Robert Recorde's
Whetstone of witte, 1557

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There is little that is original in the content of Robert Recorde's Whetstone of witte. Yet this book contains the "pair of twin paralleles of one lengthe" which Recorde used to mean "is equalle to." This was his own invention.

The year 1957 is the four hundredth anniversary of the publication of Robert Recorde's Whetstone of witte, the first algebra printed in English, the book in which the equality sign (=) was used for the first time. It is appropriate to mark this anniversary by quoting Recorde's explanation of his invention and by outlining its later history.

Contrary to the natural assumption that the value of this symbol would have been recognized at once, it develops that fully sixty years elapsed before its second appearance, although in less than a century after that time, it had general acceptance. This situation suggests that we examine the state of mathematics in England in the 1550's, that we review what we know about the author, and study the contents of the book itself.

1. The equality sign

At the beginning of his work with equations, Recorde says:

And to awoide the tedious repetition of these woordes: is equalle to: I will sette as I doe often in woork e vse, a pair of paralleles, or Gemowe (twin) lines of one lengthe, thus: = because noe .2. thynges can be more equalle.

The equality sign is Recorde's single contribution to the symbolism of algebra. Although the signs + and − were already in use, having letters represent unknown quantities was in the future. Algebra looked very different from the way it looks today.

In writing equations, Recorde's contemporaries used the word equal in its different forms as "seuales," "faciunt," "gleich." Sometimes they abbreviated these words. There was considerable experimentation with symbols, governed in part by the type the printers had on hand. In the years following the publication of the Whetstone of witte, different writers used a number of symbols to represent equality and the symbol (=) stood for a variety of meanings.1 In view of this competition and in consideration of the confusion of meanings assigned to the twin parallels, it is all the more remarkable that Recorde's invention ultimately won universal adoption. The process was slow.

The second appearance of the equality sign was in an appendix to a translation (1618) of Napier's first work on logarithms. It is supposed that this appendix was the work of William Oughtred, whose Clavis mathematicae (1631), a closely-packed work on arithmetic and algebra, was influential in winning for Recorde's symbol a general acceptance in England in the seventeenth century. By the eighteenth century, it had come into use on the continent.

1 Florian Cajori, History of Mathematical Notations (Chicago, 1928), Vol. I.
II. ROBERT RECORD AND HIS TIMES

Robert Recorde (c. 1510–1558) was born shortly after Henry VIII came to the throne of England. He died just before the accession of Elizabeth I.

His contemporaries on the continent included Cardan and Tartaglia who were doing pioneer work in mathematics in Milan and Venice. There were the German algebraists Rudolff, Stifel, and Scheubel. Copernicus, from Poland, published his great work in 1543. In 1538, Mercator, in Flanders, produced a map of the world on a projection used earlier by a Spaniard, but now called by his name. Methods of navigation were being improved. Almanacs of a sort were being published. The variation and the dip of the magnetic needle were being studied. The problem of the determination of longitude baffled mathematicians and other scientists. Sebastian Cabot maintained that he had solved it, but he died in 1557 without divulging his secret, and it was supposed that his boasts were the imaginings of an octogenarian.

England lagged behind in this activity. In fact the one important publication in mathematics prior to Recorde was Cuthbert Tunstall’s De arte Seppotandi (1522), a scholarly arithmetic in Latin based largely on continental models. So far as navigation and exploration were concerned, it is true that in 1497 the king had financed the voyage of the Genoese mariners John and Sebastian Cabot to the New World. John Cabot died the next year. Royal support stopped at this point, and Sebastian Cabot entered the employ of the King of Spain.

It was in the first half of the sixteenth century, however, that the center of world trade began to shift. Prior to this time, goods from China, India and the East Indies had been brought by caravan to the ports on the eastern shores of the Mediterranean where they were loaded on ships from Genoa and Venice and other Italian cities for distribution to different parts of Europe. The Mediterranean was still the great highway it had been in the days of Greece and Rome. But in the period under consideration, sea routes were being developed. England no longer lay at the periphery of the world but was shortly to assume an important position as a maritime power.

So far as mathematics was concerned, Englishmen were not isolated from the scholars on the continent. Tartaglia had dedicated a book to Henry VIII in 1546. John Dee (1527–1608) studied on the continent and knew some of the outstanding mathematicians personally. Cardan visited London on his way to Scotland in 1552. Robert Recorde himself seems to have read the works of a number of these men, and we know that he made considerable use of Scheubel’s algebra which was published in Paris in 1551.

But England had no mathematician to match the best of those in Europe, and so far as applied mathematics was concerned, the situation was deplorable. In England, navigation had not become a science. Map making was primitive. Surveying was casual. Little mathematics was taught. Arithmetic was neglected. Roger Ascham, tutor to the Princess Elizabeth, said that unless it was taught in moderation, mathematics overcharged the memory. It was a time when mathematics was needed to develop new techniques in surveying, navigation, and gunnery, but the workers knew no mathematics and the mathematicians, such as they were, lacked practical experience. The universities were of no help in the matter. The gap was bridged by a group, many of them amateurs, whom Dr. E. G. R. Taylor calls “Mathematical Practitioners.” Among them was Robert Recorde.

Recorde, a native of Pembroke in Wales, studied at Oxford, received the degree of Doctor of Medicine from Cam-

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bridge, and taught mathematics privately at both places, making the subject "clear to all capacities to an extent wholly unprecedented." He wrote a medical treatise of considerable importance, for it had at least ten editions from 1547 to 1665. He is reported to have practiced medicine in London, and it is claimed that he was physician to Edward VI and to Queen Mary. About 1551 he was appointed Surveyor of the Mines and Monies of Ireland and was made Comptroller of the Mint at Bristol. The Whetstone of Witte ends abruptly with the entrance of a messenger sent to fetch the author to answer charges presumably of mismanagement of one of these political jobs. Within a year he died in the King's Bench Prison.

III. Recorde's Mathematical Books

Recorde was an opportunist. In his mathematical books, his aim was to provide the reader with needed information in palatable form. Recorde's four published books in mathematics were:

The Ground of Artes, an arithmetic, 1542
or perhaps 1540
The Pathewaie to Knowledge: First Principles of Geometry, 1551
The Castle of Knowledge, an astronomy, 1551
The Whetstone of Witte, an algebra, 1557

In the prefaces of these volumes he refers to others he intends to write, in one case speaking of "other sundrye woorkes partly ended and partly to bee ended."

He took a realistic view of his qualifications as a writer. In the Preface of the Ground of Artes, he says

...I know that no man can satisfy every man, and therefore like as many do esteeme greatly other books, so I doubt not but some will like this my booke above any other English Arithmeticke hitherto written, & namely such as shall lacke instructers, for whose sake I haue plainly set forth the exa[m]ples, as no book (that I haue seene) hath hitherto.

His books were in the form of a dialogue between a Master and a Scholar, with the Scholar asking the leading questions in just the proper places. The books were well adapted to "such as shall lacke instructers."

The Pathewaie to Knowledge was dedicated to Edward VI with this explanation or apologia,

Excuse me, Gentle Reader, if ought bee amisses' strange pathes are not trode[n]al truly at the first: the way muste needed be combersome, wher none hathe gone before.... For neith[er] is my witte so finely fil[e], neither my learning so largely lettered neither yet my lasure so quiet and vncombered, that I maie performe justely so learned a labor. .... Yet may I thynke thus: This candle did I light: this light have I kindled: .... I drew the platte [plan] radiele wheron theye maye builde, whom God hath indued with learning. .... And this Gentle Reader I hartelie protest, where erroure hath happened I wishe it redreste.

As for the Whetstone of Witte, Recorde is modest, but he felt that an algebra should be written and that it behooved him to do it. He says

For better is it that a simple Coke doe prepare thy brekefast then that thou shouldest goe a hungered to bedde.

The Ground of Artes was a practical arithmetic. It found great use, as is witnessed by the fact that it had many editions over a period of a hundred and fifty years. It was quite in keeping with Recorde's purpose that the editors of later editions incorporated new things in them. The Pathewaie to Knowledge, dedicated to Edward VI, was an introduction to geometry with definitions and conclusions in the first part, and proofs of the conclusions in the second. Third and fourth parts giving applications of these principles were promised but were never printed.

Recorde's astronomy, the Castle of Knowledge, dedicated to the Princess Mary, was both practical and theoretical. Dr. Taylor states that, "Like most physicians of his day, Recorde believed that the aspects of the heavens determined the correct times for taking medicines and other remedies, and he emphasized this equally with the needs of navigation for the study of astronomy." It has been claimed that Recorde's astronomy set forth the Copernican hypothesis, but Dr.
Taylor says that Recorde "expressed himself cautiously . . . but held no brief for an unmoveable earth circled by the stars and planets." Recorde might well be excused for being cautious for it must be remembered that the date of Copernicus's great work was 1543, and that this had a preface explaining that the hypothesis that the earth moved round the sun was merely a convenience in computation. It was after Recorde's time that Kepler detected that this was an interpolation.

IV. Recorde's algebra
The full title of Recorde's algebra is

The whetstone of witte
which is the seconde parte of Arithmetike: containing the extrac-
tion of Rootes: the Cossike practise, with the rule of Equation: and the worke of Surde Numbers

Augustus de Morgan shows that this title is a play on words. The word cos, meaning a thing, was derived from the Latin causa by way of the Italian cosa. German and English writers used it to represent an unknown quantity. Consequently "Cossike practise" meant algebra. In Latin, the word cos means a grindstone. "Cossike practise" might be put into Latin as cos ingenii which in turn could be trans-
lated into English as the Whetstone of witte.

The preface is dated November 11, 1557. It should be remembered that at that time, the new year in England began March 25. There was time to print the volume before the end of 1557.

The book is dedicated to the "Venturers into Muscovia." In his introduction, Recorde says that he will

. . . shortly set forth the same a books of Naviga-
tion as if dare saie shall partly satisifie and cont-
tente, not onely your expectation but also the desire of a greate number beside wherin I will not forgette specially to touche bothe the olde attempte for the Northlie Navigators, and the later good adventure.\(^4\)

In writing this algebra, Recorde referred to the work of Johannes Scheubel (1494–1570), professor of mathematics in the University of Tübingen, whose Algebrae compendiosa facilitque descriptio was published in Paris in 1551. Recorde objects to Scheubel's classification of equations, substituting one which he considered much simpler. Having thus improved upon Scheubel, Recorde proceeded to use direct translations of Scheubel's verbal problems. In fact, not only was Recorde acquainted with Scheubel's work but he plagiarized a considerable part of it. This is true not only in the section on algebraic equations, but also in the work on surds.\(^5\)

V. The extraction of rootes
The first part of the Whetstone of witte considers numbers: whole numbers and broken numbers, "abstracte" and "contracte," evenly even and evenly odd. These last were of the type \(2^n\) and \(2(2^n + 1)\). The ratios of numbers are classi-
fied with special names for each type. The subject of diametral numbers is treated in detail. A diametral number is the product of two integers which have the property that the sum of their squares is itself a perfect square. In other words, when \(a, b,\) and \(c\) are integers such that \(a^2 + b^2 = c^2\), then \(ab\) is a diametral number. Recorde

\(^4\) The reference here is to expeditions sent out by the "mystery and Company of Merchant Venturers" with the co-operation of Sebastian Cabot, newly returned from Spain. The purpose was to find a route to India and to wider markets for English products. The 'olde attempte' was an expedition to find the North West Passage. The 'later good adventure' was sent out in 1553 to find a North East passage to India. It reached Russia instead. By penetrating the White Sea to the place where the port of Archangel now stands, the leader went overland to Moscow, where he met the tsar and obtained trading concessions. He thus circumvented the Hansatic League which held a monopoly of trade through the Baltic, and opened the way for later commercial agreements between Russia and England. The backers of this expedition received a charter for trade with Russia and became the Moscow Company. Robert Recorde was one of their advisers, presumably in questions of navigation.

\(^5\) See Mary S. Day, Scheubel as an Algebraist (Con-
tributions to Education No. 219 [Teachers College, Columbia University, 1926]).

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shows that diametral numbers must end in 0, 2, or 8. They must be divisible by 12 and they cannot themselves be square numbers.

Recorde devoted over fifty pages to the extraction of roots. Here he gives particular attention to what he calls “lower matters in warre.” For example,

A citie should bee sealed, beyng double diched. And the inner dich .32. foote broade. And the walle .21. foote high. The captaine commandeth to be made of that juste lengthe, that maie reche from the utter brow of the inner dich, to the toppe of the wal.

A bollette of yron of .7. inches diameter, doeth waine .27. pounds weighte: what shall be the diameter to that bollette that shall waine .125. pounde to the weighte?

**VI. THE Cossike Practice**

The second part of the *Whetstone of witte* deals with algebraic numbers and with equations.

Following Scheubel’s example, Recorde uses the symbol $Q$ to denote a number, $\sqrt{\ }$ for the unknown quantity or root, $\sqrt[3]{\ }$ for its square, and $\sqrt[4]{\ }$ for its cube. The fourth order of these numbers was indicated by repeating the symbol for a square, i.e., a square of a square. Recorde’s predecessors had carried this system to great lengths, but Recorde outdid them by taking it to the eightieth order. It should be noted that in any equation every term, even the constant one, had its symbol. Like Scheubel, Recorde also made use of abbreviations for these quantities—N, Ra., Pr., Se., Ter., and so on (the number, a root, the first product, the second product, etc). As an aid to the reader, Recorde lists the symbols in order, numbering them 1, 2, 3, . . . and says “By this table, maie you easily knowe the signe that shall serve for your newe somme in multiplication.”

The Scholar had difficulty in grasping the fact that $.12. \sqrt{\ }$ multiplied by $.6. \sqrt[4]{\ }$ makes $.72. \sqrt[4]{\ }$. He says

This passeth my cunninge, for the findyng of the newe signe although the multiplication of the numbers be as easie as can be.

The Master answers

If you did well remember what you haue learned before; the mister would not seme so harde.

In dealing with “Cossike numbers,” Robert Recorde introduced two signs, familiar to German writers, and familiar also to readers of the *Ground of Artes*. He says

. . . touching these twoo signes + and - which bee the figures of more and lesse, you must glue regard whether thei bee like or unlike, in those numbers that must be added: For if thei be like in nombers of one denomination, then muste thei so remain as thei be. But if thei be unlike, euermore abate the smaller nomber of thei them that followe those unlike signes out of the greater, and sette doune the reste with the signe of the greater nomber.

The Scholar is then confronted with eight examples in which cossike numbers are to be added. These are the different arrengements of two basic problems. \(^4\)

\[
\begin{array}{cc}
10x \pm 12 & 10x \pm 8 \\
4x \pm 8 & 4x \pm 12
\end{array}
\]

He says

Here haue I varied one example diversely, to the intente you maie marke the vse of your rules in theim.

He explains the addition of $4x - 8$ to $10x + 12$ as follows:

this sum is not fully $4x$ but wanteth of it $8$ and therefore if you put downe $4x$ fully, you must abate $8$ out of the $12$ in the larger summe.

Recorde had a liking for putting things that were to be memorized into rhyme. The results were interesting. Here is his verse for the rules of signs in multiplication and division.

who that will multiplie or yet divide trule:
shall like stille to haue more and mislike lesse in store.

The Scholar summarized it in these words:

So meane you that like signes multiplied together, doe make more, or $+$ and unlike sines multiplied together doe yele lesse or $-$

In Recorde’s work with polynomials, no powers of the cossike number are omitted.

\(^4\) For convenience, modern symbols are used in these illustrations and in the balance of this paper.
For example, $8x^2 + 0x^2 + 0x + 64$ is to be divided by $2x + 4$.

Having practiced the fundamental operations with polynomials, the Master shows how to add fractions whose numerators and denominators are algebraic quantities. By his scheme, horizontal lines are drawn above and below the fractions that are to be added. The common denominator is written below the bottom line and the new numerators are written above the top line.

VII. “The Rule of Equation Commonly Called Algebra’s Rule”

This Rule is called the Rule of Algebra, after the name of the inventoure, as some men thinke . . . but of his vse it is rightly called the rule of equation: because that by the equation of nombers, it doeth dissolve doubtful questions: and unfolde intricate riddles.

Recorde’s statement about the use of equations in solving problems is involved but worth considering.

When any question is propounded . . . you shall imagin a name for the number, that is to bee soughte, as you remember that you learned in the rule of false position. And with that number shall you procede, accordyng to the question, vntil you find a Cosmaske number equalle to that number that the question expresseth, whiche you shall reduce euuer more to the leaste nombers.

The Scholar compares this with the rule of false, the method of solving problems by guessing the answer and then adjusting the guess until it fits the problem. The Master goes on . . . it mai bee thoughte to bee a rule of wonderfull invention that teacheth a manne at the firste worde to name a true number before he knoweth resolutely [surely] what he hath named.

But because that name is common to many numbers [although not in one question] and therefore the name is obscure till the worke doe detect it, I thinke this rule might well bee called the rule of darke position, or of strange position, but not of false position.

And for the more easie and apte worke in this arte wee doe commonly name that dark position . . . and with it doe we worke as the question intendeneth till we come to the equation.

At this point Recorde introduced the sign of equality, following it at once, as is shown in the accompanying facsimile, by a series of equations which he then considers in detail. In the case of $14x + 15 = 71$, he says . . . you maie see one denomination on both sides of the equation which neuer ought to stood. Wherefore abating the lesser, that is 15, out of both nombers, there will remain

$$14x = 56$$

this is by reduction $x = 4$ according to the third common sentence in the Parheisit—If you abate euuen portions from thynges that bee equalle, the partes that remain shalbe equall also.

Other “common sentences” are used in solving other equations.

When confronted with the equation $26x + 10x = 9x^2 - 10x + 213$, the Scholar wonders whether to add $10x$ or to “abate them.” The Master says

In soche a case, you maie doe either of bothe at your libertie and all will be to one ende. . . . And euermore when occasion serueth to translate nombers compounde, — on the one side is equalle to + on the other side.

Robert Recorde classifies equations into two groups:

1. Where one number is equal to another number,
2. Where one number is equal to two other numbers.

Here he has departed from Scheubel whose detailed classification can be represented as follows:

First type $bx = N$

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Second type  
(1) $ax^2 + bx = N$
(2) $x + N = x^2$ or $bx + N = x^2$
(3) $bx + N = ax^2$

Third type $x^3 + N = bx$

Neither writer classified equations according to their degree. Recorde includes the equation $6x^2 = 24x$ under his first heading, one number equal to another number, but he shows that the answer is not 4 but the square root of 4. He did not recognize roots that were zero or negative.

No reasons or explanations are given. Quadratic equations are solved by completing the square.

When the Master has completed the solution of a number of equations, the Scholar says "I doe couette some apte questions, appertainyng to these equations." The Master supplies them. They are not easy.

In one of these problems two men have silk to sell, one man has 40 ells, the other 90. The first man's silk is of the poorer quality, so he has to sell a third of an ell more for an angel than does the second man. If their total receipts are 42 angels, how many ells of silk did each sell for an angel? The Scholar makes a false start. He lets his unknown quantity represent the first man's receipts. The Master does not approve and suggests that he divide each man's ells by the number he sold for an angel and the quotient will be the man's receipts. Working this way, the Scholar finally comes to the conclusion that one man sold three ells for an angel and the other three and one third, so their receipts were 12 angels and 30 angels. Not content with this, the Scholar reverses the problem. Instead of using $x$ and $x + \frac{1}{3}$, he uses $x - \frac{1}{3}$ and $x$. This time he gets one root correctly, but he also finds the other one, namely $2/21$, and says

But how I maie frame that roote to agree to this question, I doe not see.

The Master is no help to him, except to say that

. . . . the forme of the question maie easily in-
struct you whiche of these 2. rootes you shall take for your purpose.

As an example of a question where both roots fit the problem, the Master gives the following:

A gentleman, willyng to proue the cunning of a braggyng Arithmetician, saide thus: I haue in bothe my handes .8. crownes: But and if I ac-
compte the somme of eche hande by it self seuerally and put thereto the squares and the cubes of bothe, it will make in number 194. Now tell me (quod he) what is in eche hande: and I will give you all for your labour.

As would be expected, the answers 3 and 5 are the numbers in the man's hands.

In another case, the problem states that if 8 is added to a number and if 16 is taken from the square of the number, the pro-
duct of the two results is 2560. This yields the equation $x^2 + 8x^2 - 16x = 2088$. The Scholar is baffled. It is above his cunning, for here two numbers are equal to two others, or one number is equal to three numbers. The Master does not solve the problem. One suspects that he concocted the question by starting with the result. He simply says that the required number is 12 and has the Scholar show that this answer fits the equation. At this point the Master says

But to put you out of doubt, this equation is but a trifle to others that bee untouched.

There is no lack of variety in the prob-
lems. A man travels $1\frac{1}{3}$ miles the first day and increases his day's journey by $\frac{1}{8}$ mile each day. How long does it take him to go 2955 miles? In another case, the day's mileage increases in a geometric progress-
ion.

A herald is offered a bribe if he will tell
the number of his king's army. The prob-
lem goes on this way—

The Heraulde lothe to lease those giftes, and as lothe to bee vntrue to his Prince, diuiseith his answere, whiche was true, but yet not so plain, that the aduersarie could thereby understand that whiche he desired. And that answere was this. Look how many Dukes there are, and for eche of them, there are twise so many Erles. And vnder euer Erle, there are fower tymes so many sondiars, as there be Dukes in the field. And when the muster of the soldiers was taken, the .500. parte of them was .9. tymes so many as the

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number of the Dukes. That is the true declaratio of eche number, quod the Heraulte: and I haue discharged my othe. Now guessu you how many of eche sorte there was.

A man dies leaving 72 crowns to his four children in this way: the second and third together were to have seven times as much as the first. The third and fourth were to have five times as much as the second. The first and fourth were to have twice as much as the third. It might be well to note that the children received the following sums: 4\(\frac{1}{2}\), 11\(\frac{1}{4}\), 20\(\frac{1}{4}\), 36.

A captain marshals his army in a square formation. When the square was of one size, he had 284 men too many, so he tried to rearrange them in a square one man more on a side than before. This time he lacked 25 men. How many men did he have?

viii. The woorke of surde nombers

The third part of the Whetstone of witte is devoted to irrational numbers, which Recorde calls surds. He says

Nombres radicale, which commonly bee called numbers irrationale: because many of them are soche, as can not bee expressed, by common numbers abstracte, neither by any certain rationalle number. Other men call them more aptly surde numbers . . . A surde number is nothyng els, but soche a number set for a roote, as can not be expressed by any number absolute, as \(\sqrt{10}\) or \(\sqrt{18}\) or any number, that is not a square.

Surds are commensurable if they can be expressed as multiples of the same root; otherwise they are incommensurable.

Binomials made up of a rational number and an irrational one, are classified in two groups: “Nombres that be compounded with + be called Bimedialles and with — Residuales.”

Accordingly, to divide by a binomial, dividend and divisor must be multiplied by the residuale of the divisor if the divisor is a bimedial, or by the bimedium of the divisor if the divisor be a residuale.

Recorde’s square root sign was much like ours, but his signs for the cube root and the fourth root were perplexing. These are the symbols used by Scheubel, which he in turn had taken from the work of Rudolf (1525). When confronted with the symbol \(\sqrt[3]{\cdot}\) for cube root and \(\sqrt[4]{\cdot}\) for the fourth root, the Scholar speaks his mind.

It were againste reason, to take reason for these signs, which be set voluntarily to signifie any thynge; although some tymes there bee a certain apte conformitie in soche thynges. And in these figures, the number of their minomes [i.e., up-strokes] seemeth disagreeable to their order.

The Master replies:

In that there is some reason to bee thewed [instructed]: for as \(\sqrt[3]{\cdot}\) declareth the multiplication of a number, ones by itself; so \(\sqrt[4]{\cdot}\) representeth that multiplication Cubike, in whiche the roote is represented thriee. And \(\sqrt[3]{\cdot}\) standeth for \(\sqrt[4]{\cdot}\), that is .2. figures of Square multiplication: and is not expressed with .4. minomes. For so should it seeme to express moare then .2. Square multiplications. But voluntarie [i.e., arbitrary] signes, it is enough to knowe that this doe signifie. And if any Manne can diuise other, moare easier or apter in use, that mai well be received.

ix. Appraisal of the Whetstone of witte

The chances are that the Whetstone of witte had few if any readers on the continent. Anyone interested in algebra would have found more satisfaction in Scheubel’s concisely worded, elegantly printed treatise in Latin than in Recorde’s popularization of it in English. So far as the equality sign was concerned, it is more than likely that Recorde had no particular pride in his invention. It was a thing he had found convenient. On the other hand, his simplification of Scheubel’s classification of equations, in which he took apparent satisfaction, is of little interest today.

The Ground of Artes was closely connected with practical affairs. The Whetstone of witte seems to contain no practical applications, the reason being that algebraic problems which we would solve by equations of the first degree were treated by the rule of false in Recorde’s arithmetic. The Whetstone of witte certainly had a smaller public. Had Recorde been able to complete the books that were “partely to bee ended,” the algebra might

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Letters to the editor

Dear Sir:

I should like to describe the mathematics offering of the Bronx High School of Science as somewhat more accurately and adequately than it was portrayed in Mr. Baumgartner's article, "The Status of Secondary Mathematics Program for the Talented" as found in the November (1956) issue of THE MATHEMATICS TEACHER.

Our Ninth, Tenth and Eleventh Year Mathematics courses are based upon the New York State Syllabus (obtainable from the State Education Department, Albany 1, New York). These courses include Elementary Algebra, Plane Geometry, Co-ordinate Geometry, Intermediate Algebra, and Trigonometry. In this school, all the mathematics courses are considerably enriched and extended for all classes. Topics such as determinants, advanced factoring, inequalities, etc., are in our "regular" course.

Our "regular" elective program includes the following courses:
1. Advanced Algebra followed by a Higher Geometry course,
2. Advanced Algebra followed by a Higher Algebra course,
3. A combination of 1 and 2,
4. A one-year course in the mathematics of science, for which either 1 or 2 is corequisite,
5. Advanced Algebra followed or preceded by a course offered by the Science Department, "The History and Development of Science."

The Advanced Algebra course includes a substantial introduction to the calculus. The Higher Geometry course, which replaced Solid Geometry, includes a unit on the postulational basis of solid geometry, a unit on solid analytics, and a unit on vector analysis. The unit on vector analysis, developed by Mr. A. Glicksman, is a rigorous postulational system based upon algebra rather than geometry.

As needfulle, and in woorke as straunge:
Dulle things and harde it will so chaunge,
And make them sharpe, to right good vse:
All artesmen know, thei can not chuse,
But vse his helpe: yet as men see,
Noe sharpe base semeth in it to best.
The grounde of artes did brede this stone:
His Vse is greate, and moare then one.
Here if you list your wittes to whet,
Moch sharpennesse therby shal you gette.
Dull wittes hereby doe greatly monaces
Sharp wittes are fined to their full ende
Now proue, and praise, as you doe find,
And to yourself be not vnkinde.

The Higher Algebra course is based upon Allendoerfer and Oakley's Principles of Mathematics. It includes the theory of groups, rings and fields, some function theory, and additional work in the calculus. This course was developed by Messrs. Ruderman and Glicksman.

The Mathematics of Science course uses ten reference books, plus mimeographed material. The units include navigation, surveying, statistical analysis, biometrics, physical chemistry, theoretical physics and higher mathematics. This course was prepared by Mr. Greitzer.

At the present time, the Mathematics Department is working on a new Eleventh Year course of study involving a systematic development of algebra from group and field theory. Experimentation will take place in the 1957-1958 school year.

In addition to the "regular" mathematics program, described above, we have an "honors" mathematics program. Students are allowed to apply for this accelerated program at the end of the tenth year. Of the applicants, approximately two classes are selected. The minimum requirement is 90% in every major, no difficulty of any kind, excellent achievement and interest in mathematics, and the recommendation of the teachers. In the eleventh year, these two classes take a combined course including Eleventh Year Mathematics and almost all of Advanced Algebra, with all optional topics recommended in the Kenyon Plan. During the summer, after the end of the eleventh year, students are required to learn Solid Geometry by home study. Upon returning to school, these students undergo an examination which emphasizes that part of Solid Geometry which is indispensable in the study of the Calculus. There are no proofs in this examination.

The successful candidates enter the "College Mathematics" class in the twelfth year. Here they study Analytic Geometry and the Calculus. The textbooks are Wilson and Tracey.

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