, Right, Back, Left, Center of Car** 24
25. Efficiency of electric iron is primarily due to its **Stability, Durability, Increased Cleanliness, Constant Temperature, High Temperature** 25
26. The object to be photographed must be in the sun **to Absorb the Light, to Reflect the Light, to be Seen, to Cast a Shadow, to Transmit the Light** 26
27. Ammonia is made from **Wood, Salt, Coal, Ozone, Vegetable Matter** 27
28. Sunlight can be broken up into the spectrum by means of a **Mirror, Lens, Prism, Microscope, Color-Mixer** 28
29. Formaldehyde is often used as a **Dye, Vaccine, Disinfectant, Fertilizer, Stimulant** 29
30. An illustration of capillarity is found in the **Ink Blotter, Thermometer, Barometer, Force Pump, Excretion of Urea** 30
31. When a liquid contains all the dissolved substance possible, the condition is termed **Osmosis, Permeability, Fusion, Reduction, Saturation** 31
32. The propelling mechanism of an automobile is termed the **Chassis, Piston, Differential, Governor, Motor** 32
33. Humidity relates to **Dryness, Heat, Cold, Freezing, Temperature** 33
34. Substances without crystalline structure are termed **Inert, Dense, Elastic, Opaque, Amorphous** 34
35. Heat is measured in **Degrees, Calories, Candle Power, Kilowatts, Grams** 35
36. Concrete walks have joints filled with sand or tar-paper **to Prevent Wearing, to Allow the Circulation of Air, to Provide for Expansion, to Keep the Blocks Apart, to Allow for Drainage** 36
37. The hottest flame is **Blue, Green, White, Yellow, Red** 37
38. The foot-pound is a unit of **Energy, Work, Distance, Weight, Capacity** 38
39. Water rises in a suction pump because it is **Pulled Up, Pushed Up, Attracted, Repelled, Sucked Up** 39
40. A stove radiates more heat when it is **all Black, all Rusted, all Nickel Plated, all Aluminum, all Silvered** 40
41. Heating systems are placed in the cellar, because heat causes water and air to **Evaporate, Contract, Expand, Rise, Fall** 41
42. The unit of weight in the metric system is the **Litre, Ounce, Pound, Ton, Gram** 42
43. Potential energy is energy possessed by an object by virtue of its **Weight, Combustibility, Motion, Position, Density** 43
44. When ice thaws, the partly thawed ice and water are at **Different Temperatures, Equal Temperatures, at 40 F., at 31 F., at 37 F.** 44
45. Limewater is used to test for Carbon Dioxide, Oxygen, **Alcohol, Hydrogen, Chlorides** 45
46. Heat can pass through a vacuum only by means of **Convection, Conduction, Radiation, Gravitation, Combustion** 46
47. Hydrogen may be prepared for laboratory use from the action of zinc on **Alkalies, Salts, Chemicals, Acids, Water** 47
48. An airplane cannot remain in air when at **Rest, in Motion, Upside Down, Gliding, Descending** 48
49. Gas, in order to burn well, should be mixed with **Nitrogen, Air, Carbon Dioxide, Ammonia, Oil** 49
50. The weight of moisture or water vapor contained in a cubic foot of air is called the **Absolute Humidity, Degree of Saturation, Relative Humidity, Density, Concentration** 50
51. You can recognize an invisible airplane by its **Shape, Sound, Color, Wings, Smoke** 51
52. Electrolysis of water liberates hydrogen and **Chlorine, Nitrogen, Carbon-Dioxide, Ammonia, Oxygen** 52
53. Escaping illuminating gas mixes with the air of the room by **Capillarity, Diffusion, Cohesion, Gravitation, Chemical Affinity** 53
54. When air is heated, it **Contracts, Expands, Falls, Liquifies, Solidifies** 54
55. The following gas is found in impure air: **Calcium, Gold, Carbon-Dioxide, Sodium, Carbon** 55
56. Oxygen may be prepared for laboratory study from Salt, **Magnesium, Carbonate, Calcium Oxalate, Potassium Chlorate** 56
57. The attraction between molecules of a body is called **Capillarity, Adhesion, Magnetism, Cohesion, Convection** 57
58. A loud report from the engine is due to **Too Little Air, Too Little Gas, Too Much Gas, Too Much Spark, Poor Spark Plugs** 58
59. Black smoke from muffler indicates **Too Much Air, Too Much Gas, Too Little Gas, Engine Too Hot, Broken Clutch** 59
60. The capacity to do work is termed **Energy, Momentum, Efficiency, Mechanical Advantage, Velocity** 60
61. The smallest of these things is the **Molecule, Bacterium, Paramoecium, Dust Particles, Atom** 61
62. Balloons float in the air because of their **Lightness, Silvery Color, Engines, Baskets, Size** 62
63. A boat floats in water because **it is More or Less Hollow, of its Shape, it is Lighter than Water, the Water Exerts an Upward Pressure on the Boat, Water Cannot Fill the Boat** 63
64. The temperature at which pure water boils is effected by the **Height of the Flame, the Amount of Water, the Air Pressure, the Density of the Water, the Depth of the Water** 64

65. Soft coal is also known as **Anthracite, Asphalt, Lignite, Eituminous, Peat** 65
66. Petroleum is a **Chemical Compound, a Chemical Element, a Mixture, a Pure Substance, an Impure Substance** 66
67. Air brakes are controlled by a **Foot Lever, an Automatic Device, by Tension on a Strap, by Turning a Handle, by Holding a Lever** 67
68. The water pipes burst in the winter time because of **Contraction of Lead, Expansion of Water, Expansion of Lead, Chemical Action, Brittleness** 68
69. The ratio of the number of units of force applied to a machine to the number of units of force delivered by a machine is called **Efficiency, Out-Put, Available Energy, Mechanical Advantage, Waste** 69
70. An example of a chemical element is **Water, Carbon-Dioxide, Mercury, Ammonia, Nitric Acid** 70
71. On a curve, the tracks are **Higher in the Inside than Outside, Higher Outside than In, Same Height, Wider, Narrower.** 71
72. Early settlers located on bodies of water in order **to Get Pure Drinking Water, to Get Water for Personal Needs, for Pleasure and Beauty, for Navigation, to get Good Land** 72
73. Sound is produced by **Vibration of the Definite Part of the Instrument by the Movement of Air, by the Effect on the Ear of Air Waves, by Electric Waves, by Ether Waves, by Magnetic Waves** 73
74. The voice is carried along the wires by **Sound Vibrations, Electric Pulses, Magnetism, Energy, Electron** 74
75. We pay for electricity by the **Watt, Ampere, Volt, Ohm, Kilowatt-Hour** 75
76. An octave consists of **Eight Notes, of Seven and One-half Notes, of Three Major Chords, of High Notes, of a Note** 76
77. The magnetic field in Dynamos is produced by **Transformers, Natural Magnets, Electro Magnets, Condensors, Leyden Jars** 77
78. All space is believed to be filled by **Air, Oxygen, Ether, Heat, Moisture** 78
79. Which can turn somersaults most safely with his machine: **The Chauffeur, Flier, Sailor, Conductor, the Cannoneer** 79
80. The modern electric light bulb is filled with **Air, Hydrogen, Helium, Oxygen, or is a Vacuum** 80
81. The handle of a skillet becomes hot as a result of **Resistance, Conduction, Friction, Radiation, Latent Heat** 81
82. The term induction is used most in connection with **Levers, Pumps, Falling Bodies, Solutions, Electrical Currents** 82
83. Large ships are usually made of **Steel, Copper, Wood, Lead, Brass** 83
84. Combustion is another name for **Drying, Shrinking, Boiling, Burning, Melting** 84
85. An example of an alkali is **Aluminum, Sodium Hydroxide, Table Salt, Mercury, Potassium Chlorate** 85
86. The density of a solid is usually compared with that of **Air, Hydrogen, Water, Lead, Wood** 86
87. A metal which can be drawn into fine thread is said to be **Elastic, Ductile, Flexible, Malleable, Magnetic** 87
88. The resistance a body offers to being set into motion is called **Momentum, Friction, Cohesion, Erosion, Inertia** 88
89. An example of a lever of the first class is found in the **Nut Cracker, Scissors, Wheel Barrow, Inclined Plane, Biceps Muscle** 89
90. The sensitive film material is made of **Silver Chloride, Silver Bromide, Potassium Nitrate, Iron Oxalate, Potassium Chloride** 90
91. A mirage is a kind of **Body of Water, Optical Illusion, Vision, Desert, Warfare** 91
92. Sewer gas is kept from entering a house from the sewer by a **Valve, Trap, Faucet, Damper, Drain** 92
93. An example of oxidation is the **Rusting of Iron, Electrolysis of Water, Melting of Ice, Action of Acid on Zinc, Heating Potassium Chlorate** 93
94. Mosquitoes breed in **Filth, Still Water, Rivers, on the Ground, in Oceans** 94
95. Treating a child for whooping cough you would keep him **in a Close Room, Out of Doors, in Bed, Without Food, in a Turkish Bath** 95
96. The teeth should be examined by the dentist every **Half Year, Every Year, Every Two Years, Every Month, Every Ten Years** 96
97. The best method of sewage disposal is **Cess Pool, Open Sewer, Closed Sewer, Septic Tank, Surface Drain** 97
98. To reduce danger of ptomaine poisoning, a can of salmon should be **Heated Thoroughly, Protected from Flies, Emptied out of Can Promptly, Thoroughly Salted, Eaten with Vinegar** 98
99. Hemorrhages from wounds should be stopped by **Applying Pressure on Side of Blood Vessel from Which Blood is Coming, Applying Antiseptics, Keeping Clean, Shutting Out Air and Dust, Applying Dirt** 99
100. Dressings on a wound should be removed and fresh ones applied **Once a Week, Once a Day, Never, When the Wound is Well, Every Hour** 100
101. Fleas are parasitic on rats and transmit a disease called **Beri-Beri, Bubonic Plague, Malaria, Yellow Fever, Mumps** .. 101
102. The best way to make impure water safe is to **Let it Settle, Boil it, Freeze it, Use Chemicals, do Nothing** 102
103. To make milk free from bacteria, milk is **Pasteurized, Frozen, Inoculated, Poisoned, Skimmed** 103
104. Small pox is prevented by **Medicine, Vaccination, Anti-Toxin, Pasteurization, Sterilization** 104
105. Usually the most serious danger from wounds is infection which may be prevented by **Covering the Wound at Once, Keeping Wound Open and Clean, Stopping Bleeding, Putting Adhesive Over it, Putting in Salve** 105
106. The death rate from tuberculosis is highest among **Stone Cutters, House Servants, Farmers, Bookkeepers, Students** 106
107. Windows should be opened, at **Sides, Top and Bottom, Top and Sides, Bottom and Sides, Bottom** 107
108. Poisonous products secreted by bacteria are called **Enzymes, Anti-Bodies, Toxins, Vaccines, Legumes** 108
109. To treat a cut use **Lime Water, Iodine, Linseed Oil, Salve, Nothing** 109
110. The vaccine used to prevent typhoid fever consists of **Bacterial Cells, Horse Blood Serum, Anti-Toxin, a Chemical Preparation, Acids** 110
111. Wounds should be allowed to bleed **a Little, Not at All, Until They Stop Naturally, a Great Deal, Quantities** 111
112. Tight bandages should **be Left Untouched, be Loosened When Bleeding Stops, Never Be Applied, Removed When the Doctor Calls, Tightened** 112
113. Adhesive tape may be put over open wounds **Next to Skin, with Gauze Between Tape and Skin, Not at All if Freshly Cut, if There is Dirt Present, if no Dirt is Present** 113
114. Mosquitoes can be eliminated by **Swatting Them, by Importing Birds, by Destroying Their Breeding Places, by Smudges, by Poison** 114
115. Alcoholic fermentation is produced by **Mold, Yeast, Bacteria, Germs, Air** 115
116. Arterial wounds are dangerous and may be recognized because blood **Oozes Out, Jets Out, Flows Evenly, Flows Slowly, Flows Rapidly** 116
117. Tuberculosis is contracted by **Contact with Patient, Contact with Clothing, from Bacilli of Sputum, by Taking Cold, Bathing** 117
118. Tuberculosis is prevented by **Medicine, by Hygienic Living, by Massage, Osteopathy, Chiropractic** 118
119. The best temperature for a living room is **60 F., 68 F., 75 F., 78 F., 80 F.** 119
120. All cows in certified dairies are tested for **Typhoid, Tuberculosis, Mange, Diphtheria, Yellow Fever** 120
121. Milk produced under sanitary conditions and from tubercular tested cows is **Pasteurized, Sterilized, Certified, Boiled, Impure** 121
122. Why are we quarantined for the Measles? **To Protect the Patient, to Prevent the Spread of the Disease, to Satisfy Public Opinion, to Make Money, to Keep the Patient at Home** 122
123. The house fly is harmful because it **Destroys Crops, has a Poisonous Bite, Carries Bacteria, Destroys Food, it is Hard to Strike** 123
124. Open wounds should be bathed with a dilute solution of **Hydrogen Peroxide, Alcohol, Sulphuric Acid, Soda, Tobacco Juice** 124
125. The best illumination or light for working or reading is **Direct, Reflected, Indirect, White, Blue** 125
126. The source of most healthful light is the **Sun, Kerosene, Gas, Electricity, Candles** 126
127. Gas and kerosene are least desirable as light sources because of **Poor Light, Oxidation Products, Excessive Care, Expense, Smoke** 127
128. The main purpose of respiration is **Energy-Release, Elimination of CO_2, Manufacture of Food, Secretion of Water, Purification of Air** 128
129. When the child's first permanent teeth appear he is **6 or 7 Years Old, 12 Years Old, 18 Years Old, 20 Years Old, 30 Years Old** 129
130. The ovum or egg cell is produced in the **Kidney, Embryo, Ovary, Gamete, Sporagium** 130
131. Air is breathed into **Stomach, Heart, Lungs, Eyes, Liver** .. 131
132. Adenoids are found in **Mouth, Nose, Ear, Throat, Lungs** 132
133. Adenoids are disposed of by **Medicine, Massage, Operation, Chiropractors, Osteopaths** 133
134. One of the excretory organs in the body is the **Heart, Liver, Skin, Duodenum, Spleen** 134
135. The distinguishing features of the mammals is the possession of **Backbones, Hair, Two Pairs of Legs, Milk Glands, Nervous Systems** 135
136. A collection of similar cells is called an **Organism, Tissue, Gland, Muscle, Function** 136
137. The adult has **18, 30, 25, 32, 20 Teeth** 137
138. The pleura is a protection for the **Heart, Bones, Muscles, Lungs, Brain** 138
139. Air in the ear is equalized by **the Auditory Meatus, the Cochlea, the Eustachian Tube, Incus, Semi-circular Canals** 139
140. When you jerk your finger from a hot stove, the action is **Voluntary, Involuntary, Reflex, Contemplated, Premeditated** 140
141. The average pulse rate for an adult man is **100, 45, 72, 60, 50** 141
142. The kidneys **Digest Food, Clean Blood of Wastes, Build Up New Blood Cells, Support the Backbone, are Useless** 142
143. A ferment is another name for a **Bacterium, Enzyme, Toxin, Vaccine, Serum** 143
144. The part of the eye that regulates the entrance of light is **the Pupil, the Iris, the Retina, the Eye-Lid, the Lens** 144
145. Tonsils are located in the **Gullet, Throat, Nose, Ears, Lungs** 145
146. Normal respiration per minute is **15-18, 20-25, 70-75, 10-12, 103** 146
147. The vertebrae are parts of the **Heart, Muscles, Backbone, Teeth, Toes** 147
148. The teeth should be cleaned with a brush **Every Week, Three Times a Day, Every Month, Every Year, Never** 148
149. In a child's first set of teeth, there are **18 Teeth, 20 Teeth, 25 Teeth, 32 Teeth, 14 Teeth** 149
150. The hard substance of the tooth is called **Dentine, Enamel, Neck, Root, Bone** 150
151. Venous wounds may be recognized because blood flows **Slowly and Evenly, Jets Out, Oozes Out, Not at All, Rapidly** 151
152. The pulp cavity contains **Minerals, Periosteum, Nerves, Tendons, Ligaments** 152
153. The eyes are injured most by **Improper Light, Dark, Dust, Strain, Work** 153
154. Medicinal nose sprays should not be used because they **Kill Germs, Clean the Nose, Destroy Valuable Mucous Secretions, Prevent Colds, Have an Odor at All Times** .. 154
155. The ears are injured most by **Loud Music, Noises, Strain, "Boxing," Quiet** 155
156. The muscles are benefitted most by **Rest, Hard Work, Systematic Diet, Play, Systematic Exercise** 156
157. A good health motto is "Keep the head cool and the feet **Cooler," Warm, Well Clothed, Hot, Dry** 157
158. The apparatus necessary to carry messages consists of two wires, batteries, receiver and a **Mouthpiece, a Box, a Transmitter, an Electromagnet, a Bell** 158
159. The centrifugal force of a cream separator separates milk from cream because the cream is **Lighter, Heavier, Thicker, Denser, Greasier** 159
160. The separation of liquids and solids by evaporation and condensation is called **Solution, Distillation, Diffusion, Fusion, Transpiration** 160
161. Concrete is reinforced with **Iron, Wood, Straw, Cloth, Rope** 161
162. Ventilation is best secured with **Stoves, Hot Air Furnaces, Steam Heating, Hot Water Heating, Electric Heat** .. 162
163. Fusion means the same as **Evaporation, Boiling, Freezing, Dissolving, Distilling** 163
164. Fanning the body on a dry day produces a cool sensation because of **Movement of the Air, Rapid Evaporation of Moisture into the Air, Amount of Heat Taken from the Body, Creation of a Draught, Fresh Air** 164
165. Heat is carried horizontally through air by **Conduction, Convection, Radiation, Erosion, Transmigration** 165
166. The act of transfer of pollen from anther to stigma is called **Pollination, Reproduction, Fertilization, Transpiration, Mitosis, Filtration** 166
167. Water cannot be siphoned out of a boat because of **Unequal Air Pressure, Unequal Amounts of Water, Attraction of Water Particles for Each Other, Suction, Water in Boat Is too Low** 167
168. Distillation is a means of **Purifying Water, Securing Air Pressure, Pumping Water, Transmitting Water, Securing Heat** 168
169. The passage of the moon between the sun and the earth is called an **Eclipse of the Sun, Full Moon, Third Quarter, Eclipse of the Moon, Winter Solstice** 169
170. The largest of the planets is **Venus, Saturn, Mars, Jupiter, Earth** 170
171. The monthly phases of the moon are caused by its movement **On Its Axis, About the Earth, About the Sun, in Its Orbit, Newton's Law** 171
172. An eclipse of the sun is due to the position of **the Stars, the Planets, the Moon, the Constellations, the Milky Way** .. 172
173. A star is really a **Comet, a Satellite, a Planet, a Sun, a Light** 173
174. The sun and the planets form **the Constellations, the Solar System, the Milky Way, the Zenith, the Horizon** 174
175. The light from the moon is **Direct, Reflected, Invisible, Abstracted, Refracted** 175
176. "Shooting stars" are properly called **Suns, Asteroids, Moons, Comets, Meteors** 176
177. The earth was formed **of dust, by the cooling of Nebulous Gases, in Seven Days, Out of Ice, Out of Rock** 177
178. From a very great distance our solar system would look **Black, Like a Star, Like a Moon, Like Jupiter, Vacant** 178
179. Trees that have broad leaves are classified as **Soft Wood, Evergreen, Hardwood, Fruits, Shrubs** 179
180. The process of food manufacture in green plants is called **Respiration, Mitosis, Pollination, Photosynthesis, Pasteurization** 180
181. An example of a leguminous plant is the **Clover, Toadstool, Pansy, Lilac, Moss** 181
182. Insects have the following number of legs: **Four, Six, Eight, Ten, Two** 182
183. Birds have feathers **to Make Them Look Pretty, to Fluff Out in Case of Danger, to Protect Them, So They Will Have Something to Wear, to Make Pillows** 183
184. The purpose of the roots is **to Take in Oxygen, to Manufacture Starch, to Give Off CO, to Take in Soil Water, to Give Off Waste Matter** 184
185. In the dark the pupil of the cat's eye is **Larger, Smaller, of Equal Size, very Small, Absent** 185
186. Butterflies may be distinguished from moths for **They Fly by Day, Are Larger Than Moths, Are More Brightly Colored, They Eat Leaves, They Do Not Live Long** 186
187. The process by which a plant is made to grow on the stem of another plant is **Pruning, Slipping, Grafting, Spraying, Planting** 187
188. Grasshoppers may be distinguished from other insects by **Large Pair of Jumping Legs, Large Wings, Bright Green Color, Presence Near Flowers, Numbers** 188
189. All our food comes directly or indirectly from **Rock, Animals, Plants, Air, Mines** 189
190. An insect is a **Bug, Animal, Bird, Fish, Vertebrate** 190
191. A general term for any living thing is **Plant, Larva, Animal, Organism, Mammal** 191
192. We should attract birds to our city because **They Eat Fruits, They Are Beautiful, They Are Useful, They Sing, They Build Nests** 192
193. The cypress trees grow **on the Hills, in Swamp, on Dry Land, in Rocky Soil, on Mountains** 193
194. An organism that reproduces by means of spores is the **Maple, Amoeba, Bread Mold, Sponge, Earthworm** 194
195. The process by which plants and animals change their food materials into soluble form is known as **Absorption, Digestion, Photosynthesis, Osmosis, Respiration** 195
196. A great bird student in our country was **Roosevelt, Burroughs, Darwin, Edison, Longfellow** 196
197. Which of the following insects are beneficial? **Housefly, Mosquito, Lady Bug, San Jose Scale Insect, Hessian Fly** 197
198. Plants take in their food through their **Leaves, Bloom, Roots, Stomata, Vertebrae** 198
199. The corolla is made up of the **Petals, Pistils, Sepals, Stamens, Ovaries** 199
200. Trees that have needles are called **Birch, Pine, Oaks, Gums, Evergreen** 200
201. Birds suffer most from **Lack of Food and Water, the Cold, the Heat, Other Bird Enemies, Animals** 201
202. The colored parts of a flower are **Sepals, Pistil, Petals, Stamens, Corolla** 202
203. The yellow dust on a flower is **Chlorophyll, Ovules, Protoplasm, Pollen, Dirt** 203
204. The calyx is made up of the **Petals, Stamens, Petioles, Pistils, Sepals** 204
205. Fruit trees are generally propagated **by Seeds, by Cuttings, by Grafting, by Settings, by Seedlings** 205
206. Perspiration contains: **Sugar, Salt, Fat, CO_2, Food** 206
207. The flowers of the elm trees are pollinated by **People, Wind, Animals, Water, Insects** 207
208. The unborn young of an animal is termed the **Larva, Embryo, Chrysalis, Ovum, Sperm** 208
209. Animals which secure food directly from the bodies of other animals are **Parasites, Hydrophytes, Mesophytes, Saphrophytes, Sulphites** 209
210. The anther is part of the **Calyx, Corolla, Ovary, Pistil, Stamen** 210
211. The purpose of flowers on a plant is to develop **Roots, Seeds, Leaves, Perfume, Branches** 211
212. Pollen is produced in the **Ovary, Calyx, Stamen, Stigma, Pistil** 212
213. The simplest independent living structure is the **Nucleus, Protoplasm, Cell, Embryo, Atom** 213
214. The greatest damage is done to trees by **Birds, Worms, Larva of Moths, Grasshoppers, Bees** 214
215. Birds go south in winter because **It Is Cold Farther North, They Don't Like Snow, They Can Find Little Food, They Find Little Material for Their Nests, They Like the Flowers** 215
216. Mosquitoes lay eggs **on Salt Water, Stagnant Water, Fresh Water, on the Ground, in Garbage** 216
217. The nucleus is believed to play a prominent part in **Digestion, Respiration, Heredity, Storage of Food, Nerve-Conduction** 217
218. Birds sing **to Make Us Happy, to Make Their Little Ones Happy, to Attract Their Mates, to Warn Other Birds That Danger Is Near, Because They Like Music** 218
219. An example of a fungus plant is the **Orchid, Pondscum, Breadmold, Mother of Vinegar, Indian Pipe** 219
220. Insects have the following number of pairs of wings: **One, Two, Three, Four, Five** 220
221. House flies lay their eggs **in Wood, on the Water, in Animal and Vegetable Waste, in Nests, in the Sand** 221

222. The age of a tree is told by **Branches, Rings in Cross Section of Trunk, Height, Size of Trunk, Color** 222

223. Geese fly in a V-shaped formation because **They Think It Looks Pretty, They Fly in a Flock, They Will Be Protected, They Can Fly Easier Together, They Like Geometrical Figures** 223

224. Gases enter and leave the leaves of plants through organs called **Stipules, Root-Hairs, Stomata, Micropyles, Chloroplasts** 224

225. The food which is most important to be kept in the coldest part of the refrigerator is **Bread, Cooked Foods, Vegetables, Milk, Butter** 225

226. Cheese is rich in **Fats, Proteins, Oils, Carbohydrates, Water** 226

227. Oleomargarine is a **Milk Product, an Animal Fat, a Vegetable Oil, an Adulteration, Better Than Butter** 277

228. Coffee should be boiled **One Minute, Three Minutes, Ten Minutes, Fifteen Minutes, Twenty Minutes** 228

229. Refrigerators should be cleaned by using *Kerosene, Gasoline, Warm Water and Soda, Vinegar, Salt* 229

230. The water best fitted to remove dirt is **Hot Hard, Hot Soft, Cold Hard, Cold Soft, Tepid Hard** 230

231. Green vegetables should be started to cook in **Cold, Warm, Boiling, Tepid** or **Freezing** water 231

232. Refrigerators should be made of **Material Which Is a Poor Conductor of Heat, Iron, Material Which Is a Good Conductor of Heat, Rough Material, Smooth Material** 232

233. Large warehouses where perishable foods are kept are kept cool by **Electric Fans, Iceless Refrigerators, Large Quantities of Ice, Keeping Windows Open, Thick Walls** 233

234. Milk is tested for the amount contained of **Butter Fat, Water, Proteins, Butter, Buttermilk** 234

235. A food rich in carbohydrate is **Beefsteak, Olive Oil, Cucumbers, Watermelon, Honey** 235

236. Food should be kept in a refrigerator because **It Is More Palatable When Cold, Some Things Stay Solid When Cold, Low Temperature Retards Growth of Molds, Yeasts and Bacteria, Some Things Stay Crisp, It Tastes Better** 236

237. The best lining for refrigerator is **Tin, Enamel, Copper, Iron, Zinc** 237

238. The coldest place for food in a refrigerator which is iced at the bottom is **the Lowest Shelf, the Top Shelf, the Side, the Center, the Back** 238

239. Foods which contain nitrogen as a part of their chemical composition are called **Proteins, Fats, Carbohydrates, Hydrocarbons, Liquids** 239

240. **Tea should never be drawn in vessels of Aluminum, Tin, Granite, Silver, China** 240

241. **The cheapest food on the basis of calorific value is Wheat Flour, Butter, Meat, Milk, Celery** 241

242. **The proper way to keep ice in a refrigerator is to Wrap Ice in Heavy Paper, to Leave Door Open, to Keep Ice Unwrapped, to Wrap Ice in Burlap, to Look at It Often** 242

243. Glucose is found in large quantities in **Eggs, Olive Oil, Beefsteak, Onions, Sugar Beets** 243

244. The general direction of the wind in front of a low pressure area is **East, West, North, South, Northeast** 244

245. The best soil for general purposes is **Clay, Loam, Sand, Subsoil, Gravel** 245

246. The following is classed as a garden crop: **Oats, Rice, Sweet Peas, Lettuce, Barley** 246

247. The rainbow is seen **Directly Overhead, in the North, in the South, in the East,** or **in the West** 247

248. Arid regions are made productive by **Irrigation, Drainage, Ridging, Fertilizer, Pasteurization** 248

249. The processes which tend to level down the earth's surface are collectively termed **Vulcanism, Sedimentation, Erosion, Metamorphism, Stratification** 249

250. The wheat region of North America is **Alaska, Mexico, Middle West, Rocky Mountains, East** 250

251. A winding stream is said to **Circulate, Migrate, Meander, Drain, Circumnavigate** 251

252. Distance measured above sea level is called **Longitude, Altitude, Declination, Inclination, Latitude** 252

253. *Forests prevent floods because* **They Keep the Soil Loose, They Hold the Water Back, the Trees Absorb Water, They Prevent Rivers from Overflowing, They Stop the Water** 253

254. A bright blue sky indicates **Bad, Fair, Rainy, Gloomy, Stormy** weather 254

255. Wind-deposited piles of sand are called **Moraines, Deltas, Drumlins, Dunes, Monadnocks** 255

256. The path of a heavenly body is called its **Orbit, Radius, Equator, Latitude, Declination** 256

257. The earth rotates on its axis once in **12 Hours, 24 Hours, 7 Days, 3 Months, 365¼ Days** 257

258. Another term for an anti-cyclone is a **Low Pressure Area, Tornado, High Pressure Area, Typhoon, Horse Latitudes** 258

259. Of the four places named the sun is visible the fewest number of hours on June twenty-first at **the North Pole, the Equator, Forty Degrees North Latitude, Twenty Degrees South Latitude, South Pole** 259

260. Erosion can be prevented by **Building, Irrigation, Planting Forests, Cutting Down Forests, Making Ditches** 260

261. One erosive agent is the **Moon, Water, Telegraph, Birds, Planets** 261

262. Ice cracks rock because **It Is Cold, Water Expands When It Freezes, It Melts When It Gets Warm, It Is Heavy, It It Brittle** 262

263. A river and its tributaries together form what is called a **River, Flood, Sound, Basin, System** 263

264. Glaciers cause erosion because they **Are Made of Snow, Are Heavy, Move, Melt, Are Cold** 264

265. A family living near a large body of water finds the climate all the year around **Hot, Cold, Almost Even, Wet, Dry** 265

266. Rain is water vapor **Distilled, Evaporated, Condensed, Filtered, Concentrated** 266

267. New York City gets its water supply from the **Hudson River, Atlantic Ocean, Lake Champlain, Catskill Mountains Region, Long Island Sound** 267

268. Isobars are used in **Temperature, Air Pressure, Humidity, Winds, Gravitation** 268

269. Soil deposited *at the mouth of a river is called a* **Peninsula, Delta, Strait, Island, a Cape** 269

270. The air in Minnesota homes in winter is commonly unhealthful because of **Insufficiency of Oxygen, Excess of Carbon Dioxide, Bad Odors, Improper Humidity, Cold** 270

271. A violent circular windstorm of small area is a **Cyclone, Tornado, Monsoon, Norther, Blizzard** 271

272. Dew comes from the **Earth, Plants, Air, Clouds, Grass** 272

273. Decaying vegetable matter in soils is termed **Mineral, Phosphates, Lichens, Potash, Humus** 273

274. Distance east and west around the earth is called **Longitude, Altitude, Declination, Revolution, Latitude** 274

275. Volcanoes are most likely to be found in **Deserts, Coastal Plains, Mountains, Deltas, Islands** 275

276. One of the three most important elements of the soil required for the growing of crops is **Oxygen, Nitrogen, Sodium, Carbon, Hydrogen** 276

277. A dynamo is a machine for generating **Heat, Light, Electric Current, Sound, Music** 277

278. A hydrometer is used to measure **Temperature, Volume, Pressure, Density, Length** 278

279. Oil is used in an automobile engine to **Cool It, to Clear It, to Lubricate It, to Burn, to Silence It** 279

280. The break on a train is operated by **Steam, Compressed Air, Carbon Dioxide, Leverage, Momentum** 280

281. The system of pipes by which water is supplied and sewerage taken away from a house is called **Ventilation, Heating, Plumbing, Refrigeration, Drainage** 281

282. *Voltaic cells are studied about in* **Botany, Bacteriology, Zoology, Electricity, Psychology** 282

283. *The device in water or steam pipes for stopping the flow at any point is called a* **Damper, a Faucet, Valve, Switch, Stoker** 283

284. *A lifting crane gains power in doing work, by the use of the* **Wheel and Axle, the Lever, the Pulley, the Inclined Plane, an Engine** 284

285. *A cream separator is made by* **Conklin, McCormick, De Laval, Darwin, Steinway** 285

286. Boats of all kinds are steered by means of **Sets of Wheels, Paddles, Rudders, Wings, Motors** 286

287. The first electric incandescent lamp was made by **Edison, Burroughs, Watt, Priestly, Westinghouse** 287

288. Large buildings are best heated by a **Pipeless Furnace, Hot Air, Hot Water, Steam, Electric Heat** 288

289. Concrete is usually in the form of **Bricks, Slabs, Cylinders, a Hardened Mass, Blocks** 289

290. An anemometer is an instrument used by the weather bureau to measure **the Amount of Sunshine, Amount of Rainfall, Air Pressure, Wind Velocity, Atmospheric Pressure** 290

291. The rudder of a ship is in the **Front, Side, Rear, Center, Bottom** 291

292. A thermometer is used to measure **Temperature, Pressure, Weight, Heat, Cold** 292

293. The device for protecting lights and motors from an overcharge of electricity is called a **Magnet, a Fuse, a Switch, a Barometer, a Rectifier** 293

294. *The contrivance used to raise bricks, mortar, etc., as a building is going up, is called* **an Elevator, a Crane, a Hoist, a Lever, a Jack** 294

295. The telephone was invented in 1876 by **James Watt, Samuel Morse, Alexander G. Bell, Marconi, S. F. B. Morse** 295

296. A kodak *is a* **Mouth Organ, Picture Taking Device, Music Box, Brownie, Film** 296

297. The purpose of the mouthpiece on a telephone is **to Concentrate the Sound Waves, to Protect the Transmitter, for Sanitary Purposes, to Keep Moisture from the Wires, to Protect the Speaker** 297

298. A chimney on a lamp is for **Ornamentation, to Make the Light More Intense, to Create a Draft, to Make the Flame Burn, to Save Oil** 298

299. The home gas consumption is measured by a **Velocipede, Speedometer, Meter, Galvanometer, Ammeter** 299

300. A device for automatically regulating furnace fire is called **a Thermometer, a Thermostat, a Barometer, a Galvanometer, a Draft** 300

INFORMATION AND INSTRUCTIONS for persons giving the "GENERAL SCIENCE INFORMATION" test.

This test is for the purpose of ascertaining the degree with whic certain fundamental "science" facts are acquired by pupils in different science courses and for ascertaining the degree with which these facts a are acquired by pupils NOT taking science courses. This information, if carefully and accurately secured, will make it possible to revise "General Science" and other science courses in the High School, or else it will tend to show that these courses are satisfactory as they are. Certainly it will indicate whether these courses are functioning in bringing about the acquisition of the information contained in the test. In no case is it designed to criticize the science teaching in any particular school.

To be valid the results must be secured from all the pupils in the 8th grade and in the four years of High School. Results for your school will be available to you if you want them. Please follow the INSTRUCTIONS as carefully as you can. When thru fill out the blanks below and tie this sheet in with the tests when you turn them in. The purpose of the information asked for below is to ascertain whether anything exceptional is to be considered in figuring up the results and in case the results should be exceptional in any way to make it possible to address a personal letter to you asking for further information.

INSTRUCTIONS

1. See that all pupils are seated and have a pencil or pen.
2. Announce that they are about to take a test to ascertain how many scientific statements they can complete correctly.
3. Tell the pupils to do the very best they can; where they do not know, to guess. All pupils are to complete the test. Allow all the time they require to complete the test.
4. Put the following samples on the board and explain carefully what is to be done. See that each pupil understands the method.
   (a) A fly is AN ANIMAL, A FISH, AN INSECT, A REPTILE, A BUILDING.
   (b) The heart pumps BLOOD, WATER, OIL, AIR, SAND.
   "AN INSECT" and "BLOOD" are to be underlined after the pupils have been asked which they would underline so as to make correct statements.
5. Tell pupils to leave pamphlets face downward until told to turn them.
6. Distribute pamphlet face downward.
7. At a signal tell pupils to turn pamphlets, fill out questions at the head of the first page under Part I and then proceed to underline carefully the correct endings in all statements, in each case underlining the one item which makes the best sense.
8. The examiner may answer questions pertaining to Part I. No questions pertaining to Part II are to be allowed.
9. When all pupils are thru collect pamphlets, tie into a bundle and turn in at office.
10. Return unused pamphlets.

A. Were all instructions followed to the best of your knowledge?_____
B. Were there any excepticns to the instructions?_____If so, explain on the back of this page.
C. Did anything occur which might invalidate results?_____If so, explain on the back of this page.
D. Your name_____Address_____
E. Do you wish a statement of results?_____

APPENDIX III

CORRECT RESPONSES FOR GENERAL SCIENCE SCALE, FORM R-1.

GROUP I

1. Fair
2. Carries bacteria
3. Lightness
4. Boil it
5. Warm water and soda
6. Flier
7. The sun
8. Set fire to inflammable material
9. Once a day
10. Pasteurized
11. Vaccination
12. Temperature
13. Larger
14. Expansion of water
15. Large pair of jumping legs
16. Top and bottom
17. Destroying their breeding places
18. Hot soft
19. Butter fat
20. Expands

GROUP II

21. Picture taking device
22. Enamel
23. Emptied out of can promptly
24. Milk
25. Petals
26. In the east
27. Tuberculosis
28. Iron
29. 6 or 7 years old
30. Clean blood of wastes
31. Motor
32. Energy
33. With gauze between tape and skin
34. Tin
35. Enamel
36. In still water
37. Lowest shelf
38. Applying pressure on side of blood vessel from which blood is coming.
39. Two
40. 72

GROUP III

41. Digestion
42. Bacteria
43. Bubonic Plague
44. Backbone
45. Strain
46. Heating effect due to resistance of a conductor
47. Closed sewer
48. Electro Magnets
49. Electricity
50. Rise
51. Steam
52. Clover
53. Armature
54. Valve
55. Absolute humidity
56. Diffusion
57. Bread mold
58. Wind
59. Brushes
60. Conduction.

APPENDIX III (Cont'd)

CORRECT RESPONSES FOR GENERAL SCIENCE SCALE, FORM S-2

GROUP I	GROUP II	GROUP III
1. Hygienic living	21. Burning	41. Prism
2. Delta	22. Reflected	42. Organism
3. 98.6 F	23. Insulation	43. Air pressure
4. Mountains	24. Kilowatt-hour	44. Photosynthesis
5. Alexander G.Bell	25. Cell	45. Rapid evaporation of moisture into the air
6. At rest	26. Fuse	
7. Rings in cross section of trunk	27. Electrical currents	46. Honey
8. Iodine	28. Pollination	47. Bread mold
9. Eclipse of the sun	29. Carbon-dioxide	48. Wind velocity
10. Meter	30. From bacilli of sputum	49. Position
11. Systematic exercise	31. Dryness	50. Embryo
12. To concentrate the sound waves	32. 100	51. Sun
13. Bituminous	33. Atom	52. Larva of moths
14. Lubricate it	34. Proteins	53. Ether
15. Edison	35. Ovary	54. Elimination of CO_2
16. Grafting	36. Oxygen	55. Amorphous
17. Yeast	37. Toxins	56. Alcohol
18. Black	38. Lighter	57. Calories
19. Parasites	39. Trap	58. Enzyme
20. Evergreen	40. Optical illusion	59. Skin
		60. 4 C.

APPENDIX III (Cont'd)

CORRECT RESPONSES FOR GENERAL SCIENCE SCALE, FORM T-2.

GROUP I

1. In animal and vegetable waste
2. Purifying water
3. 24 hours
4. A little
5. Pollen
6. Plants
7. Electric current
8. Water expands when it freezes
9. 6 or 7 years old
10. Clean blood of wastes
11. Orbit
12. On stagnant water
13. Carbon-dioxide
14. Seeds
15. Moon
16. Too much gas
17. Lens
18. Half year
19. Take in soil water
20. 68 F.

GROUP II

21. Higher outside than in
22. 32 F.
23. Meteors
24. Ink blotter
25. Saturation
26. Distillation
27. Rusting of iron
28. Petals
29. Current
30. Hot air furnaces
31. Condensed
32. Air pressure
33. Water in boat is too low
34. Reflect the light
35. Blue
36. Proteins
37. Tissue
38. Radiation
39. The pulley
40. Jupiter

GROUP III

41. To create a draft
42. Scissors
43. Water
44. Stamen
45. Efficiency
46. Mercury
47. Wheatflour
48. Work
49. Inertia
50. Indirect
51. Light
52. Stomata
53. Heredity
54. South
55. A mixture
56. Bacterial cells
57. Iris
58. Milk glands
59. Cohesion
60. Pushed up

TABLE IV APPENDIX

COMPUTATION OF ITEM VALUE OR DIFFICULTY WORKED FROM TABLE III*

Test Item Number	%-8 Girls	%Deviation from Median	P.E. Value & P.E. Value' for -8 Girls	%-8 Boys	%Deviation from Median	P.E. Value for -8 Boys	P.E. Difference	P.E. Value' for -8Boys	%+9 Girls	%Deviation from Median	P.E. Value for +9 Girls	P.E. Difference	P.E.Value' for +9 Girls	%+9 Boys	%Deviation from Median	P.E. Value for +9 Boys	P.E.Difference	P.E. Value' for +9 Boys	Weighted average P.E. Value'	Value of each Item above arbitrary Zero
1	2	3	4*a.b	5	6	7*a	8*c	9*b	10	11	12*a	13*c	14*b	15	16	17*a	18*c	19*b	20*d	21*e
78	2.8	-47.2	-2.834	11.5	-38.5	-1.780	1.054	-1.944	17.4	-32.6	-1.391	.389	-1.969	28.4	-21.6	- .847	.544	-1.511	-1.884	92.63
27	3.2	-46.8	-2.746	5.0	-45.0	-2.439	.307	-2.603	5.3	-44.7	-2.397	.042	-2.975	6.5	-43.5	-2.245	.152	-2.909	-2.808	101.87
35	3.8	-46.2	-2.631	5.2	-44.8	-2.411	.220	-2.575	22.1	-27.9	-1.140	1.271	-1.718	18.2	-31.8	-1.346	-.206	-2.010	-2.110	94.89
128	3.8	-46.2	-2.631	7.2	-42.7	-2.155	.476	-2.319	20.2	-29.8	-1.238	.917	-1.816	25.2	-24.8	- .991	.247	-1.655	-1.923	93.02
173	4.2	-45.8	-2.562	8.2	-41.8	-2.064	.498	-2.228	21.4	-28.6	-1.176	.888	-1.754	27.9	-22.1	- .869	.307	-1.533	-1.807	91.86
16	4.8	-45.2	-2.468	16.8	-33.2	-1.427	1.041	-1.591	5.5	-44.5	-2.370	-.943	-2.948	35.2	-14.8	- .563	1.807	-1.227	-1.228	86.07
87	5.4	-44.6	-2.384	5.2	-44.8	-2.411	-.027	-2.575	3.2	-46.8	-2.746	.335	-3.324	4.4	-45.6	-2.530	.216	-3.194	-2.869	102.48
228	5.4	-44.6	-2.384	3.8	-46.2	-2.631	-.247	-2.795	7.4	-42.6	-2.145	.486	-2.723	4.2	-45.8	-2.562	-.417	-3.226	-2.782	101.61
39	5.8	-44.2	-2.331	4.0	-46.0	-2.597	-.266	-2.761	15.1	-34.9	-1.531	1.066	-2.109	14.0	-36.0	-1.602	-.071	-2.266	-2.307	96.86
57	6.2	-43.8	-2.281	9.8	-40.2	-1.918	.363	-2.082	6.3	-43.7	-2.269	-.351	-2.847	8.3	-41.7	-2.054	.215	-2.718	-2.402	97.81
134	6.2	-43.8	-2.281	5.8	-44.2	-2.331	-.050	-2.495	19.8	-30.2	-1.259	1.072	-1.837	13.5	-36.5	-1.636	-.377	-2.300	-2.175	95.54
67	6.2	-43.8	-2.281	15.8	-34.2	-1.487	.794	-1.651	6.5	-43.5	-2.245	-.758	-2.823	16.3	-33.7	-1.456	.789	-2.120	-2.107	94.86
18	6.6	-43.4	-2.234	9.0	-41.0	-1.988	.246	-2.152	24.4	-25.6	-1.028	.960	-1.606	27.0	-23.0	- .909	.119	-1.573	-1.799	91.78
143	6.8	-43.2	-2.211	11.8	-38.2	-1.757	.454	-1.921	16.0	-34.0	-1.475	.282	-2.053	13.3	-36.7	-1.649	-.174	-2.313	-2.112	94.91
144	7.4	-42.6	-2.145	11.2	-38.8	-1.803	.342	-1.967	12.3	-37.7	-1.720	.083	-2.298	16.6	-33.4	-1.438	.282	-2.102	-2.125	95.04
164	7.4	-42.6	-2.145	10.2	-39.8	-1.884	.261	-2.048	32.5	-17.5	- .673	1.211	-1.251	31.2	-18.8	- .727	-.054	-1.391	-1.556	89.35
81	7.6	-42.4	-2.124	14.0	-36.0	-1.602	.522	-1.766	38.6	-11.4	- .430	1.172	-1.008	44.7	- 5.3	- .198	.232	- .862	-1.229	86.08
249	8.0	-42.0	-2.083	10.5	-39.5	-1.859	.224	-2.023	40.8	- 9.2	- .345	1.514	- .923	41.4	- 8.6	- .322	.023	- .986	-1.293	86.71
28	8.8	-41.2	-2.007	14.8	-35.2	-1.549	.458	-1.713	32.9	-17.1	- .656	.893	-1.234	41.7	- 8.3	- .311	.345	- .975	-1.324	87.03
43	9.4	-40.6	-1.953	10.8	-39.2	-1.835	.118	-1.999	30.5	-19.5	- .756	1.079	-1.334	24.2	-25.8	-1.038	-.282	-1.702	-1.688	90.67
58	9.6	-40.4	-1.935	9.2	-40.8	-1.971	-.036	-2.135	7.4	-42.6	-3.145	-.174	-2.723	8.8	-41.2	-2.007	.138	-2.671	-2.255	96.34
38	9.6	-40.4	-1.935	8.8	-41.2	-2.007	-.072	-2.171	26.7	-23.3	- .922	1.085	-1.500	27.7	-22.3	- .878	.044	-1.543	-1.674	90.53
6	9.8	-40.2	-1.918	9.0	-41.0	-1.988	-.070	-2.152	11.9	-38.1	-1.749	.239	-2.327	9.3	-40.7	-1.962	-.213	-2.628	-2.255	96.34
66	9.8	-40.2	-1.918	12.0	-38.0	-1.742	.176	-1.906	12.6	-37.4	-1.699	.043	-2.277	15.1	-34.9	-1.531	.168	-2.195	-2.074	94.53
224	10.0	-40.0	-1.900	11.0	-39.0	-1.819	.081	-1.983	21.4	-28.6	-1.176	.643	-1.754	25.2	-24.8	- .991	.185	-1.655	-1.799	91.78
64	10.4	-39.6	-1.867	7.0	-43.0	-2.188	-.321	-2.352	35.7	-14.3	- .543	1.645	-1.131	36.7	-13.3	- .504	.039	-1.168	-1.419	87.98
135	10.8	-39.2	-1.835	10.2	-39.8	-1.884	-.049	-2.048	14.0	-36.0	-1.602	.282	-2.180	12.8	-37.2	-1.685	-.083	-2.349	-2.102	94.81
180	11.0	-39.0	-1.819	13.2	-36.8	-1.656	.163	-1.820	38.2	-11.8	- .445	1.211	-1.023	32.5	-17.5	- .673	-.228	-1.337	-1.419	87.98
208	11.0	-39.0	-1.819	10.0	-40.0	-1.900	-.081	-2.064	27.0	-23.0	- .909	.991	-1.487	23.3	-26.7	-1.081	-.172	-1.745	-1.737	91.16
219	11.4	-38.6	-1.788	12.8	-37.2	-1.685	.103	-1.849	25.4	-24.6	- .982	.703	-1.560	33.5	-17.5	- .673	.309	-1.337	-1.587	89.66
273	11.4	-38.6	-1.788	11.2	-38.8	-1.803	-.015	-1.967	40.9	- 9.1	- .341	1.462	- .919	38.6	-11.4	- .430	-.089	-1.094	-1.333	87.12
15	11.8	-38.2	-1.757	29.2	-20.8	- .812	.945	- .976	35.5	-14.5	- .551	.261	-1.129	60.8	10.8	.407	.958	- .057	-0.893	82.72
34	11.8	-38.2	-1.757	15.0	-35.0	-1.537	.220	-1.701	13.5	-36.5	-1.636	-.099	-2.214	14.8	-35.2	-1.549	.087	-2.313	-1.971	93.50
90	11.8	-38.2	-1.757	14.2	-35.8	-1.589	.168	-1.753	20.5	-29.5	-1.222	.367	-1.800	25.8	-24.2	- .963	.259	-1.627	-1.719	90.98
280	12.2	-37.8	-1.728	43.0	- 7.0	- .261	1.467	- .425	37.7	-12.3	- .464	-.203	-1.042	66.9	16.9	.648	1.112	- .016	-0.699	80.78
124	12.4	-37.6	-1.713	14.8	-35.2	-1.549	.164	-1.713	14.4	-35.6	-1.576	-.027	-2.154	12.4	-37.6	-1.713	-.137	-3.377	-1.989	93.68
10	12.6	-37.4	-1.699	11.2	-38.8	-1.803	-.104	-1.967	46.2	- 3.8	- .141	1.662	- .719	40.0	-10.0	- .376	-.235	-1.040	-1.237	86.16
217	12.6	-37.4	-1.699	13.8	-36.2	-1.616	.083	-1.780	17.5	-32.5	-1.386	.230	-1.964	16.8	-33.2	-1.427	-.041	-2.091	-1.883	92.62
278	12.6	-37.4	-1.699	13.8	-36.2	-1.616	.083	-1.780	24.0	-26.0	-1.047	.569	-1.625	25.4	-24.6	-. 982	.065	-1.646	-1.681	90.60
270	12.6	-37.4	-1.699	12.2	-37.8	-1.728	-.029	-1.892	42.7	- 7.2	- .269	1.459	- .847	31.8	-18.2	- .702	-.433	-1.366	-1.361	87.40
121	13.0	-37.0	-1.670	18.8	-31.2	-1.313	.357	-1.477	33.8	-16.2	- .620	.693	-1.198	32.7	-17.3	- .665	-.045	-1.329	-1.379	87.58
258	13.0	-37.0	-1.670	12.8	-37.2	-1.685	-.015	-1.849	20.7	-29.3	-1.211	.474	-1.789	22.8	-27.2	-1.105	.106	-1.769	-1.769	91.48

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
170	13.2	-36.8	-1.656	18.5	-31.5	-1.329	.327	-1.493	32.7	-17.3	- .665	.664	-1.243	46.0	- 4.0	- .149	.516	- .813	-1.233	86.12
88	13.2	-36.8	-1.656	17.8	-32.2	-1.368	.288	-1.532	33.1	-26.9	-1.091	.277	-1.669	20.8	-29.2	-1. 206	-.115	-1.870	-1.682	90.61
110	13.2	-36.8	-1.656	15.5	-34.5	-1.506	.150	-1.670	6.8	-43.2	-2.311	-.705	-2.789	9.5	-40.5	- 1.944	.267	-2.608	-2.094	94.73
140	14.0	-36.0	-1.602	11.2	-38.8	-1.803	-.201	-1.967	20.7	-29.3	-1.211	.592	-1.789	18.0	-32.0	- 1.357	-.146	-2.021	-1.844	92.33
290	14.0	-36.0	-1.602	15.8	-34.2	-1.487	.115	-1.651	18.4	-31.6	-1.335	.152	-1.913	27.0	-33.0	- .909	.426	-1.573	-1.668	90.47
260	14.2	-35.8	-1.589	24.2	-25.8	-1.038	.551	-1.202	43.3	- 6.7	- .250	.788	- .828	55.7	5.7	.213	.463	- .451	-0.923	83.02
56	14.4	-35.6	-1.576	22.5	-27.5	-1.120	.456	-1.284	34.6	-15.4	- .588	.532	-1.166	33.7	-16.3	- .624	-.036	-1.288	-1.303	86.82
251	14.6	-35.4	-1.563	17.8	-32.2	-1.368	.195	-1.532	31.4	-18.6	- .719	.649	-1.297	31.6	-18.4	- .710	.009	-1.374	-1.415	87.94
149	14.8	-35.2	-1.549	13.0	-37.0	-1.670	-.121	-1.834	26.7	-23.3	- .922	.748	-1.500	18.6	-31.4	- 1.324	-.402	-1.988	-1.690	90.67
89	14.8	-35.2	-1.549	14.5	-35.5	-1.569	-.020	-1.733	37.4	-12.6	- .476	1.093	-1.054	37.7	-13.3	- .464	.012	-1.128	-1.297	86.76
9	14.8	-35.2	-1.549	10.2	-39.8	-1.884	-.335	-2.048	20.0	-30.0	-1.248	.636	-1.826	25.6	-24.4	- .972	.276	-1.636	-1.746	91.25
86	15.0	-35.0	-1.537	17.8	-32.2	-1.368	.169	-1.532	24.0	-26.0	-1.047	.321	-1.625	37.2	-13.8	- .484	.583	-1.148	-1.394	87.73
D91	15.2	-34.8	-1.524	16.0	-34.0	-1.475	.049	-1.639	35.3	-14.7	- .559	.916	-1.137	37.7	-13.3	- .464	.095	-1.128	-1.300	86.79
244	15.2	-34.8	-1.524	17.0	-33.0	-1.415	.109	-1.579	10.5	-39.5	-1.859	-.444	-2.437	14.8	-35.2	- 1.549	.310	-2.313	-1.938	93.17
11	15.4	-34.6	-1.512	15.5	-34.5	-1.506	.008	-1.670	36.2	-13.8	- .523	.983	-1.101	46.9	- 3.1	- .115	.408	- .779	-1.184	85.63
283	16.0	-34.0	-1.475	33.5	-16.5	- .632	.843	- .796	42.7	- 7.3	- .273	.359	- .851	50.0	0	0	.273	- .664	-0.887	82.66
4	16.2	-33.8	-1.462	23.5	-26.5	-1.071	.391	-1.235	13.3	-36.7	-1.649	-.578	-2.227	31.8	-18.2	- .703	.947	-1.366	-1.543	89.22
267	16.2	-33.8	-1.462	33.2	-16.8	- .644	.818	- .808	27.9	-22.1	- .869	-.235	-1.447	43.5	- 6.5	- .243	.626	- .907	-1.122	85.01
194	16.2	-33.8	-1.462	11.0	-33.0	-1.415	.047	-1.579	34.8	-15.2	- .579	.836	-1.157	49.8	.2	.007	.586	- .657	-1.137	85.16
300	16.4	-33.6	-1.450	22.2	-27.8	-1.135	.315	-1.299	17.5	-32.5	-1.386	-.251	-1.984	32.9	-17.1	- .656	.730	-1.320	-1.482	88.61
243	16.4	-33.6	-1.450	23.8	-26.2	-1.057	.393	-1.221	41.4	- 8.6	- .322	.735	- .900	27.0	-23.0	- .909	-.587	-1.573	-1.374	86.53
92	16.6	-33.4	-1.438	22.5	-27.5	-1.120	.318	-1.284	30.0	-20.0	- .778	.342	-1.356	45.0	- 5.0	- .187	.591	- .851	-1.200	85.79
163	16.6	-33.4	-1.438	16.8	-33.2	-1.427	.011	-1.591	29.1	-20.9	- .816	.611	-1.394	33.2	-16.8	- .644	.172	-1.308	-1.412	87.91
214	16.8	-33.2	-1.427	13.0	-37.0	-1.670	-.243	-1.834	19.4	-30.6	-1.279	.391	-1.857	19.1	-30.9	-1. 296	-.017	-1.960	-1.769	91.48
259	16.8	-33.2	-1.427	19.8	-30.2	-1.259	.168	-1.423	20.7	-29.3	-1.211	.048	-1.789	29.8	-20.2	- .786	.425	-1.450	-1.512	88.91
50	17.0	-33.0	-1.415	18.2	-31.8	-1.346	.069	-1.510	44.7	- 5.3	- .198	1.148	- .776	45.7	- 4.3	- .160	.038	-. 824	-1.048	84.27
44	17.2	-32.8	-1.403	24.8	-25.2	-1.009	.394	-1.173	36.9	-13.1	- .496	.513	-1.074	39.8	-20.2	- .786	-.390	-1.450	-1.271	86.50
177	17.2	-32.8	-1.403	22.2	-27.8	-1.135	.268	-1.299	39.0	-11.0	- .414	.721	- .992	38.6	-11.4	- .430	-.016	-1.094	-1.158	85.37
235	17.4	-32.6	-1.391	11.0	-39.0	-1.196	.195	-1.360	31.4	-18.6	- .719	.477	-1.297	16.8	-33.2	- 1.427	-.708	-2.091	-1.500	88.79
210	17.6	-32.4	-1.380	18.8	-31.2	-1.313	.067	-1.477	36.4	-13.6	- .516	.797	-1.094	32.8	-17.2	- .660	-.144	-1.324	-1.291	86.70
19	17.6	-32.4	-1.380	35.8	-14.2	- .539	.841	- .703	47.9	- 2.1	- .078	.461	- .656	65.2	15.2	.579	.657	- .085	-0.494	78.73
69	17.6	-32.4	-1.380	14.0	-36.0	-1.602	-.222	-1.766	29.3	-20.7	- .807	.795	-1.385	28.7	-21.3	- .834	-.027	-1.498	-1.490	88.69
298	17.8	-32.2	-1.368	28.0	-22.0	- .864	.504	-1.028	25.4	-24.6	- .982	-.118	-1.560	34.8	-15.2	- .579	.403	-1.243	-1.292	86.71
125	18.0	-32.0	-1.357	10.2	-39.8	-1.884	-.527	-2.048	23.7	-26.3	-1.063	.822	-1.640	23.3	-26.7	- 1.081	-.019	-1.745	-1.697	90.76
127	18.0	-32.0	-1.357	20.8	-29.2	-1.206	.151	-1.370	28.8	-21.2	- .829	.377	-1.407	27.5	-22.5	- .886	-.057	-1.550	-1.435	88.14
207	18.6	-31.4	-1.324	21.0	-29.0	-1.196	.128	-1.360	43.1	- 6.9	- .258	.938	- .836	36.5	-13.5	- .512	-.254	-1.176	-1.132	85.11
61	19.0	-31.0	-1.302	28.5	-21.5	- .842	.460	-1.006	42.2	- 7.8	- .292	.550	- .870	47.2	- 2.8	- .104	.188	- .768	-0.951	83.30
47	19.2	-30.8	-1.291	21.2	-28.8	-1.186	.105	-1.350	31.4	-18.6	- .719	.467	-1.297	36.0	-14.0	- .531	.188	-1.195	-1.274	86.53
171	19.2	-30.8	-1.291	24.0	-26.0	-1.047	.244	-1.211	26.5	-23.5	- .931	.116	-1.509	34.6	-15.4	- .588	.343	-1.252	-1.331	87.10
241	19.2	-30.8	-1.291	23.2	-27.8	-1.135	.156	-1.299	18.4	-31.6	-1.335	-.200	-1.913	20.0	-30.0	- 1.248	.087	-1.912	-1.604	89.83
5	19.6	-30.4	-1.269	29.2	-20.8	- .812	.457	- .976	73.7	23.7	.940	1.752	- .362	72.1	22.1	.869	-.071	.205	-0.325	77.04
85	19.6	-30.4	-1.269	26.2	-23.8	- .945	.324	-1.109	27.0	-23.0	- .909	.036	-1.487	27.0	- 23.0	- .909	0	-1.573	-1.389	87.48
91	20.4	-29.6	-1.227	28.8	-21.2	- .829	.398	- .993	21.5	-28.5	-1.170	-.341	-1.748	37.0	- 13.0	- .493	.678	-1.156	-1.229	86.08
205	20.4	-29.6	-1.227	25.5	-24.5	- .977	.250	-1.141	31.2	-18.8	- .727	.250	-1.305	35.5	-14.5	- .551	.176	-1.215	-1.221	86.00
253	20.4	-29.6	-1.227	22.0	-28.0	-1.145	.082	-1.309	26.1	-23.9	- .949	.196	-1.527	32.3	-17.7	- .681	.268	-1.345	-1.373	87.52
53	20.6	-29.4	-1.217	31.5	-28.5	-1.170	.047	-1.334	45.0	- 5.0	- .187	.983	- .765	43.8	- 6.2	- .231	-.044	- .895	-1.034	84.13
174	20.6	-29.4	-1.217	32.0	-18.0	- .693	.524	- .857	63.6	13.6	.516	1.209	- .062	65.8	15.8	.603	.087	- .061	-0.475	78.54
179	20.6	-29.4	-1.217	27.5	-22.5	- .886	.331	-1.050	21.7	-28.3	-1.160	-.274	-1.738	25.4	-24.6	- .982	.178	-1.646	-1.397	87.76
204	20.6	-29.4	-1.217	31.5	-28.5	-1.170	.047	-1.334	27.3	-22.7	- .895	.275	-1.473	25.7	-24.3	- .968	-.073	-1.632	-1.448	88.37
74	21.2	-28.8	-1.186	19.5	-30.5	-1.275	-.089	-1.439	6.5	-43.5	-2.245	-.970	-2.823	30.5	-29.5	-1 .232	1.023	-1.886	-1.692	90.71
294	21.2	-28.8	-1.186	18.0	-32.0	-1.357	-.171	-1.521	17.0	-33.0	-1.415	-.058	-1.993	27.7	-22.3	- .878	.537	-1.542	-1.148	85.27
108	21.4	-28.6	-1.176	24.0	-26.0	-1.047	.129	-1.211	36.7	-13.3	- .504	.543	-1.082	36.5	-13.5	- .512	-.008	-1.176	-1.153	85.32
212	22.2	-27.8	-1.135	21.8	-28.2	-1.155	.020	-1.319	27.3	-22.6	- .891	.264	-1.469	26.7	-23.3	- .922	-.031	-1.586	-1.415	87.94
282	22.6	-27.4	-1.115	30.8	-19.2	- .744	.371	- .908	46.6	- 3.4	- .127	.617	- .705	54.8	4.8	.179	.306	- .485	-0.768	81.47

TABLE IV CONTINUED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
36	23.0	-27.0	-1.096	44.2	- 5.8	- .216	.880	- .380	47.7	- 2.3	- .085	.131	- .663	63.6	13.6	.516	.601	- .148	-0.513	78.92
138	23.0	-27.0	-1.096	20.2	-29.8	-1 .238	-.142	-1.402	25.6	-24.4	- .972	.266	-1.550	46.9	- 3.1	-.115	.857	- .779	-1.196	85.75
159	23.0	-27.0	-1.096	25.8	-24.2	- .963	.133	-1.127	40.2	- 9.8	- .368	.595	- .946	31.2	-18.8	-.737	- .359	- 1.391	-1.145	85.24
130	23.2	-26.8	-1.086	21.2	-28.8	-1.186	-.100	-1.350	46.3	- 3.7	- .138	1.048	- .716	40.7	- 8.3	-.349	- .211	-1.013	-0.997	83.76
70	23.6	-26.4	-1.067	23.0	-27.0	-1.096	-.029	-1.260	19.1	-30.9	-1.296	- .200	-1.874	21.7	-28.3	-1.160	.136	-1.824	-1.506	88.85
284	23.8	-26.2	-1.057	21.8	-28.2	-1.155	-.098	-1.319	32.1	-17.9	- .689	.466	-1.267	36.7	-13.3	- .504	.185	-1.168	-1.212	85.91
288	24.0	-26.0	-1.047	36.5	-13.5	- .512	.535	- .676	41.0	- 8.0	- .337	.175	- .915	46.9	- 3.1	- .115	.232	- .779	-0.833	82.12
52	24.2	-25.8	-1.038	24.8	-25.2	-1.009	.029	-1.173	38.7	-11.3	- .426	.583	-1.004	39.3	-10.7	- .403	.023	-1.067	-1.061	84.40
261	24.2	-25.8	-1.038	26.0	-24.0	- .954	.084	-1.118	50.0	0	0	.954	- .578	51.8	1.8	.067	.067	- .597	-0.809	81.88
206	24.4	-25.6	-1.028	27.8	-22.2	- .873	.155	-1.037	25.8	-24.2	- .963	- .090	-1.541	35.7	-14.3	- .543	.420	-1.207	-1.232	86.01
26	24.6	-25.4	-1.019	27.8	-22.2	- .873	.146	-1.037	45.2	- 4.8	- .179	.694	- .757	38.8	-11.2	- .422	-.243	-1.086	-0.969	83.48
7	24.6	-25.4	-1.019	23.0	-27.0	-1.096	-.079	-1.260	21.9	-28.1	-1.150	- .054	-1.728	29.3	-20.7	- .807	.343	-1.471	-1.384	87.63
17	24.6	-25.4	-1.019	29.5	-20.5	- .799	.220	- .963	31.4	-18.6	- .719	.080	-1.297	44.7	- 5.3	- .198	.521	- .862	-1.037	84.16
266	24.8	-25.2	-1.009	23.8	-27.2	-1.105	-.096	-1.269	54.4	4.4	.164	1.269	- .414	47.4	- 2.6	- .097	-.261	- .761	-0.794	81.73
37	25.0	-25.0	-1.000	32.2	-17.8	- .685	.315	- .849	36.7	-13.3	- .504	.181	-1.082	41.7	- 8.3	- .311	.193	- .975	-0.974	83.53
227	25.2	-24.8	- .991	25.8	-24.2	- .963	.028	-1.127	25.2	-24.8	- .991	- .028	-1.569	26.6	-33.4	- .927	.064	-1.591	-1.319	86.98
8	25.2	-24.8	- .991	24.8	-25.2	-1.009	-.018	-1.173	67.4	17.4	.669	1.678	.091	74.8	24.8	.991	.323	.327	-0.354	77.33
73	25.2	-24.8	- .991	26.5	-23.5	- .931	.060	-1.095	27.4	-23.6	- .891	.040	-1.469	26.3	-23.7	- .940	-.069	-1.604	-1.289	86.68
80	25.4	-24.6	- .982	42.2	- 7.8	- .292	.690	- .456	72.1	22.1	.869	1.161	.291	78.3	28.3	1.160	.291	.496	-0.236	76.15
12	25.4	-24.6	- .982	35.0	-25.0	-1.000	-.018	-1.164	52.5	2.5	.093	1.093	- .485	46.7	- 3.3	- .123	-.216	- .787	-0.830	81.99
41	25.4	-24.6	- .982	30.5	-19.5	- .756	.226	- .920	50.0	0	0	.756	- .578	54.2	4.2	.156	.156	- .508	-0.747	81.26
276	25.4	-24.6	- .982	19.8	-30.2	-1.259	-.277	-1.423	39.3	-10.7	- .403	.856	- .981	40.4	- 9.6	- .360	.043	-1.034	-1.066	84.45
268	26.0	-24.0	- .954	36.5	-13.5	- .512	.442	- .676	45.9	- 4.1	- .153	.359	- .731	44.3	- 5.7	- .213	-.060	- .877	-0.809	81.88
226	26.4	-23.6	- .936	23.0	-28.0	-1.145	-.209	-1.309	44.0	- 6.0	- .224	.921	- .803	32.7	-17.3	- .665	-.441	-1.329	-1.070	84.49
167	26.6	-23.4	- .927	33.2	-16.8	- .644	.283	- .808	34.8	-15.2	- .579	.085	-1.157	44.0	- 6.0	- .224	.355	- .888	-0.945	83.24
22	26.8	-23.2	- .918	33.5	-16.5	- .632	.286	- .796	55.6	5.6	.209	.841	- .369	83.2	33.2	1.427	1.218	.763	-0.451	78.30
231	26.8	-23.2	- .918	23.8	-26.2	-1.057	-.139	-1.321	36.2	-13.8	- .523	.534	-1.101	22.4	-27.6	-1.125	-.602	-1.789	-1.195	85.74
77	27.0	-23.0	- .909	34.2	-15.8	- .603	.306	- .767	54.8	4.8	.179	.782	- .399	57.0	7.0	.261	.082	- .403	-0.619	79.98
30	27.2	-22.8	- .900	36.5	-13.5	- .512	.388	- .676	56.3	6.3	.235	.747	- .343	68.6	18.6	.719	.484	.055	-0.466	78.45
146	27.2	-22.8	- .900	27.2	-22.8	- .900	0	-1.064	36.7	-23.3	- .922	- .022	-1.500	24.9	-35.1	-1.005	-.083	-1.669	-1.240	86.19
116	27.8	-22.8	- .873	39.0	-11.0	- .414	.459	- .578	31.2	-18.8	- .727	- .313	-1.305	50.0	0	0	.727	- .664	-0.855	82.34
29	27.8	-22.2	- .873	29.0	-21.0	- .820	.053	- .984	50.7	.7	.026	.846	- .552	49.8	- .2	- .007	-.033	- .671	-0.770	81.49
157	28.0	-22.0	- .864	31.5	-18.5	- .714	.150	- .878	36.2	-13.8	- .523	.191	-1.101	36.5	-13.5	- .512	.013	-1.176	-1.005	83.84
236	28.0	-22.0	- .864	29.2	-20.8	- .813	.052	- .976	66.1	16.1	.616	.196	.038	55.6	5.6	.209	-.407	- .455	-0.564	79.43
293	28.0	-22.0	- .864	31.5	-18.5	- .714	.150	- .878	56.7	6.7	.250	.964	- .328	70.4	20.4	.795	.545	.131	-0.485	78.64
82	28.2	-21.8	- .855	41.5	- 8.5	- .318	.537	- .482	40.0	-10.0	- .376	- .058	- .954	59.1	9.1	.341	-.035	- .323	-0.653	80.32
218	28.6	-21.4	- .838	32.8	-17.2	- .660	.178	- .824	46.3	- 3.7	- .138	.522	- .716	49.6	- .4	- .015	.123	- .679	-0.764	81.43
223	28.8	-21.2	- .829	36.2	-13.8	- .523	.306	- .687	30.1	-19.8	- .773	- .250	-1.351	27.9	-22.1	- .869	-.076	-1.533	-1.100	84.79
193	29.0	-21.0	- .820	50.2	.2	.007	.813	- .157	32.5	-17.5	- .673	- .680	-1.251	60.3	10.3	.387	1.060	- .277	-0.626	80.05
49	29.2	-20.8	- .812	24.8	-25.2	-1.009	-.197	-1.173	58.1	8.1	.303	1.312	- .275	64.2	14.2	.539	.236	- .125	-0.532	79.11
46	29.4	-20.6	- .803	25.0	-25.0	-1.000	-.197	-1.164	18.6	-31.4	-1.324	- .324	-1.902	26.3	-23.7	- .940	.384	-1.604	-1.327	87.06
233	29.4	-20.6	- .803	37.5	-12.5	- .472	.331	- .636	45.6	- 4.4	- .164	.308	- .742	57.7	7.7	.288	.452	- .376	-0.639	80.18
289	29.4	-20.6	- .803	38.5	-11.5	- .434	.369	- .598	31.4	-18.6	- .719	- .385	-1.297	40.0	-10.0	- .376	.343	-1.040	-0.934	83.13
160	29.6	-20.4	- .795	44.8	- 5.2	- .194	.601	- .358	49.3	.7	- .026	.168	- .604	63.8	13.8	.523	.549	- .141	-0.474	78.53
31	29.8	-20.2	- .786	35.2	-14.8	- .563	.223	- .727	57.7	7.7	.288	.851	- .290	62.3	12.3	.484	.176	- .200	-0.500	78.79
106	29.8	-20.2	- .786	27.2	-22.8	- .900	-.114	-1.064	25.8	-24.2	- .963	- .063	-1.541	24.9	-25.1	-1.005	-.042	-1.669	-1.220	85.99
45	30.0	-20.0	- .778	35.2	-14.8	- .563	.215	- .727	43.1	- 6.9	- .258	.305	- .836	53.3	3.3	.123	.381	- .541	-0.720	80.99
178	30.0	-20.0	- .778	33.0	-17.0	- .652	.126	- .816	46.9	- 3.1	- .115	.537	- .693	51.4	1.4	.053	.167	- .612	-0.725	81.04
136	30.2	-19.8	- .769	26.7	-23.3	- .922	-.153	-1.086	32.5	-17.5	- .673	.249	-1.251	33.8	-16.2	- .620	.053	-1.284	-1.097	84.76
2	30.2	-19.8	- .769	28.0	-22.0	- .864	-.095	-1.028	82.8	32.8	1.403	2.287	.825	73.4	23.4	.927	-.476	.363	-0.288	76.67
166	30.2	-19.8	- .769	28.8	-21.2	- .829	-.060	- .993	57.7	7.7	.288	1.117	- .290	54.4	4.4	.164	-.124	- .500	-0.638	80.17
33	30.4	-19.6	- .761	32.5	-17.5	- .673	.088	- .837	38.7	-11.3	- .426	.247	-1.004	50.2	.2	.007	.433	- .657	-0.815	81.94
117	30.4	-19.6	- .761	29.8	-20.2	- .786	-.025	- .950	56.1	6.1	.228	1.014	- .350	49.6	- .4	- .015	-.213	- .679	-0.685	80.64

TABLE IV CONTINUED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
182	30.4	-19.6	-.761	35.5	-14.5	-.551	.210	-.715	38.6	-11.4	- .430	.121	-1.008	39.3	-10.7	- .403	.027	-1.067	-0.888	82.67
21	31.8	-18.2	-.702	41.2	- 8.8	-.330	.372	-.494	34.8	-15.2	- .579	- .249	-1.157	58.8	8.2	.307	.886	- .357	-0.677	80.56
162	31.8	-18.2	-.702	36.8	-13.2	-.500	.202	-.664	39.0	-11.0	- .414	- .086	- .992	53.5	3.5	.130	.544	- .534	-0.723	81.02
84	32.4	-17.6	-.677	35.8	-14.2	-.539	.138	-.703	69.3	19.3	.748	1.287	.170	64.0	14.0	.531	-.217	- .133	-0.336	77.15
93	32.6	-17.4	-.669	38.8	-11.2	-.422	.247	-.586	49.2	- .8	- .030	.393	- .608	54.2	4.2	.156	.186	- .508	-0.593	79.72
152	32.8	-17.2	-.660	38.0	-12.0	-.453	.207	-.617	44.7	- 5.3	- .198	.255	- .776	45.7	- 4.3	- .160	.038	- .824	-0.719	80.98
232	32.8	-17.2	-.660	47.2	- 2.8	-.104	.556	-.268	76.5	26.5	1.071	1.175	.493	81.2	31.2	1.313	.242	.649	-0.075	74.54
291	33.0	-17.0	-.652	66.0	16.0	.612	.040	.448	29.6	-20.4	- .795	-1.407	-1.373	78.3	28.3	1.160	1.955	.496	-0.355	77.34
59	33.6	-16.4	-.628	68.2	18.2	.702	-.074	.538	50.7	6.7	.250	- .452	- .328	71.6	21.6	.847	.597	.183	-0.059	74.38
158	33.6	-16.4	-.628	49.8	- .2	-.007	.621	-.171	51.8	1.8	.067	.074	- .521	59.0	9.0	.337	.270	- .327	-0.412	77.91
101	34.0	-16.0	-.612	35.0	-15.0	-.571	.041	-.735	51.8	1.8	.067	.638	- .521	59.5	9.5	.357	.290	- .307	-0.544	79.23
264	34.0	-16.0	-.612	36.5	-13.5	-.513	.100	-.676	58.4	8.4	.315	.829	- .263	54.2	4.2	.156	- .159	- .508	-0.515	78.94
72	34.2	-15.8	-.603	59.8	9.8	.368	.235	.204	50.7	.7	.026	- .342	- .552	53.4	3.4	.127	.101	- .537	-0.372	77.51
181	34.2	-15.8	-.603	34.2	-15.8	-.603	0	-.767	38.4	-11.6	- .437	.166	-1.015	43.1	-6.9	-.258	.179	- .922	-0.827	82.06
175	34.6	-15.4	-.588	42.2	- 7.8	-.292	.296	-.456	60.2	10.2	.383	.675	- .195	64.0	14.0	.531	.148	- .133	-0.343	77.22
155	35.4	-14.6	-.555	36.5	-13.5	-.512	.043	-.676	35.7	-14.3	- .543	- .031	-1.121	36.9	-13.1	-.496	.047	-1.160	-0.878	82.57
286	35.4	-14.6	-.555	70.8	20.8	.812	-.257	.648	41.4	- 8.6	- .322	-1.134	- .900	83.1	33.1	1.421	1.743	.757	-0.098	74.77
75	36.4	-13.6	-.516	42.2	- 7.8	-.292	.224	-.456	53.0	3.0	.112	.404	- .466	61.3	11.3	.426	.314	- .238	-0.419	77.98
42	36.4	-13.6	-.516	38.8	-11.2	-.422	.094	-.586	57.7	7 .7	.288	.710	- .290	56.5	6.5	.343	- .045	- .421	-0.453	78.32
71	36.4	-13.6	-.516	67.0	17.0	.652	1.168	.488	44.0	- 6.0	- .224	- .876	- .802	51.2	1.2	.044	.268	- .620	-0.362	77.41
245	36.6	-13.4	-.508	50.8	.8	.030	.538	-.134	56.5	6.5	.243	.213	- .335	70.7	20.7	.807	.564	.143	-0.208	75.87
151	37.0	-13.0	-.492	42.2	- 7.8	-.292	.300	-.456	47.7	- 2.3	- .085	.207	- .663	46.3	- 3.7	- .138	- .053	- .802	-0.603	79.82
105	37.0	-13.0	-.492	32.5	-17.5	-.673	-.181	-.837	42.4	- 7.6	- .284	.389	- .862	42.4	- 7.6	- .284	.002	- .948	-0.785	81.64
139	37.4	-12.6	-.476	32.5	-17.5	-.673	-.197	-.837	30.0	-20.0	- .778	- .105	-1.356	37.8	-12.2	- .461	.317	-1.125	-0.948	83.27
165	37.6	-12.4	-.468	27.8	-22.2	-.873	-.405	-1.037	24.7	-25.3	-1.014	- .141	-1.592	30.0	-20.0	- .778	.236	-1.442	-1.084	84.63
176	38.0	-12.0	-.453	47.2	- 2.8	-.104	.349	-.268	51.7	1.7	.083	.167	- .515	55.8	5.8	.216	.153	- .448	-0.421	78.00
209	38.0	-12.0	-.453	35.8	-14.2	-.529	-.076	-.693	71.2	21.2	.829	1.358	.251	63.1	13.1	.496	-.333	- .168	-0.266	76.45
281	38.2	-11.8	-.445	39.5	-10.5	-.395	.050	-.559	51.8	1.8	.067	.462	- .511	50.2	.2	.007	-.060	- .657	-0.543	79.22
97	38.6	-11.4	-.430	46.5	- 3.5	-.130	.300	-.294	41.7	- 8.3	- .311	-.181	- .889	44.9	- 5.1	- .190	.121	- .854	-0.617	79.96
272	38.6	-11.4	-.430	61.0	11.0	.414	.844	.250	48.2	- 1.8	- .067	-.481	- .645	48.2	- 1.8	- .067	0	- .731	-0.389	77.68
184	39.0	-11.0	-.414	48.2	- 1.8	-.067	.347	-.231	60.3	10.3	.387	.454	- .191	69.5	19.5	.756	.369	.092	-0.186	75.65
201	39.0	-11.0	-.414	34.0	-16.0	-.612	-.198	-.776	35.3	-14.7	- .559	.053	-1.137	29.8	-20.2	- .786	-.337	-1.450	-0.944	83.33
239	39.0	-11.0	-414	30.8	-19.2	-.744	-.330	-.908	36.4	-13.6	- .516	.228	-1.094	38.8	-11.2	- .422	.094	-1.086	-0.875	82.54
285	39.0	-11.0	-.414	56.2	6.2	.231	.183	.067	62.3	12.3	.464	.133	- .114	69.3	19.3	.748	.284	.084	-0.094	74.73
252	39.4	-10.6	-.399	50.2	.2	.007	.406	-.157	56.5	6.5	.243	.236	- .335	68.3	18.3	.706	.463	.042	-0.212	75.91
20	40.0	-10.0	-.376	57.8	7.8	.292	.668	.128	64.8	14. 8	.563	.271	- .015	64.0	14.0	.531	-.032	- .133	-0.099	74.78
187	40.0	-10.0	-.376	49.2	- .8	-.030	.346	-.194	75.3	25.3	1.014	1.044	.436	73.8	23,8	.945	-.069	.281	-0.008	73.87
25	40.8	- 9.2	-.345	41.0	- 9.0	-.337	.008	-.501	46.9	- 3.1	- .115	.223	- .693	50.5	.5	.019	.134	- .645	-0.546	79.95
199	41.0	- 9.0	-.337	39.5	-10.5	-.395	-.058	-.559	46.7	- 3.3	- .123	.272	- .701	44.5	- 5.5	- .205	- .082	- .869	-0.616	79.95
172	41.4	- 8.6	-.322	59.8	9.8	.368	.690	.204	60.8	10.8	.407	.039	- .171	70.7	20.7	.807	.400	.143	-0.036	74.15
277	41.4	- 8.6	-.322	67.8	17.8	.685	1.007	.521	76.7	26.7	1.081	.396	- .503	86.2	36.2	1.616	.535	.952	0.335	70.44
242	41.6	- 8.4	-.315	35.5	-14.5	-.551	-.236	-.715	50.7	.7	.026	.577	- .552	45.7	- 4.3	- .160	- .186	- .824	-0.601	79.80
271	41.6	-8 .4	-.315	43.2	- 6.8	-.254	.061	-.418	51.8	1.8	.067	.321	- .511	46.5	- 3.5	- .130	- .197	- .794	-0.509	78.88
94	42.2	- 7.8	-.292	57.0	7.0	.261	.553	.097	65.6	15. 6	.596	.335	.018	69.3	19.3	.748	.152	.084	-0.023	74.02
95	42.8	- 7.2	-.269	36.5	-13.5	-.512	-.243	-.676	49.8	- . 2	- .007	.505	- .585	38.8	-11.2	- .422	- .415	-1.086	-0.654	80.33
211	42.8	- 7.2	-.269	46.0	- 4.0	.149	.418	-.015	74.2	24.2	.963	.814	.385	68.2	18.2	.702	- .261	.038	0.035	73.44
119	43.4	- 6.6	-.246	46.5	- 3.5	-.130	.116	-.294	59.0	9.0	.337	.467	- .241	64.7	14.7	.559	.222	- .105	-0.221	76.00
255	43.6	- 6.4	-.239	58.5	8.5	.318	-.079	.154	64.0	14.0	.531	.213	- .047	75.3	25.3	1.014	.483	.350	0.021	73.58
213	43.8	- 6.2	-.231	40.2	- 9.8	-.368	-.137	-.532	47.4	- 2.6	- .097	.271	- .675	47.4	- 2.6	- .097	0	- .761	-0.549	79.38
13	44.0	- 6.0	-.224	50.1	.1	.004	.228	-.160	36.8	-13.2	- .500	- .504	-1.078	50.2	.2	.007	.507	- .657	-0.529	79.08
215	44.0	- 6.0	-.224	46.8	- 3.2	-.119	.105	-.283	50.9	.9	.033	.152	- .545	46.9	- 3.1	- .115	- .148	- .779	-0.458	78.37
63	44.4	- 5.6	-.209	40.5	- 9.5	-.357	-.148	-.521	47.9	- 3.1	- .078	.279	- .656	46.7	- 3.3	- .123	- .045	- .787	-0.543	79.22
195	44.4	- 5.6	-.209	49.8	- .2	-.007	.202	-.171	50.0	0	0	.007	- .578	61.2	11.2	.422	.422	- .242	-0.300	76.79
216	44.4	- 5.6	-.209	61.0	11.0	.414	.623	.250	76.7	26.7	1.081	.667	.503	80.0	30.0	1.248	.167	.584	0.216	71.63

TABLE IV CONTINUED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
186	44.6	-5.4	- .201	38.5	-11.5	- .434	- .233	- .598	51.6	1.6	.059	,493	9 .519	42.8	- 7.2	- .269	- .328	- .933	-0.563	79.42
147	44.8	-5.2	- .194	44.8	- 5.2	- .194	0	- .358	50,7	.7	.026	.220	- .552	52.3	2.3	.085	.059	- .579	-0.421	78.00
262	45.6	-4.4	- .164	58.8	8.8	.330	.494	.166	84.4	34.4	1.499	1.169	.921	84.4	34.4	1.506	.007	.842	0.331	70.48
141	45.8	-4.2	- .156	49.2	- .8	- .030	.126	- .194	58.6	8.8	.322	.352	- .256	56.5	6.5	.243	- .079	- .421	-0.257	76.36
265	45.8	-4.2	- .156	49.2	- .8	- .030	.126	- .194	61.2	11.2	.422	.452	- .156	62.6	12.6	.476	.054	- .188	-0.173	75.52
55	46.4	-3.6	- .134	49.8	- .2	- .007	.127	- .171	72.5	22.5	.886	.893	.308	78.8	28.8	1.186	.300	.522	0.088	73.91
154	46.4	-3.6	- .134	46.0	- 4.0	- .149	- .015	- .313	66.5	16.5	.632	.781	.054	60.4	10.4	.391	- .241	- .273	-0.166	75.45
115	46.6	-3.4	- .127	53.8	3.8	.141	.268	- .023	59.2	9.2	.345	.204	- .233	64.5	14.5	.551	.206	- .113	-0.124	75.03
197	47.0	-3.0	- .112	58.0	8.0	.299	.411	.135	53.0	3.0	.112	-.187	- .466	54.2	4.2	.156	.044	- .508	-0.238	76.17
274	48.0	-2.0	- .074	52.2	2.2	.083	.156	- .082	54.4	4.4	.164	.082	- .414	57.7	7.7	.288	.124	- .376	-0.236	76.15
279	48.2	-1.8	- .067	63.2	13.2	.500	.567	.336	61.8	11.8	.445	-.055	- .133	78.8	28.6	1.176	.731	.512	0.123	72.56
99	48.8	-1.2	- .044	52.8	2.8	.104	.148	- .060	62.8	12.8	.484	.380	- .094	60.4	10.4	.391	- .093	- .273	-0.118	74.97
256	49.4	- .6	- .022	56.8	6.8	.254	.276	.090	73.7	23.7	.940	.686	.362	79.3	29.3	1.211	.271	.547	0.210	71.69
200	49.6	- .4	- .015	59.5	9.5	.357	.372	.193	50.3	.3	.011	-.346	- .567	58.8	8.8	.330	.319	- .334	-0.181	75.60
137	50.0	0	0	49.5	- .5	- .019	- .019	- .183	58.6	8.8	.322	.341	- .356	51.8	1.8	.067	- .255	- .597	-0.259	76.38
263	50.2	.2	.007	59.0	9.0	.337	.339	.173	64.9	14.9	.567	.230	- .011	64.7	14.7	.559	- .008	- .105	0.016	73.63
153	51.4	1.4	.052	44.0	- 6.0	- .224	- .276	- .388	50.7	.7	.026	.250	- .552	38.6	-11.4	- .430	- .456	-1.094	-0.495	78.74
238	51.6	1.6	.059	53.0	3.0	.112	.053	- .052	61.2	11.2	.422	.310	- .156	63.6	13.6	.516	.094	- .148	-0.074	74.53
196	52.6	2.6	.097	54.2	4.2	.156	.059	- .008	55.4	5.4	.201	.045	- .377	64.0	14.0	.531	.330	- .133	-0.105	74.84
297	52.6	2.6	.097	61.0	11.0	.414	.317	.250	71.6	21.6	.847	.433	.269	73.8	23.8	.945	.098	.281	0.234	71.55
112	52.6	2.6	.097	57.2	7.2	.269	.172	.105	61.4	11.4	.430	.161	- .148	60.7	10.7	.403	- .027	- .361	-0.052	74.31
65	53.0	3.0	.112	62.5	12.5	.472	.360	.308	60.0	10.0	.376	-.096	- .202	69.8	19.8	.769	.393	.105	0.080	72.99
240	53.8	3.8	.141	70.8	20.8	.812	.671	.648	65.8	15.8	.603	-.209	.025	54.7	4.7	.175	- .428	- .489	0.081	73.98
54	54.0	4.0	.149	92.0	42.0	2.083	1.934	1.919	85.6	35.6	1.576	-.507	.998	84.7	34.7	1.518	- .058	.854	0.734	66.45
68	54.0	4.0	.149	95.8	45.8	2.562	2.413	2.398	89.1	39.1	1.827	-.735	1.249	90.2	40.2	1.918	.091	1.254	0 .948	64.31
287	54.6	4.6	.172	54.0	4.0	.149	- .023	- .015	50.3	.3	.011	-.138	- .567	71.2	21.2	.829	.818	.165	-0.061	74.40
1	55.4	5.4	.201	82.2	32.2	1.368	1.167	1.204	76.4	26.4	1.067	-.301	.489	78.6	28.6	1.176	.109	.513	0.544	68.35
113	55.6	5.6	.209	66.0	16.0	.612	.403	.448	62.7	12.7	.480	-.132	- .098	61.4	11.4	.430	- .050	- .234	0.081	72.98
96	56.0	6.0	.224	52.2	2.2	.083	- .142	- .082	58.1	8.1	.303	.221	- .275	56.3	6.3	.235	- .068	- .429	-0.140	75.19
14	56.2	6.2	.231	64.8	14.8	.563	.332	.399	58.6	8.6	.322	-.241	- .256	56.5	6.5	.243	- .079	- .421	-0.012	73.91
109	57.4	7.4	.277	60.8	10.8	.407	.130	.243	72.9	22.9	.904	.497	.326	79.8	29.8	1.238	.334	.574	0.330	70.49
222	57.6	7.6	.284	75.0	25.0	1.000	.716	.836	54.0	4.0	.149	-.851	- .429	90.7	40.7	1.962	1.813	1.298	0.355	70.34
40	57.8	7.8	.292	55.5	5.5	.205	- .087	.041	57.9	7.9	.296	.091	- .282	57.8	7.8	.292	- .004	- .372	-0.080	74.59
220	58.2	8.2	.307	54.0	4.0	.149	- .158	- .015	55.6	5.6	.209	.060	- .369	50.7	.7	.026	- .183	- .638	-0.179	75.59
168	58.4	8.4	.315	65.5	15.5	.593	.277	.428	83.3	33.3	1.432	.840	.854	89.3	39.3	1.843	.411	1.179	0.635	67.44
161	58.8	8.8	.330	73.5	23.5	.931	.601	.787	59.8	9.8	.368	-.563	- .210	78.6	28.6	1.176	.808	.512	0.332	70.47
237	59.2	9.2	.345	39.5	-10.5	- .395	- .740	- .559	65.4	15.4	.588	.983	.010	68.4	18.4	.710	.123	.046	-0.039	74.18
299	59.2	9.2	.345	62.8	12.8	.484	.139	.320	67.9	17.9	.689	.205	.111	72.3	22.3	.878	.189	.314	0.247	71.32
156	59.4	9.4	.353	57.8	7.8	.292	- .061	.128	70.2	20.2	.788	.494	.208	63.6	13.6	.516	- .370	- .148	0.135	72.44
120	59.6	9.6	.360	64.5	14.5	.551	.191	.387	81.2	31.2	1.313	.762	.735	74.2	24.2	.963	- .350	.389	0.413	69.66
169	59.8	9.8	.368	66.2	16.2	.620	.252	.456	62.8	12.8	.484	- .136	- .094	73.7	23.7	.940	.456	.276	0.251	71.28
60	60.2	10.2	.383	52.0	2.0	.074	- .309	- .090	76.5	26.5	1.071	.997	.493	71.2	21.2	.829	- .242	.165	0.209	71.70
142	62.8	12.8	.484	61.5	11.5	.434	- .050	.270	79.3	29.3	1.211	.777	.633	68.2	18.2	.702	- .509	.038	0.325	70.54
247	63.0	13.0	.492	69.0	19.0	.735	.243	.571	72.1	22.1	.869	.134	.291	70.9	20.9	.816	- .053	.152	0.376	70.03
189	63.6	13.6	.516	66.5	16.5	.632	.116	.468	81.2	31.2	1.313	.681	.735	74.7	24.7	.986	- .327	.322	0.485	68.04
111	63.8	13.8	.523	76.2	26.2	1.057	.534	.893	75.4	25.4	1.019	- .038	.441	76.2	26.2	1.057	.038	.393	0.556	68.23
221	63.8	13.8	.523	70.2	20.2	.786	.263	.622	81.9	31.9	1.351	.565	.773	84.2	34.2	1.487	.136	.623	0.657	67.22
114	65.0	15.0	.571	74.2	24.2	.963	.392	.799	89.8	39.8	1.884	.921	1.306	90.7	40.7	1.962	.078	1.298	0.916	64.63
32	65.0	15.0	.571	60.0	10.0	.376	- .195	.212	65.8	15.8	.603	.227	.025	65.3	15.3	.579	- .024	- .085	0.180	71.99
269	65.6	15.6	.596	72.8	23.8	.900	.304	.736	80.9	30.9	1.296	.396	.718	84.7	34.7	1.518	.222	.854	0.710	66.69
118	66.0	16.0	.612	59.8	9.8	.368	- .244	.204	89.6	39.6	1.867	1.499	1.289	82.8	32.8	1.403	- .464	.739	0.635	67.44
257	66.0	16.0	.612	76.0	26.0	1 .047	.435	.883	73.5	23.5	.931	- .116	.353	76.0	26.0	1.047	.116	.383	0.539	68.40
203	66.2	16.2	.620	60.8	10.8	.407	- .213	.243	79.1	29.1	1.201	.794	.623	77.9	27.9	1.140	- .061	.476	0.476	69.03
48.	66.8	16.8	.644	69.8	19.8	.769	.125	.605	72.3	22.3	.878	.109	.300	75.3	25.3	1.014	.136	.350	0.488	68.91

TABLE IV CONTINUED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
275	67.6	17.6	.677	86.2	36.2	1.616	.939	1.452	71.9	21.9	.860	- .756	.282	72.1	22.1	.869	.009	.305	0.565	68.14
295	67.8	17.8	.685	76.0	26.0	1.047	.362	.883	76.5	26.5	1.071	.034	.493	81.2	31.2	1.313	.242	.649	0.500	68.79
234	68.4	18.4	.710	74.2	24.2	.963	.253	.799	77.7	27.7	1.130	.187	.553	84.4	34.4	1.499	.369	.835	0.731	66.48
150	69.6	19.6	.761	72.2	22.2	.873	.112	.709	81.9	31.9	1.351	.478	.773	80.0	30.0	1.348	-.103	.584	0.714	66.65
129	69.8	19.8	.769	61.5	11.5	.434	-.335	.270	71.9	21.9	.960	.426	.282	63.7	12.7	.480	-.380	-.184	0.284	70.95
192	70.4	20.4	.795	73.8	23.8	.945	.150	.781	90.0	40.0	1.900	.955	1.323	85.4	35.4	1.583	-.337	.899	0.909	64.70
202	72.8	22.8	.900	64.0	14.0	.531	-.369	.367	75.6	25.6	1.028	.497	.450	70.9	20.9	.816	-.312	.153	0.469	69.10
248	73.4	23.4	.927	76.2	26.2	1.057	.130	.893	83.7	33.7	1.456	.399	.878	81.8	31.8	1.348	-.110	.682	0.856	65.33
132	74.8	24.8	.991	66.5	16.5	.632	-.359	.468	82.3	32.3	1.374	.742	.796	73.7	23.7	.940	-.434	.276	0.614	67.65
183	74.8	24.8	.991	66.0	16.0	.613	-.379	.448	89.1	39.1	1.827	1.315	1.249	78.3	28.3	1.160	-.667	.496	0.777	66.02
225	75.2	25.2	1.009	63.2	13.2	.500	-.509	.338	85.8	35.8	1.589	1.089	1.011	74.1	24.1	.958	-.631	.294	0.575	68.04
98	75.4	25.4	1.019	66.0	16.0	.612	-.407	.448	86.0	36.0	1.602	.990	1.024	72.5	22.5	.886	-.716	.232	0.592	67.87
51	75.8	25.8	1.038	77.5	27.5	1.120	.082	.956	86.5	36.5	1.636	.518	1.058	84.0	34.0	1.475	-.161	.811	0.965	64.14
107	77.0	27.0	1.096	73.5	23.5	.931	-.165	.767	92.3	42.3	2.114	1.183	1.536	87.7	37.7	1.720	-.394	1.056	1.004	63.86
188	77.0	27.0	1.096	82.2	32.2	1.368	.272	1.204	81.6	31.6	1.335	- .033	.757	87.0	37.0	1.670	.335	1.006	1.015	63.64
230	77.2	27.2	1.105	69.2	19.2	.744	-.361	.580	94.7	44.7	2.397	1.653	1.819	83.5	33.5	1.444	-.953	.780	0.902	64.77
198	77.6	27.6	1.125	82.2	32.2	1.368	.243	1.204	75.1	25.1	1.005	- .363	.437	77.7	27.7	1.130	.125	.466	0.805	65.74
250	77.8	27.8	1.135	83.5	33.5	1.444	.309	1.280	82.8	32.8	1.403	- .041	.825	89.3	39.3	1.843	.440	1.149	1.097	62.82
103	79.2	29.2	1.206	76.0	26.0	1.047	-.159	.883	98.4	48.4	3.182	3.135	3.604	94.4	44.4	3.357	-.825	1.693	1.263	61.16
76	79.6	29.6	1.227	67.0	17.0	.652	-.575	.488	81.6	31.6	1.335	.683	.757	70.0	20.0	.778	-.557	.114	0.591	67.88
296	79.8	29.8	1.238	59.0	9.0	.337	-.901	.173	85.1	35.1	1.543	1.206	.965	82.8	32.8	1.403	-.140	.739	0.892	66.87
292	81.0	31.0	1.302	78.8	28.8	1.186	-.116	1.022	90.2	40.1	1.918	.732	1.340	86.3	36.3	1.622	-.296	.958	1.155	62.24
100	82.2	32.2	1.368	85.8	35.8	1.589	.221	1.425	89.1	39.1	1.827	.238	1.249	85.6	35.6	1.576	-.351	.912	1.238	61.41
102	83.4	33.4	1.438	88.8	38.8	1.803	.365	1.639	94.7	44.7	2.397	.594	1.819	92.3	42.3	2.114	-.283	1.450	1.570	58.09
246	83.4	33.4	1.438	79.2	29.2	1.206	-.232	1.042	91.6	41.6	2.044	.838	1.466	83.8	33.8	1.462	-.582	.798	1.146	62.33
123	83.6	33.6	1.450	85.2	35.2	1.549	.099	1.385	97.7	47.7	2.958	1.409	2.380	95.1	45.1	2.453	-.505	1.789	1.639	57.40
23	84.6	34.6	1.512	91.5	41.5	2.035	.523	1.871	83.9	33.9	1.469	- .566	.891	91.4	41.4	2.028	.557	1.362	1.339	60.40
126	84.6	34.6	1.512	84.5	34.5	1.506	-.006	1.342	92.1	42.1	2.093	.587	1.515	90.4	40.4	1.935	-.158	1.271	1.395	59.84
79	84.8	34.8	1.524	87.2	37.2	1.685	.161	1.521	90.0	40.0	1.900	.215	1.322	93.7	43.7	2.269	.369	1.605	1.477	59.02
104	85.8	35.8	1.589	77.8	27.8	1.135	-.454	.971	91.6	41.6	2.044	.909	1.466	86.6	36.6	1.643	-.401	.979	1.220	61.59
185	86.0	36.0	1.602	74.2	24.2	.963	-.639	.799	89.3	39.3	1.843	.880	1.285	81.8	31.8	1.348	-.497	.682	1.046	63.33
229	86.6	36.6	1.643	82.0	32.0	1.357	-.286	1.193	97.7	47.7	2.958	1.601	2.380	87.5	37.5	1.706	-1.252	1.042	1.448	59.31
190	87.6	37.6	1.713	84.8	34.8	1.524	-.189	1.360	89.1	39.1	1.827	.303	1.249	85.3	35.3	1.556	-.271	.893	1.303	60.78
83	89.0	39.0	1.819	92.3	42.2	2.103	.284	1.939	86.9	36.9	1.663	- .440	1.085	93.7	43.7	2.269	.606	1.605	1.557	58.32
3	89.2	39.2	1.835	93.8	43.8	2.281	.446	2.117	96.5	46.5	2.686	.405	2.108	95.4	45.4	2.498	-.188	1.834	1.945	54.34
254	89.6	39.6	1.867	87.5	37.5	1.706	-.161	1.542	93.5	43.5	2.245	.539	1.667	91.2	41.2	2.007	-.238	1.343	1.638	57.41
62	90.0	40.0	1.900	86.5	36.5	1.636	-.364	1.472	96.5	46.5	2.686	1.050	2.108	88.6	38.6	1.788	-.898	1.124	1.586	57.93
133	91.8	41.8	2.084	84.5	34.5	1.506	-.558	1.342	97.2	47.2	2.834	1.328	2.256	90.7	40.7	1.962	-.873	1.298	1.800	57.79
131	92.4	42.4	2.124	94.5	44.5	2.370	.246	2.206	99.5	49.5	3.820	1.450	3.242	98.0	48.0	2.597	-1.223	1.933	2.203	51.76
122	93.0	43.0	2.188	90.2	40.2	1.918	-.270	1.754	95.8	45.8	2.562	.644	1.984	96.5	46.5	2.686	.124	2.022	1.940	54.39
145	94.2	44.2	2.331	90.2	40.2	1.918	-.413	1.754	97.7	47.7	2.958	1.040	2.380	94.9	44.9	2.425	-.533	1.761	1.997	53.82
24	97.0	47.0	2.789	99.0	49.0	3.450	.661	3.286	98.6	48.6	3.258	- .192	2.680	98.1	48.1	3.077	-.181	2.413	2.791	45.88
148	98.2	48.2	3.111	97.2	47.2	2.834	-.277	3.670	99.3	49.3	3.643	.809	3.065	97.0	47.0	2.789	-.854	2.125	2.670	48.09
							49.295					129.305					26.821			

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